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Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

Final Report

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Final Report

Trinomics

Contract details

European Commission – DG Energy

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Executive Summary

The European Union (EU) aims to be climate-neutral by 2050 and has committed to reducing the net emissions by at least 55%, by 2030 — an increase from the 40% target set previously. As the production and use of energy (including energy used in households, industry, services and transport) accounts for more than 75% of EU's total greenhouse gas emissions, increasing the share of renewable energy use across all sectors of the economy will be essential to achieve the new target. A revision of the Renewable Energy Directive 2018/2001/EU (RED II) is necessary to make this existing piece of legislation fit for 55% emission reduction, and to ensure that renewable energy fully contributes to achieving the climate ambition of the EU. The revision of RED II would be built upon the 2030 Climate Target Plan, and should also implement EU strategies, such as the Energy System Integration and the Hydrogen Strategies, the Renovation Wave, the Offshore Renewable Energy Strategy and the EU Biodiversity Strategy for 2030.

To support the European Commission in this policy review, a request for services was issued to provide *technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration* (ENER/ C1/2020-440). The project, which started in September 2020, was awarded to a consortium, which includes Trinomics (Lead), Ludwig-Bölkow-Systemtechnik (LBST), Artelys and E3-Modelling (E3M). The consortium supported the European Commission, DG Energy, in identifying and assessing various regulatory options to foster renewable energy deployment that is aligned with the climate ambitions and other EU strategies. The main objective of the request was to assist DG Energy to identify existing sources and develop a series of arguments to be used as evidence in the impact assessment analysis. The regulatory options considered in this assessment were grouped in five topic areas, namely *renewables in buildings, including heating and cooling*, *renewables and other low carbon fuels in the transport sector*, further deployment of *renewable electricity*, *transversal elements* and *bioenergy*. Further, an open public consultation (OPC) process was launched in November 2020, and two online workshops were organised in December 2020 and March 2021. The results of the analysis and the inputs received from stakeholders and citizens, contributed to the impact assessment that DG ENERGY submitted to the Regulatory Scrutiny Board in April 2021.

Project overview

The objectives of the study

The broad objective of this assignment was to provide assistance to the European Commission in the process of reviewing the current approach to foster renewable energy deployment as defined by the Renewable Energy Directive 2018/2001/EU (RED II).

Specifically, the project team supported DG Energy during the impact assessment process by:

- analysing emerging issues and areas for improvements of RED;
- helping DG Energy in identifying and designing the main policy options to be evaluated;
- identifying evidence to support the qualitative and quantitative assessment of the impacts of the main options considered (Economic, Environmental, Effectiveness, Administrative burden, Coherence);
- modelling of the main policy scenarios and key options;
- support with stakeholder consultations.

Assistance was also provided during the finalisation of the impact assessment, by giving ad-hoc support to address the feedback of the Regulatory Scrutiny Board of the Commission's Impact Assessment on the Renewable Energy Directive.

Scope

The project was set up in three separate tasks:

1. **Task 1 IA and regulatory options.** Support to the Commission in analysing the regulatory options to foster renewable energy deployment that are in line with Green Deal ambitions, an integrated energy system approach and the energy efficiency first principle. In terms of scope:
   a. The analysis covered a number of themes:
      - Overall target;
      - System integration;
      - Renewable electricity;
      - Heating and cooling (H&C);
      - Buildings;
      - Transport;
      - Industry;
      - Bioenergy.

   b. **Time coverage:** the modelling analysis carried out with PRIMES produced results at five-years interval up to 2050. On the other hand, the semi-qualitative analysis carried out to support the assessment of single options was more focussed on the medium-short term, in particular with a view to 2030.

   c. **Geography:** the modelling analysis covered EU27 and results were also provided at Member State level. The semi-qualitative analysis carried out to support the assessment of single options, while also centred on EU27, has, where relevant, analysed impacts beyond the EU (for example, related to bioenergy) or has used historical data series that was not available at EU27 aggregate. Where this was the case, it was appropriately flagged in the analysis. When looking at impacts, possible impacts of the regulatory measures on third countries were also considered, and this was included in the Annex were relevant (for example, Annex H Bioenergy for impacts on forests in non-EU countries; Annex C electricity for impacts on third countries of regional cooperation).

2. **Task 2 Stakeholder consultation and events**. This included the launch of a formal written public consultation on the EU Survey Platform, which was open for 12 weeks, from 17 November 2020 to 9 February 2021. Responses were analysed and presented in separate report (Annex I - RED II Open Public Consultation). In addition, two stakeholder engagement events were organised, on 11 December 2020 and 22 March 2021 respectively. A summary report of these two events has also been produced.
3. **Support for impact assessment finalisation.** This task involved providing ad-hoc support to the Commission, in particular to address observations received at the different steps of the internal quality assurance process. A key step was the submission of the analysis to the Regulatory Scrutiny Board (RSB) in March and then in April 2021.

Below, further details are provided on the scope and methodology of the main project phases and on the outcome of each task.

GANTT chart

This project was carried out over a period of 9 months, beginning with the inception phase in September 2020. Several activities of the project took place in parallel. The process of selection and designing of options for the review of RED II, which began in October 2020, was carried out over 6 months. This process overlapped with the open public consultation process, which allowed the project team to take into consideration the inputs and feedback received from various stakeholders. Detailed work on options started in January 2021, and specific reports were provided for the first submission of the IA in March, with the presentation to the Regulatory Scrutiny Board in April. The final set of annexes containing the main analysis was concluded and submitted in May based on updated and fine-tuned contributions.

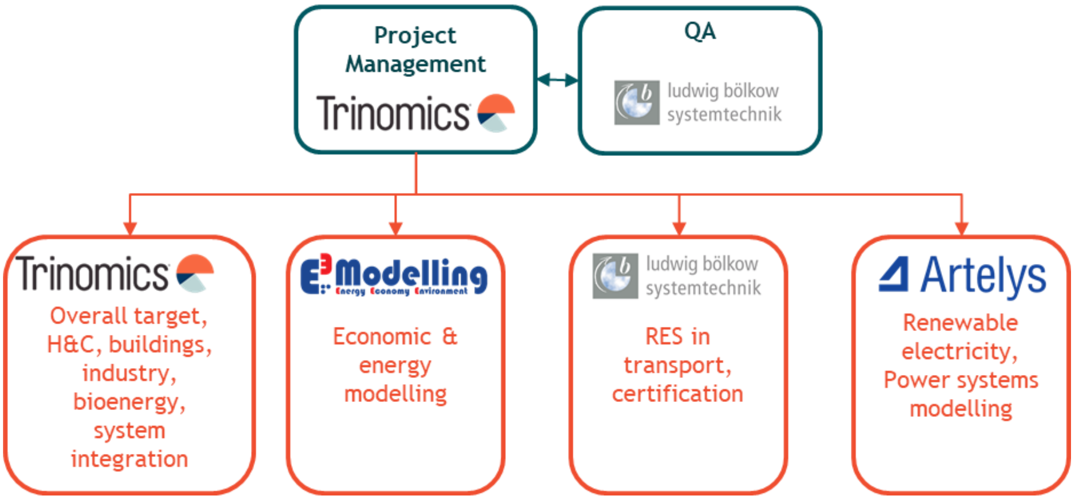
Table 1-1 Project GANTT chart

	September		October		November		December		January		February		March		April		May	
Tasks																		
Inception	■	■	■															
Options design			■	■	■	■	■	■										
Option assessment								■	■	■	■	■						
Stakeholder consultations																		
OPC					■	■	■	■	■	■								
Finalisation													■	■	■	■	■	■
Meetings & deliverables																		
Kick off meeting		■																
Draft inception report & preliminary list of options			■															
Final inception report				■														
Problem definition					■													
Final long list of options					■													
Task 1 reports draft										■								
Task 1 reports final											■							
Task 1 reports update																		■
Task 2 reports draft							■				■		■					
Task 2 reports final								■				■						■
Final report draft																	■	
Final report final																		■

Project team

The project team was made of experts from four different organisations, each one specialising in an area of the directive (Figure 1-1), with Trinomics being the leading partner and in charge of the overall project management.

Figure 1-1 Organogram



The four members of the consortiums divided the nine topic areas according to the expertise of their staff and took the lead for supporting DG Energy with the options concerned.

Among the partners, E3M (in charge of modelling) provided support directly to the relevant services at DG Energy. For confidentiality reasons and due to the high time pressure for submitting the IAs in the *Fit-for-55* context, modelling results came at a late stage and a Chinese wall was established between their work and the work of the rest of the team. This resulted in the teams that were working on the various topic areas to have very limited access to the outcome of the modelling analysis, and having to focus on qualitative analyses based on other sources.

Project phases

Task 0 - Inception

During the inception phase, interactions with DG Energy focused on:

- Clarifying the scope of the assignment;
- Defining the key milestones and deliverables required by the Commission.
- Guided by the discussion with DG Energy, the project team focused on:
- Improving the project team's understanding of the topics covered;
- Developing an appropriate methodological approach based on the refined understanding of the scope and nature of support required. This included the modelling approach;
- Establishing contact with relevant staff at DG Energy;
- Further elaborating on the options provided by DG Energy in the assignment's ToRs.

Task 1 - Options design and assessment

During this phase, the project team delved into the options and engaged regularly with DG Energy. Each team also began bilateral engagement with stakeholders in possession of information that could be relevant in order to carry out the assessment, such as trade associations, business associations and representatives.

Given the high number of options considered, the workload was split across nine topic areas. Some areas had then to be further split down (in sub-areas). At this level, the team developed and analysed a range of options, generally as additive options (for example, option 1; option 2 = option 1 + additional requirements; option 3 = option 2 + alternative requirements; etc.). However, these were sometimes developed as alternative options (e.g., option 2 as an alternative course of action compared to option 1). For some options, a further level was introduced (variants) which explored alternatives to the design of the option considered.

Table 1-2 Approach for developing options

Topics/area	Sub-topics/area	Options	Sub-options (variants)
E.g., H&C, system integration. transport, bioenergy	E.g., set an H&C target, district heating, waste heat, certification…	E.g., mandatory target of X%	E.g., mandatory target with flexibility, mandatory target only for some sub-sector etc.

The nine topics areas and sub-areas considered were:

A. Overall target:
   1. Ambition gap;
   2. Delivery gap.
B. System integration, including certification:
   1. Waste Heat;
   2. RES-Based electrification;
   3. Certification;
   4. Promotion of renewable and low-carbon fuels across transport and H&C.
C. Electricity:
   1. Promote power purchase agreements;
   2. Foster regional cooperation.
D. H&C:
   1. Nature & level of the RES H&C target(s);
   2. Accelerate the share of renewables in District H&C;
   3. Accompanying measures.
E. Buildings;
F. Transport;
G. Industry;
H. Green Public Procurement (GPP);
I. Bioenergy sustainability.

In order to provide consistent feedback, the project team used a structured template to develop the analysis and applied it to each of the nine topic areas analysed. The scope of the document was to provide DG Energy with a solid evidence base to be used as part of the IA. At the same time, having the standalone template allowed the team to work much faster with various teams at DG Energy, as topic-specific documents could be exchanged with relevant policy officers in a timely manner. Beyond the template, the various topic teams focussed on the areas indicated by the Commission at various stages of during the process, aiming to fill in the gaps identified by the Commission. This resulted in a series of annexes that, although broadly aligned, give prominence to different aspects of the analysis.

Box 1-1 Structure of template for analysis report

Structure of the document

1. Background
How is this area related to RED? How is the topic area addressed in RED II?
 	
2. Design
• Problem definition
• Objective setting
  o Related to the problems identified for each topic area
• Analysis criteria
  o Criteria used to shortlist options
  o Criteria to be used to compare options (Effectiveness; Efficiency; Coherence; Proportionality; and subsidiarity)
• Development of policy options
  o Description of the baseline (option 0)
  o Description of the alternative options shortlisted
• Mapping of potential impacts
  o Mapping of **economic**, **environmental** and **social** impacts according to
    ▪ **Direction:** Positive or negative;
    ▪ **Magnitude:** Limited or significant;
    ▪ **Horizon:** Short- to long-term;
    ▪ **Affected parties:** .
  ➔ Identification of key impacts to be analysed
 	
3. Analysis
• Semi-quantitative assessment
  o Where data is available and relevant, off-modelling analysis of some trends and key indicators (e.g. number of operators affected, expected costs etc.)
• Qualitative assessment
  o Based on literature review, stakeholder feedback (from workshop and follow-up direct contact), and expert judgment. It covers some common aspects (direct/indirect costs and benefits, key stakeholders affected, main economic, environmental, and social impacts). In addition, it covers some specific questions to the topic areas when relevant (for example, security of supply for electricity, distributional analysis (energy poverty) for buildings and H&C etc.)
 	
4. Synthesis
• Comparison of options across economic, social and environmental impacts
 	
5. Conclusion (optional)

The modelling experts engaged with DG Energy in parallel to define the baseline and the main scenarios to be considered as part of the modelling work. Scenarios were developed as a set of options, broadly aligned in terms of ambition and approach (REG55, MIX55 and MIX55 CP). The scenarios also aligned with other similar scenarios developed across other analytical work ongoing at the same time.

The allocated time to carry out the option assessment was shorter than initially envisaged for two reasons:

1. It took longer than expected to agree on the final policy options;

2. The project timetable was speed up, in order to allow the Regulatory Scrutiny Board to review the IA together with other submissions of the *Fit-for-55* initiative, in particular the submission concerning modification to the ETS.

Task 2 - Stakeholder consultations

The project team also supported DG Energy in the stakeholder consultation, which included the launch of an online questionnaire, as well as the organisation of two online stakeholder events. The Open Public Consultation (OPC) was carried out over the period of November 2020 to March 2021.

The project team analysed the responses of more than 39,000 participants from the formal written public consultation that was published on the EU Survey Platform, as well as several position papers from various organisations that were received separately (not via the OPC questionnaire platform). Further, Trinomics also provided support in the organisation of the two stakeholder workshops that were carried out on 11 December 2020, and 22 March 2021. This concerned administrative and coordination support, including:

- Management of a contact list of stakeholders;
- Creation of the online events;
- Managing registrations;
- Setting of agendas / programme;
- Identification of keynote speakers / panellists;
- Sending out e-mail invitations to keynote speakers / panellists, moderators;
- Preparations and compilation of materials for the presentation slides and panellists' profiles;
- Provision of a guide for moderators;
- Note-taking;
- Drafting of post-event reports;
- Post-event follow-ups with participants of the events;
- Responding to e-mail queries etc.

In addition, technical support was also provided, where:

- Technical dry runs were organised for keynote speakers / panellists and moderators before the events;
- Provision of guidance materials with regards to the use of Zoom, and other stakeholder interaction tools;
- Provision of technical support to all attendees during the event;
- Management and operation of various aspects of the online platform (Zoom);
- Usage of stakeholder interaction tools such as the in-house polling option in Zoom, and Sli.do, management of the Q&A functions, allowing general participants to have the floor to speak etc.

Task 3 - Finalisation of the IA for the review of the Renewable Energy Directive to be submitted to the Regulatory Scrutiny Board

The finalisation phase of the IA was carried out throughout March and April. During this time, the project team worked with DG Energy to refine the analysis, and to address the gaps and the comments received from the RSB. During this phase, the team provided updates and responses to further technical questions received from the RSB, followed-up with their opinion, and in some cases provided input to new or streamlined options.

Based on the emerging evidence and feedback received from the Commission, including RSB, a number of options had been either discarded or redesigned. The key directions for the analysis taken were:

- To abandon the idea of supporting RES deployment via GPP, as none of the options seemed to offer reasonable prospects;
- To focus the analysis on the ambition gap rather than the delivery gap;
- To not consider sub-topic areas within the set of options.

A summary of the support provided following the comments on the initial submission is presented in Table 1-3 below.

Table 1-3 Work by topic

Summary of further support provided	
A - Overall target	No additional analyses were requested following the draft submission by the end of February. Additional work was carried out to restructure the paper in line with the updated definition and scoping of the options and to address minor feedback on the texts and analyses.
B -Energy System Integration	**Options for B1 to Facilitate the use of waste heat:** No further technical questions received since March, therefore the only activities since then were writing the context and problem statement. **Options for B2 to Promote RES-based electrification:** The consortium refined many aspects related to the promotion of RES-based electrification by better integrating electricity in transport and H&C, including several additional model runs to better understand demand response over time and under different scenarios, substantial consultation with stakeholders (aggregators, virtual power plant operators, home storage providers, RTOs, DSOs and other experts) jointly with DG policy officers to better understand the need for fine-tuned and targeted policy interventions regarding interoperability and accessibility of infrastructure, aspects of social equity and potential market distortions under different scenarios. **Options for B3 Certification of renewable and low carbon fuels:** The policy options were developed to a further detail in collaboration with the Commission staff. An additional option, considering introduction of real-time Guarantees of Origin, was formulated, and assessed. The impact of considered policy options was consulted with industry stakeholders, particularly with the certification schemes operators. **Options for B4 Promotion of renewable and low carbon fuels:** Additional support for RFNBOs focusses on the interlinkage between the European ETS and sector-specific targets or supply obligations for RFNBOs (and low carbon fuels). In transport, an extension to all transport segments would require a significant increase in ETS prices to incentivize the market uptake of RFNBOs, indicating the need for additional measures. In case of industry, the impact of sectoral sub-targets strongly depends on existing decarbonization alternatives and additional policy instruments in the specific sub-sectors. Different variants to implement such a target have been discussed, also regarding different industry segments like refineries, ammonia, or methanol production.
C - Electricity	The IA on wind offshore options was extended by a dedicated analysis of the environmental benefits and reduction in risks of negative impacts related to the joint planning of offshore renewable energy projects. The analysis of PPAs and Guarantees of Origin was updated by integrating the results from the additional model runs carried out with the METIS model for the analysis of demand side response relating also to Option B2 (cf. Annex B – Energy System Integration).

D – Heating and Cooling	The IA has been strengthened in terms of administrative & compliance costs, and coherence with other instruments, especially with the ETS and EPBD, by the following measures: capacity building, risk mitigation, heat purchase agreements, planned replacement schemes, and renewable heat planning requirements. This was developed considering the high level of integration of the concerned options with other existing instruments (at national level) and global policy measures, that hamper isolating the cost for one specific instrument. The IA also further developed the option on risk mitigation for large RES heat projects and infrastructure. It elaborated more on compliance costs regarding the DHC target, on stakeholders benefits of mandatory targets for renewable shares (considering DHC oldness), and on consumer rights, looking at the synergies with other instruments such as ETS/ETD. More was provided regarding the cost-benefit balance of DHC, especially the new generation with all their advantages (e.g. using multiple sources), compared to individual systems and related constraints (and a one-by-one replacement), and the advantages of DHC at providing energy system integration (using thermal storage, and enhanced coordination with gas system operators). More case studies were added including quantifications & examples to illustrate compliance costs and coherence issues, including addressing price advantages cost savings during life time, and easier access to cheaper finance for the different options.
E - Buildings	The IA has been strengthened in terms of administrative costs & compliance costs coherence with other instruments, especially with the ETS and EPBD, for the updated certification requirements of installers. It further elaborated on administrative and compliance costs and coherence with EPBD regarding the indicative EU RES share target for the building stock, liaising with the ongoing discussions on the Minimum Energy Performance Standards. It touched upon the synergy with the implementation of energy efficiency measures (in the frame of the EPBD). A quick inquiry/survey was carried out among key H&C stakeholders to list what exact skills are missing and should be defined at EU level. Exchanges with stakeholders also helped to describe in more details the option on certification (RED article 18 & its annex on training & theoretical and/or practical part the training). It assessed several national certification and training schemes in order to compare the different contexts and approaches. Finally, we proposed a set of changes to article 18 and the annex IV of RED II (which was transferred to the EC, but not inserted in the IA).
F - Transport	The IA has been strengthened with regard to a comparative analysis of fuel and GHG reduction costs. Based on these results, investment volumes required for a significant market ramp-up of biofuels from feedstocks listed in Annex IX or RFNBOs and the implications on employment were estimated. Further transport-related topics refined include potential risks and challenges in meeting an increased renewable fuel demand (for renewable electricity, advanced biofuels, and RFNBOs) as well as possible drivers and arguments in favour of a target for RFNBOs in transport – covering hydrogen, but also RFNBOs in general. In view of the different options to formulate the transport target (i.e. in terms of energy or GHG emission), aspects on certification costs have been included, supported by a discussion on the development of GHG savings of biofuels in Germany. Finally, the formulations of policy options have been slightly adapted, taking into account the feedback of DG Energy.
G - Industry	Regarding the assessment of targets for renewable energy in industry two sub-options (A – voluntary targets and B – mandatory targets) were envisioned. Based on further considerations, it was decided to focus the assessment on mandatory targets. This was based on the justification that the impact on economy/environment/society can be assumed to be similar (but weaker) if targets are expected to be voluntarily enforced. In addition, aspects related to a voluntary type of targets are also reflected under the analysis of the option on Voluntary Agreements. In addition, the IA further analysed the impact of mainstreaming renewables in energy audits, and of a renewable product label on improving market conditions of renewables in industry, on increasing awareness & knowledge, and on addressing more broadly barriers to the deployment of renewables in the industry. Coherence with the ETS was

	assessed for the indicative renewable target, the energy audit and the label, while administrative and compliance costs were addressed for the energy audits.
H - Bioenergy sustainability	Options on bioenergy sustainability evolved over time, also reflecting the wide differences of opinion between stakeholders, with business and some government authorities in favour of the current approach and stakeholders from academia, NGOs and civil society having a diametrically opposite view. Initially, options shortlisted included full harmonisation of sustainability criteria; requirement to demonstrate compliance with sustainability and LULUCF criteria at the biomass sourcing area level or the forest unit level; and limiting forest feedstock based on Annex IX or on roundwood diameter. Among these, during the final phases of the project (finalisation), only the option concerning roundwood diameter was retained (although formulated either as a ban or a cap) and a new option (Option 5, cap on forest biomass) was included. Further work during the finalisation phase concerned an extended qualitative analysis of administrative burden, which proved particularly challenging due to the lack of implementation and cost data concerning the application of RED II criteria; a review of the analysis of primary forest area and an update to the quantities of forest biomass affected, based on new analysis emerging from the JRC; estimate of biomass installations captured by different thresholds for option 3; a discussion over air pollution.

Key challenges of this assignment

Given the ambitious Commission legislative roadmap for 2020-2021, providing high-quality and timely deliverables, respecting all Better Regulation Guidelines requirements and keeping to the timelines, were the key challenges of this assignment.

Other significant challenges of the study faced by the project team were:

- The extensive number of issues, options and variants covered by the assignment, including inter-related or transversal aspects such as systems integration;
- The fact that not all options had been identified early on in the process and that some options were defined only at a later stage. This was due to a number of reasons, such as feedback from stakeholders, coherence with other ongoing policy reviews as part of the Green Deal initiative, or the emergence of new evidence;
- Delays in the approval of the original long list of options to be considered, and in the final list of options;
- The confidentiality of quantitative modelling carried out across policies, which meant that part of the project team was not immediately privy to emerging evidence concerning the impacts of certain scenarios, and when modelling results were shared these were limited in terms of details (i.e., full output tables were not provided to the topical teams). Delays with the release of modelling results were a result of challenging project timeline and the need to ensure consistency of the RED analysis with several other modelling work carried out at the same time by other policy teams working on the Green Deal.

Technical support provided

Problem definition

The main problem that the revision of RED II aims to address is the difference between the current ambition of the directive and the increased ambition of the Green Deal. The assessment of the 2030 Climate Target Plan[1] (which analysed a number of scenarios to reach the 2050 net zero target), highlighted a discrepancy between the optimal level of renewables in the system and the share of renewables that the current policy framework is expected to deliver. Their analysis showed that renewable energy sources would need to rise to take a 38-40% share of final energy consumption to meet the 2030 target of reducing emissions by at least 55% compared to 1990. As a result, both the current EU renewable energy target (at least 32% by 2030) and the aggregate ambition of the Member States (33-34% by 2030, based on NECPs) are no longer sufficient.

In order to reach the new ambition, it is also necessary to understand which elements of RED II should be revised, so that Member States are given appropriate boundaries to keep their effort focused. For this reason, the project team analysed eight separate areas to identify current issues and shortfalls so that new policy proposals could be developed, either to extend the current range of the directive or to increase its strength.

The areas considered and the problems identified are presented in Table 2-1.

Table 2-1 Problems identified

Area	Problems identified
System integration	Underutilisation of waste heat and lack of recognition of its recovery
	Lack of integration between RES-based electricity in H&C and transport
	The scope of renewable energy certification systems is not adjusted to cover consumption of all renewable and low carbon fuels, especially hydrogen, in all end-use sectors
	Lack of promotion of renewable and low carbon fuels
Electricity	Insufficient legislative environment to reach the newly agreed climate ambition
	RED does not provide sufficient support to PPAs
Heating and cooling	Slow uptake of renewables in the H&C sector
	Lack of a coherent approach regarding the future of energy infrastructures and the decarbonisation of all H&C carriers
	Lack of a combined and integrated strategy to decarbonise the heating and cooling sector addressing at the same time the deployment of renewable technologies and energy efficiency
Buildings	Slow uptake of RES in buildings due to the lack of level playing field
	Lack of the required skills and trained workforce
	Lack of integrated approach to deploy renewable technologies and energy efficiency
Transport	The target of 14% RES in transport by 2030 is insufficient to meet the new emission reduction target
	Incomplete sectoral coverage in RES-T
	Lack of harmonization
	Insufficient support for hydrogen and RFNBOs in transport
Green Public Procurement	RED II is not fully driving public administration to perform an exemplary role in driving the deployment of renewable energy
Bioenergy	Insufficient guidance for the implementation of current sustainability criteria

[1]Commission staff working document (2020), *impact assessment*, accompanying the communication on stepping up Europe's 2030 climate ambition, Investing in a climate-neutral future for the benefit of our people. SWD/2020/176 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020SC0176

	Coverage of sustainability criteria is not as extensive as it could be
	The risk-based approach may be inadequate to ensure sustainability of forest exploitation
Industry	RES in industry is very low compared to energy used by the sector
	Heat use in industry is currently not properly targeted by RED

The major challenge encountered during the task was the identification of sufficient evidence. Due to the limited time since the new directive has been in force, and that the implementation deadline for MS is only in June 2021, the team could only rely on a limited amount of evidence to identify and define the problems. Evidence on the effects of current implementation was essentially very rare or non-existent, and was based on information submitted by MS in the NECPs. In some sectors, e.g. biomass, recent data were also unavailable despite having some recent studies done.

Options design

As part of the assignment, DG Energy provided the project team with a preliminary list of options that could be considered as part of the project. The list was based on DG Energy's own understanding of possible options to improve on the current RED II directive.

The team analysed critically the original list and used it as a starting point to identify additional options, in parallel with the problem definition phase. The project teams then focussed on fleshing out the options further (making them clearer by adding implementation details and practical considerations) and started an iterative process of refinement. This process was carried out in close collaboration with policy officers at DG Energy and allowed the team to submit an initial long list of policy options by the end of October 2020.

After further work to refine the options following comments from DG Energy, the team submitted a further iteration of the list. Options were grouped in six separate areas:

- Options to foster renewables in buildings, including heating and cooling;
- Renewables and other low carbon fuels in the transport sector;
- Further Deployment of renewable electricity;
- Transversal elements:
  - System integration;
  - GPP;
  - Terminology;
  - Certification;
  - Negative emissions and CCUS.
- Increased EU ambition for RES and target achievement;
- Bioenergy.

As part of this phase, the team also developed a preliminary assessment of impacts (impacts mapping) by identifying the key areas that each option may affect, and the expected direction of change. Option mapping allowed the project team to focus the in-depth analysis to those areas where the impacts were expected to be more material.

Following this phase, a number of areas were abandoned as the development of options and preliminary assessment suggested a limited scope for intervention. The areas (or sub-areas) abandoned were:

- Green Public Procurement;
- Options to avoid a delivery gap;

- Options to promote negative emissions and CCUS.

Other areas and options were grouped or reformulated. The final list of options was agreed by early December and options were further fine-tuned during the process. This stage took longer than originally expected, and even when this phase was formally closed, some options were still being reconsidered and/or added to the list.

Options assessment

Once the final list of options was formally provided by DG Energy, the project team began the options assessment process. Rather than defining a top-down approach at team level, the project team agreed on a loose assessment template (see 1.5.2) and then worked directly with policy officers responsible for the various policy areas analysed. This allowed to tailor the analysis more closely to the needs of DG Energy, and to complement the results to be provided via modelling.

The team analysed each option one by one by:

- Describing the practical implications of each options;
- Identifying stakeholders affected;
- Identifying sources (reports, articles, datasets, analysis produced by the EC and EU agencies) that could help analysing the effect of the change proposed;
- Assessing the change generated by the option, and the cost it would impose (particularly administrative costs), based on the evidence available and expert judgment;
- Providing a range of complementary considerations, such as: stakeholders support; possible interactions with other directives and strategies; practical considerations concerning possible implementation pathways. During this stage, the team was able to refer to the insights deriving from the consultation (both the workshops and the questionnaire).

The various options considered for the different areas were either:

- Additive: where one option was built on top of the previous one;
- Alternative: where two or more options could not be implemented at the same time, but a choice between them would have to be made.

The different options for each area were then contrasted across the three main areas of impacts: economic, social and environmental. The scope of the analysis was not to arrive at a recommended option, but to provide DG Energy with sufficient evidence to arrive at the preferred option in the IA.

Modelling

In parallel to the detailed definition and the non-modelled assessment of options, part of the project team focussed on quantitative analysis with the use of PRIMES, in close collaboration with the analytical services at DG Energy.

Due to practical reasons and in order to align with other parallel analysis, the modelling was carried out at scenario level which looked at a combination of options across all areas considered. The support provided by the project team were:

- Updating the baseline;
- Defining inputs to model three main scenarios (REG55, MIX55 and MIX55 CP);
- Running the model and extracting key results;

- Running the model to calculate results for main variants (sensitivities around single policies) as discussed with DG ENER, including on Hydrogen.

Consultations

As part of the open public consultation (OPC) process on the revision of the Renewable Energy Directive 2018/2001, the European Commission, DG Energy, carried out an online questionnaire and two online events over a period of four months, from November 2020 to March 2021. The OPC activities were organised as part of this service contract. The stakeholder consultation events were conducted online due to the measures imposed to prevent the spread of COVID-19. The OPC process attracted the attention and participation of many stakeholders from various sectors and EU citizens. While there were many discussions on various issues, there is a clear and unambiguous support by the various stakeholders to raise the ambitions and to increase the share of renewable energy in the energy mix of the EU. Further details on the OPC activities can be found in Annexes I, J and K.

OPC questionnaire (17 November 2020 – 9 February 2021)

The online questionnaire remained open for 12 weeks, and consists of 54 closed questions and 42 open questions. The questionnaire was uploaded on the EU Survey Platform at https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12553-Revision-of-the-Renewable-Energy-Directive-EU-2018-2001/public-consultation.

The questionnaire attracted more than 39,000 responses, of which the vast majority (just over 38,000 responses) came from a coordinated campaign regarding the use of feedstock for biomass. Out of all the responses received, 670 were received from organisations, of which 71% represented business associations and companies and 16% represented NGOs and environmental organisations. The questionnaire also received responses from central governments or central agencies from 13 Member States, namely: Belgium, Czechia, Estonia, France, Germany, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Slovakia, Spain, and Sweden. Participation of EU citizens from Spain, the Netherlands, Germany and Sweden accounted for over 40% of the responses received. The full analysis of the responses received for the OPC questionnaire can be found in Annex I.

Stakeholder event (11 December 2020)

The first stakeholder event was held on 11 December, from 10h00 to 18h00, CET, including a lunch break. The event received about 700 registrations from over 250 different organisations. About 50% of the attendees represented business organisations, while about 20% of attendees were representatives from public authorities. A total of 32 external speakers were invited to speak throughout the seven sessions, namely: *The role of renewables in 2030 on the way to a carbon-neutral economy, Renewable energy in heating and cooling, buildings and district heating; Renewable energy in transport; Renewables in industry; Measures for a further uptake of renewables in electricity; Bioenergy sustainability, and a European system for certification of renewable and low-carbon fuels, including hydrogen*. The event was opened by Ditte Juul Jørgensen, Director-General at DG Energy, and was closed by Paula Abreu Marques, Head of Unit for Renewables and CCS Policy, DG Energy. The event also engaged with the audience by using stakeholder interaction tools available in Zoom, where a total of 12 polls were launched.

Second stakeholder event (22 March 2021)

The second stakeholder event was held in spring 2021, on 22 March 2021, from 10h00 to 17h00, including a lunch break. The event included presentations of seven keynote speakers, which covered three main areas of RED II, namely *renewable energy in transport*; *renewable energy in heating and* *cooling, buildings and district heating*; and *sustainability of forest biomass for energy*. Over 1,000 registrations from over 600 different organisations were received. Representatives of business organisations represented the largest group of attendees (53%), while representatives of public authorities accounted for 20% of the attendees. The event was opened by Kadri Simson, the Commissioner for Energy at the European Commission, and was closed by Ditte Juul Jørgensen, Director-General, DG Energy. A copy of the slides for the event was also made available online on the European Commission webpage at https://ec.europa.eu/info/events/workshop-revision-renewable-energy-directive-2021-mar-22_en.

Annex list

Table 4-1 Summary table of annexes

Task	Annex	Title	File Name
Impact Assessments (Task 1)	A	Overall EU target	Annex A - Overall EU target
	B	System integration	Annex B - Energy System Integration
	C	Renewable electricity	Annex C - Renewable Electricity
	D	Heating and cooling	Annex D – Heating and Cooling
	E	Buildings	Annex E - Buildings
	F	Transport	Annex F - Transport
	G	Industry	Annex G - Industry
	H	Bioenergy	Annex H - Bioenergy
Open Public Consultations (Task 2)	I	OPC Questionnaire	Annex I - RED II Open Public Consultation
Modelling	J	Overview of modelling support	Annex J – Modelling support

Annex A - Overall EU Target

Annex A to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

Acronym	Full name
EE	Energy Efficiency
EED	Energy Efficiency Directive
EU	European Union
EU ETS	EU Emissions Trading System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IEA	International Energy Agency
MS	Member State of the European Union
NECP	National Energy and Climate Plan
PV	Photovoltaic
RD&I	Research, Development and Innovation
RED	Renewable Energy Directive
RED II	Renewable Energy Directive recast
RES	Renewable Energy Sources

Background

This document provides input to the impact assessment for the revision of the Renewable Energy Directive (RED II). Part of the revisions considered are a range of policy options to ensure that the revised RED II can deliver an increased renewable energy share in 2030 in a cost-efficient way in line with the Climate Target Plan. A set of options for setting the overall renewable energy target is also included in these options which are elaborated and assessed in detail in this document. In Chapter Design, we first introduce the problem definition for setting the overall target. Next, we define the policy options that are considered for addressing the problem. In the subsequent chapters, we assess the merits of each policy option per the most relevant assessment criteria. Finally, in the last chapter, we synthesize the findings and draw overarching conclusions.

Design

a. Problem definition

To deliver on the increased greenhouse gas (GHG) reduction target for 2030 that has been set out in the Climate Target Plan, the share of renewable energy sources (RES) would need to rise to 38-40% of final energy consumption.[2] As a result, both the current EU renewable energy target (at least 32% by 2030) and the aggregate ambition of the MSs (33-34% by 2030[3]) are no longer ambitious enough. This is problematic, as without sufficiently high ambition levels, it is less likely that the share of renewable energy will increase at the rate required for reaching the GHG reduction target in a cost-effective manner.

The problem of insufficiently high renewables' targets can be discussed at two levels. At the more fundamental level, the lack of (insufficiently high) RES targets, could result in a higher reliance on other instruments to reach the climate targets, which may not be equally reliable in delivering GHG emission reductions. They may also be suboptimal, as they do not further contribute to other policy objectives other than reaching the climate targets. For example, in the absence of a (sufficiently high) RES target, stricter regulation around energy efficiency (EE) and/or carbon pricing would be needed. While potentially effective for reaching the climate objectives, such instruments do not create investor certainty for renewables specifically and may not translate into a similar rate of renewable energy deployment. As a result, the progress in reducing the energy import bill and improving security of supply may be less than optimal and the opportunities for EU industry and RD&I to develop, innovate, and attain a position of global leadership in the renewables sector are not supported to a similar extent. Furthermore, there may be less support for upscaling less mature renewable energy technologies, which are not yet competitive enough to rely on carbon pricing alone. Finally, a greater reliance on carbon pricing in particular may have suboptimal distributional impacts, placing a disproportionately large part of the burden on less affluent people and countries who rely on cheap fossil fuels and lack the capital to sufficiently invest in EE measures and local renewable energy generation. Hence, a (sufficiently ambitious) RES target is important for reaching the climate targets in a way that is beneficial for a wider range of policy objectives.

At the more practical level, the problem of insufficiently high renewables targets can be broken down into three components. Firstly, the lack of a sufficiently high EU target creates a lack of incentives and political pressure for MSs to be more ambitious. In particular, when such incentives and political pressure are applied to all EU MSs collectively, this can serve as an important condition for raising national ambition levels without the risk of compromising on a level playing field for the domestic industry. Hence, a revised EU target could be an important starting point to stimulate higher ambition levels at the Member State level. Secondly, there is no revision of the national ambition levels foreseen before 2024 in the current governance process set out by the Governance Regulation. Hence, even with an increased EU target, there is no collective requirement for MSs to increase their ambition levels in the short term, nor to report on it, leaving any increased ambition level up to national initiatives.

[2] COM(2020)562 final. Stepping up Europe's 2030 climate ambition – Investing in a climate neutral future for the benefit of our people.
[3] Based on the assessment of the National Energy and Climate Plans: COM(2020) 564 final. An EU-wide assessment of National Energy and Climate Plans: Driving forward the green transition and promoting economic recovery through integrated energy and climate planning.

Additionally, there may be a certain degree of political inertia that prevents a country from increasing its RES share as rapidly as would be optimal. Thirdly, even when an increased EU target and an earlier resubmission of the ambition levels of MSs would be agreed upon, there is uncertainty around the contributions that MSs will make when revising their NECPs and ambition levels. This creates a risk that the increased ambitions are not adequate for meeting the increased EU target and that an ambition gap between the EU and the collective target of MSs emerges. Policy options to mitigate the risk of such an ambition gap may therefore also be required.

Without EU intervention, it is highly likely that possible upwards revisions of national contributions, either before 2024 or during the revision process of the NECP, would not add up to the increase that is necessary to reach the level of RES consistent with the EU Climate Target Plan by 2030.

b. Option description

The policy options that are considered for addressing insufficiently high RES targets while avoiding a collective "ambition gap" can be broken down into options to raise the EU target and options to adjust the nature of the target. The options that have been considered for raising the EU target are:

2. No change to the target (keep at least 32% target);
3. Raise target to 38-40%;

The options that have been considered for adjusting the nature of the target are:

1. No change to the nature of the target (rely on existing governance process with NECPs);
2. National binding targets.

The options are defined in more detail in the following sections of this chapter.

i. *Level of the EU target*

Option 0: No change to the target - Baseline scenario

This option is the baseline scenario in which the EU RES target is not updated to reflect the increased climate ambition and MSs are not encouraged to revise their national contributions upwards. Still, MSs may voluntarily revise their ambitions upwards in the context of national policy updates and/or for the NECP update scheduled for 2024 and may be encouraged by the Commission to do so as part of the NECP revision process (see Article 31 of the Governance Regulation).

It is important to note that in the absence of an increased overall EU RES target, other energy legislation (EED for example) or market-based instruments such as higher carbon prices through the EU ETS may be increased to compensate for not increasing the overall EU RES target.

Option 1: Raise EU target to 38-40% as indicated in the CTP

In this option, the EU target will be increased to 38-40% which is the level that is required for realising the ambitions set out in the Climate Target Plan. The revised ambition will be included in the updated RED II.

An increase beyond 40% has been considered briefly, but has not been assessed in detail as the Climate Target Plan concluded that 38-40% is the best ambition level to realise the 55% GHG emission reduction target.

ii. *Nature of the target*

Once the EU target has been raised, an ambition gap automatically emerges, as the national contributions documented in the NECPs are no longer sufficiently ambitious to collectively achieve the EU target. Hence, a decision needs to be made on how to address this ambition gap in the best way. For this, two main options are considered: relying on the existing governance process (option 0) or introducing binding targets (option 1). Additionally, some features are considered to reinforce the existing governance process, which are discussed as part of option 0.

Option 0: No immediate updates. Revision of national contributions as part of 2023-2024 NECP update

In this option, MSs are requested to make changes to their national contributions to the EU RES target and are required to update their final NECPs by the end of June 2024 at the latest, as it is currently the case under the Governance Regulation. The national contributions are collected and converted to an aggregated EU ambition, which is compared to the EU target for 2030. In this case, MSs will probably experience pressure to increase their ambition level at that point, due to the increased EU target and the application of Article 31 of the Governance Regulation, which stipulates that if the national contributions are not ambitious enough to collectively reach the EU's RES target, the EC might make suggestions to MSs with an insufficient level of ambition based on the indicative formula in Annex II. The timeline applies as currently stipulated in the Governance Regulation without any changes.

It is important to underline that this process is identical to the process applied for developing and improving the first NECPs, which proved to be effective in realising a sufficiently high collective ambition for reaching the previous 2030 RES targets.

This option is realistic in terms of timing. The proposal to revise RED II will be adopted in summer 2021, after which co-decision negotiations could start quickly and be finished within 12 months, for example by September 2022. At this date, the level of the EU RES target will be formalised, as well as the contributions of MSs.

Under the Governance Regulation, the MSs must submit their draft updates to their NECPs by June 2023. In that draft NECP update, the MSs can already show their increased national contribution and provide some elements of how they are planning to reach the new higher target. In the submission of the final updated NECPs by the end of June 2024, the MSs will be able to present concrete measures leading to more ambitious RES achievement.

A variant of this option is to add a reinforced mechanism to address any remaining collective ambition gap between the updated NECPs and the increased EU RES target. This mechanism would be triggered in case the aggregated contributions of MSs are still insufficient after the final NECP assessment. In that case, the Commission will evaluate which MSs are still not ambitious enough, applying the formula set out in Annex II of the Regulation to indicate national contributions for the share of RES in 2030[4]. MS(s) with contributions below the calculated contributions, are requested to either increase the ambition level of their national contributions, or make a proportionate payment to the Union Renewable Energy Financing Mechanism.[5] Based on the total payments of MSs and the expected contribution from those, the mechanism would be assigned a renewable energy target which would close (part of) the EU ambition gap.

[4] Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action
[5] Commission implementing regulation (EU) 2020/1294 on the Union renewable energy financing mechanism

Furthermore, sector-specific, EU-wide targets and measures can be strengthened to the extent needed to close the ambition gap, for example requiring higher RES shares in heating and cooling, transport or electricity specifically after co-legislation.

Option 1: Establish national binding targets for RES in 2030 (and adaptation of NECPs to them)

In this option, national binding targets for the 2030 RES share are introduced, similar to what was in place in the first Renewable Energy Directive (RED I). The EU will re-calculate the formula set out in Annex II of the Governance Regulation taking into account the increased EU RES target for 2030, to indicate new national contributions that would close the ambition gap between the latest NECP submissions and the updated 2030 EU target. The resulting national contributions will become the new national binding targets for 2030.

The MSs will be requested to update their NECPs, adopt the new targets for 2030, and outline policy measures to achieve the new ambition. As a consequence, the revision process of the updated NECPs will be focused solely on the policy measures as the ambition level would already be predefined.

The mandatory nature of the targets means that the European Commission can impose sanctions on MSs that fail to meet their targets, including financial penalties resulting from an infringement procedure. In practice, MSs that fail to meet the target would generally first be encouraged to buy additional renewable energy through a statistical transfer from another Member State.[6] While this statistical transfer does not increase the renewable energy share of the EU as a whole, it does provide a strong incentive to MSs for reaching their RES targets because the costs of buying additional RES can be significant. Moreover, these costs do not contribute to the economy of the buying country as opposed to investing in renewables deployment domestically.

b. Discarded options

As part of the options around the nature of the target, it was considered to update/align the necessary legislative framework to include mandatory and earlier resubmission of NECPs and national contributions. In this option, a required resubmission of the NECPs (including the national contributions to the RES targets) would be introduced. This resubmission would be required in the short-term, well before the scheduled 2024 resubmission, and would ensure that MSs reconsider their national contributions to the increased EU RES target at the earliest. Similar to option 0, the EC may make suggestions to MSs with insufficient ambition to reach the updated EU target.

The difference with option 0 is that an additional NECP submission would be required, which would probably result in earlier action to realise the increased ambition levels. However, considering this option in more detail, it turns out that the required legislative changes would be challenging to deliver in a sufficiently short timeframe to realise an NECP submission that is earlier than the already scheduled NECP update. As a result, this option does not have any significant merits over the baseline option (option 0) and has thus been discarded.

c. Mapping of potential impacts

[6] Luxembourg makes use of transfers of excess renewable energy from Estonia and Lithuania for instance (COM(2019) 225 final - Renewable Energy Progress Report). The Netherlands also uses a statistical transfer of renewable energy (from Denmark) to meet its targets.

In order to identify the impacts of the options for RES target setting, it is important to define that not raising the RES target would not entail a reduced burden on the EU and its MSs to reach the GHG target. Hence, if no increased RES ambition would be agreed, other policies and instruments would have to play a bigger role. The assessment of impacts not only considers the absolute impact of increasing RES deployment, but also compares the impacts to other main groups of policies and instruments (carbon pricing and EE), if applicable for the indicator. With that in mind, the following impacts are considered as most relevant for the assessment:

1. Cost-effectiveness: What is the cost-effectiveness of increased RES ambition versus other policy instruments to reduce GHG emissions?
2. Investor certainty: What is the effect on investor certainty of an increased RES ambition and how does that compare to other instruments? To what extent does the market already provide sufficient investor certainty for renewables?
3. Macroeconomic impacts: What are the macroeconomic impacts of increased RES deployment? How are investments, jobs, and GDP affected? How does this compare to a greater reliance on other instruments?
4. Security of supply: What are the impacts of increased RES deployment on import dependency? How resilient is the renewables sector to external shocks such as the COVID crisis?
5. Innovation: What is the impact of increased RES deployment on innovation in the EU? How does that compare to the impacts of other instruments?
6. Distributional impacts: Who takes most of the burden for enhanced GHG reduction? How do the impacts differ across countries and income classes?
7. GHG emission reductions: How effective will the option be in realising increased RES deployment? What emission reductions will be associated with this?
8. Administrative burden: What are the implications for the burden on EU and policy makers of MSs? Are additional NECP updates required?
9. Political feasibility: To what extent is it expected that the options would reach a political agreement? Should any option be discarded a priori due to lack of political feasibility?
10. Coherence: How effective are the measures in addressing an ambition gap between EU and MSs' targets and policies?

The options are assessed per the above impacts in the next chapter.

Analysis

The options for target setting are sub-divided into two groups of options: options for setting the level of the overall EU target and options on the nature of the target in order to avoid an ambition gap between the contributions of MSs and the EU target. The assessment of impacts in this chapter and in the last chapter will discuss each group of options separately.

d. Options for setting the level of the EU target

i. Cost-effectiveness

When looking at the cost effectiveness of policy options for raising the EU target, we compare against the following two groups of possible alternative instruments:

1. Carbon pricing: instruments that aim to reduce emissions by putting a price on emissions. Most notably, the EU ETS (and its potential extension to buildings and transport), supported by a carbon border adjustment mechanism, with potential further contributions from the Energy Taxation Directive;
2. Energy efficiency: instruments that aim to reduce emissions by reducing energy consumption, including the Energy Efficiency Directive, Energy Performance of Buildings Directive, and the Ecodesign and Energy Labelling directives.

For the comparison to the carbon pricing instrument, it is important to realise that the EU ETS results in cost-optimal emission reductions by design, as permits can be traded, which would result in the market delivering emission reductions, where the costs are lowest. Hence, pushing for emission reductions through specific measures, such as increased RES deployment, will often be less cost-effective (and at best be equally cost-effective), in cases where RES deployment is among the solutions that the market would deliver.

Compared to energy efficiency measures, an important insight is that there are many energy efficiency measures that are profitable without any incentives while RES deployment is generally still enabled by subsidies and/or market design. An insightful metric for this comparison is the GHG abatement costs of energy efficiency measures and renewable energy measures which the IEA reports on.[7] For the main categories of energy efficiency measures, which are retrofits and new builds, efficient appliances, and industrial energy efficiency, the global average abatement cost is negative, indicating that such measures are profitable. For renewables, there are still positive abatement costs for all forms of renewable energy (on average), albeit limited for hydro, wind, and solar PV. Hence, increased RES deployment appears to be less cost effective than increased energy efficiency progress. However, in practice, it turns out to be challenging to make rapid progress in increasing energy efficiency, in spite of profitable business cases, and it is less clear-cut on what would be needed to speed up energy efficiency progress and how costly that would be. Furthermore, the variance in abatement costs for energy efficiency measures is very large, and may result in sharply increasing abatement costs once the initial low hanging fruits have been harvested. This may make the global average abatement cost less representative for specific countries.

[7] IEA. (2020). GHG abatement costs for selected measures of the Sustainable Recovery Plan. Available at: https://www.iea.org/data-and-statistics/charts/ghg-abatement-costs-for-selected-measures-of-the-sustainable-recovery-plan

Overall, we conclude that increased RES progress is slightly less cost-effective than relying on other policy instruments, although large variation exists in the costs of energy efficiency measures, which may make increased RES deployment cheaper than increased energy efficiency progress in specific countries. However, cost effectiveness of increasing RES continues to improve rather rapidly. Therefore, option 1 (raising the target) is less cost effective than option 0 at present, but this may change over time.

ii. Investor certainty

While renewables have shown impressive cost reductions over the past decade, and continue to do so, investments in most MSs still rely on subsidies. As a result, the RES ambition level of policy makers is still an important signal of the extent to which future market growth will be supported by policy making. A higher RES target can therefore be expected to enhance investor certainty in the renewables sector, attracting more players to enter the market, resulting in higher competition and lower prices for renewables. Furthermore, the (perceived) risk of adverse policy changes for renewables will be smaller with a higher RES target, which will lower the cost of capital for renewable energy investments.[8,9] An adverse effect of higher RES targets may be a more severe risk of price cannibalisation for intermittent renewables (wind and solar PV).[10] Prices for wind energy are currently already 10% to 20% lower than average wholesale prices in leading renewables markets such as Germany and Denmark.[11] The extent to which further price erosion would materialise depends to a large extent on the effectiveness of flexibility measures to absorb the intermittent generation and is therefore hard to predict. Overall, we consider a higher RES target as a positive sign for the investors in the renewables market.

It is hard to compare the impact on investor certainty of an increased RES target to that of increased reliance on other policies to reduce GHG emissions. Both carbon pricing and energy efficiency measures improve investment certainty, too, but affect different market segments. However, stepping up ambitions in RES would not preclude increased ambitions in other sectors. Hence, the positive effect of an increased RES target on investor certainty will remain in any case.

Overall, we conclude that a higher RES target is beneficial for investor certainty in the RES sector. As a result, option 1 has a positive impact on investor certainty and option 0 has no impact on investor certainty.

iii. Macroeconomic impacts

Considering that the increased RES target will translate into increased RES deployment, there will be several macroeconomic impacts. Increased RES deployment will require additional investment, creating new jobs and contributing to GDP growth. On the other hand, investing in increased RES deployment may not necessarily be the most attractive option for stimulating the economy and is not always economical itself as evidenced by the need for subsidies, which are, however, decreasing. The modelling results delivered in a separate part of the study (see Annex J: Modelling support) assess the macroeconomic impacts in more detail and will be instrumental in estimating the net macroeconomic

[8] Diacore. (2016). The impact of risks in renewable energy investments and the role of smart policies
[9] Trinomics, Cambridge Econometrics and E3M. (forthcoming). Study on the Macroeconomics of the Energy Union, Report on literature review and stakeholder interviews regarding the representation and implications of the financing challenge
[10] Ibid.
[11] Trinomics and Enerdata. (2020). Study on energy prices, costs and their impact on industry and households, task 3.

impact. Hence, we will not draw a separate conclusion on the macroeconomic impacts in this assessment.

iv. *Security of supply*

The benefit of most renewable energy sources is that they produce energy locally as opposed to fossil fuels, for which the EU relies heavily on imports. Hence, increased renewables deployment reduces import dependency and thereby enhances security of supply. The model results from the Climate Target Plan and the modelling conducted for this study show that increasing the RES share to 38–40% by 2030 would reduce the import dependency by 0–2% compared to the baseline scenario (from 54% import dependency down to 52% at most). The impact on security of supply becomes more pronounced beyond 2030 when the RES share is increased further, with the RES share already reaching 51% in 2035 (baseline: 35%) which would reduce import dependency to 44-45% (baseline 53%).

A key difference between most renewables and fossil fuels is that renewables rely more heavily on upfront investment while for fossil fuels, the operational fuel costs are a larger part of the costs. A potential risk for sustained renewables deployment at the required rate is that investments may diminish during economic downturns. Fortunately, during the recent COVID-19 crisis the renewables sector demonstrated quite a high level of resilience to the crisis with record investments raised in the EU wind sector in the first semester of 2020[12] and a more than 10% annual increase in solar capacity installed in the EU[13].

Furthermore, supply chains for renewable technologies may be subject to disruptions and geopolitical issues which may lead to supply shortages and limit capacity additions. The COVID-19 crisis demonstrated this, with initially several supply disruptions emerging in the production and import of raw materials and components. However, most proved to be relatively short-lived as evidenced by the high investments and capacity additions in 2020 as indicated above. The supply chains for renewables are also relatively resilient to geopolitical pressures as the supplier base is sufficiently diverse for most components and there are substitutes available for the most critical raw materials.[14]

Overall, we conclude that increasing the RES target has a positive impact on security of supply by creating reduced import dependency while being resilient to external shocks and geopolitical pressures.

v. *Innovation*

An increased EU RES target and the resulting increased RES deployment is relevant for innovation because it creates and enlarges markets for renewable energy technologies which in turn creates a market for technologies that facilitate high levels of RES deployment such as batteries and power-to-X. Thanks to this market formation, EU companies can attain a first-mover advantage and the EU research sector can more easily commercialise its inventions and learn from the practical application. Additionally, the EU industry can benefit from accelerated learning-by-doing and increased economies of scale, increasing the prospects of global leadership in renewables.[15]

The impact on renewable technologies differs depending on the commercial readiness of the technology. For relatively mature technologies such as wind energy and solar PV, the increased RES

[12] WindEurope. (2020)The impact of COVID-19 on Europe's wind sector
[13] SolarPower Europe. (2020). EU Market Outlook for Solar Power 2020-2024.
[14] Trinomics et. al. (2019). Study on energy technology dependence
[15] IRENA. (2014). Renewable energy technology innovation policy

target is less essential for innovation because those technologies may be deployed at a similar rate when relying on carbon pricing due to their competitiveness with other options to reduce carbon emissions. For less mature technologies in general and specifically those that can be applied in sectors with less competitive renewable technologies available, such as transport and heating and cooling, the impact would be much larger. For those sectors, the increased EU RES target could be essential for market formation, in particular if the target is supported by increased sector-specific ambitions, targets and measures to enhance capacity building and raise consumer awareness. The same holds for specific segments of the electricity sector such as offshore RES deployment.

The modelling results confirm that increased RES and GHG reduction ambitions result in earlier and higher uptake of technologies that are currently less mature, such as offshore wind, battery storage, hydrogen production and other renewables. The differences between the scenarios with different policy mixes to realise the climate ambitions provide mixed results. The scenario relying more on regulation (including increased RES ambition and measures) pushes hydrogen production more effectively while the scenario relying more on carbon pricing promotes the early uptake of offshore wind and battery storage slightly better. But overall, the technology mix in all scenarios is largely similar with only minor differences.

vi. Distributional impacts

Generally speaking, increasing the RES target allows for better distribution of impacts across MSs and income classes than relying on carbon pricing, as the latter simply increases the costs of carbon intensive consumption without any consideration for income levels, while the former can be financed in a way that does account for a just distribution of costs.[16] Additionally, low income households may be less able to cut consumption in response to higher costs, due to a lack of capital and other barriers. Indeed, the impact assessment carried out for the Climate Target Plan confirmed that the scenario relying most on carbon pricing has the highest negative impact on low income households.[17] This depends, however, on how the carbon pricing revenues are used. In cases where they are used for redistributive measures such as lump-sum transfers to low income households, a large part of the negative distributional impacts can be offset. Furthermore, the extent to which RES deployment accounts for distributional impacts may differ, based on how financing is designed. A simple RES surcharge on all energy consumption, irrespective of the income levels, would for instance, have little benefit over a carbon price.

Comparing an increased RES target across MSs to a higher reliance on EE measures, the RES target could have adverse distributional impacts.[18] This is because energy consumption is responsible for a larger than average share of the expenditure of low-income households which makes any measures that cut energy consumption, i.e. energy efficiency measures, more impactful for low-income households. Meanwhile, the impacts of increased RES deployment on low-income households depend mainly on how it is financed and do not affect low income households differently than high-income households a priori. Further, for countries that have already harvested the low hanging fruits from energy efficiency measures, the marginal costs for implementing additional measures may be much higher as compared to RES deployment.

[16] Eurelectric. (2020). E-quality. Shaping an inclusive energy transition.
[17] SWD(2020) 176 final. Impact assessment accompanying the document "Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people"
[18] Eurelectric. (2020). E-quality. Shaping an inclusive energy transition

The distribution of the costs and benefits of an increased RES target across MSs will rely heavily on how the contributions of MSs will be determined and can therefore not be fully evaluated yet. However, it is clear that countries that already have relatively high RES ambitions will probably be less affected as their contributions may still be considered sufficient in the context of an increased RES target. Additionally, lower income MSs will have a larger share of lower income households which makes them subject to the same distributional issues as identified in the previous paragraph on income classes.

Overall, we conclude that RES targets, energy efficiency targets and carbon pricing could have distributional impacts, although each type of measure could be configured in a way that mitigates these adverse impacts.

vii. *GHG emission reductions*

Increased RES deployment will displace fossil fuel consumption and thereby reduce GHG emissions. Hence, a higher RES target will have a positive contribution to GHG emission reductions to the extent that the target is realised.

Comparing the impacts on GHG emission reductions to those of other policy measures such as carbon pricing and energy efficiency is challenging as the impacts largely depend on the ambition level of the policy measures, rather than the type of measure used. Overall, most projections for reaching carbon neutrality rely on a mix of policy measures with high ambition levels for each, indicating that rapid progress on all dimensions (RES, EE, GHG) is needed to realise the overall ambitions.

Overall, we conclude that raising the RES target (option 1) has a more favourable emission reduction impact than not raising the target (option 0).

viii. *Administrative burden*

The impacts of an increased EU RES target on the administrative burden will be limited as there are no recurring administrative requirements introduced by increasing the RES target.

ix. *Political feasibility*

The increased 2030 targets for GHG emissions have been agreed politically and already indicate a potential requirement for increasing the RES target, which signals that it may be politically feasible to increase the RES targets. The level at which the RES target would be raised may still result in some discussion, as some MSs have been supportive for ambitious GHG targets while others have been less in favour of having RES targets. On the other hand, if not agreeing on a higher RES target results in more ambitious ETS and EE policies, there may be little benefit to opposing a higher RES target. Overall, we consider both options politically feasible.

e. Options for the nature of the target

i. *Cost-effectiveness*

For assessing the cost-effectiveness of the options to avoid an ambition gap, we also consider that not raising the contributions of MSs would have to be compensated for by other instruments, similar to the discussion on raising the overall EU target. Hence, we compare the cost-effectiveness of different instruments to realise the collective GHG reduction ambition.

Similar to the overall target setting discussion, the main alternative instruments are carbon pricing (with better or equal cost-effectiveness albeit with the drawback of carbon price volatility) and energy efficiency (with better, but decreasing cost-effectiveness). Hence, not requiring MSs to increase their contributions (option 0) would not necessarily have negative impacts on cost effectiveness. However, at this level, another option is to rely more on sectoral RES targets, which limits the flexibility of MSs to increase RES / reduce GHG emissions in the most efficient way. Hence, if such an option would become the alternative, it would be more cost-effective to implement binding targets (option 1). Furthermore, an alternative is to utilise the Union Renewable Energy Financing Mechanism (variant to option 0) which could be very cost-effective because RES deployment can be realised across the EU, at locations with favourable conditions. However, the use of this mechanism is not exclusive to these options and may therefore be applied in conjunction with the other options, too.

Overall, there is no clear indication that any of the options is more cost-effective than the other.

ii. *Investor certainty*

Binding targets (option 1) provide the largest investor certainty as there will be high targets (no ambition gap) and high certainty that MSs will realise those targets due to the binding nature of the targets. The other option provides less investor certainty as there is a higher chance that an ambition gap remains and provides less assurance that ambitions will be realised. The variant to option 0 with the reinforced mechanism to solve an ambition gap adds to the investor certainty of the base option though, as the probability that an ambition gap emerges would be less.

iii. *Macroeconomic impacts*

The macroeconomic impacts depend on the extent to which the different options lead to different rates of RES deployment. In principle, the options that require most urgent and the most binding action should lead to the highest ambition level and rate of deployment, so option 1 (binding target) has better macroeconomic impacts than option 0 (current governance process), with the variant of a reinforced mechanism offering higher macroeconomic impacts than the base option (option 0). However, there are several nuances to this assessment. First, the approach used in the current governance process (option 0) has proven to be effective in closing an ambition gap in the first round of NECP submissions and is therefore not necessarily less effective than a binding target. Secondly, some countries that did not meet their binding targets have resolved this by a statistical transfer from another EU country, rather than increasing RES deployment domestically, leading to no net contribution to the overall EU economy. So, while the order of the options in terms of macroeconomic impacts outlined above remains valid, the differences are not necessarily very large.

iv. *Security of supply*

For security of supply, the considerations are similar to those mentioned for macroeconomic impacts- to the extent that the more stringent options lead to higher RES deployment, they have better impacts in terms of security of supply.

v. *Innovation*

The impacts on innovation are to an extent similar to the macroeconomic and security of supply impacts where more stringent options lead to a better innovation climate to the extent they lead to higher RES deployment. For innovation, there is an additional nuance, however, as increased RES deployment may not necessarily translate to a better innovation climate if it is delivered through upscaling the most mature technologies (i.e. the most common designs for onshore wind and solar PV). Only if progress is delivered in sectors that rely on less mature renewable energy technologies or when there are specific policies to push less mature RES technologies to the market, is there a positive impact on innovation. We do not expect the decision between more or less stringent ambition gap filling measures to play a significant role in this regard and therefore conclude that the impacts on innovation will not be significant either.

vi. *Distributional impacts*

As mentioned in the discussion on the EU target setting options, RES targets, energy efficiency targets and carbon pricing could have distributional impacts, although measures put forward to achieve such targets could be configured in a way to mitigate these adverse impacts. It is important to note here that the formula to estimate the ambition level of the binding targets does account for GDP differences among MSs and thereby addressing a potentially too high burden on countries with lower GDP.

vii. *GHG emission reductions*

For GHG emission reductions, the considerations are similar to those mentioned for macroeconomic impacts whereby the impact on GHG emission reductions depends on the extent to which the more stringent options lead to higher RES deployment.

viii. *Administrative burden*

The administrative burden of the target setting is rather limited because it concerns only one-off efforts to develop and evaluate plans, without any implications for industry and citizens. Hence, we conclude that the differences in administrative burden are not impactful enough to have implications for the assessment of the policy options.

ix. *Political feasibility*

Political feasibility is a particular issue for binding targets (option 1). While binding targets were applied in the first Renewable Energy Directive (RED I), they have not been applied in its successor (RED II). At this stage, there was still support for such targets from leading renewable energy countries (Germany and Denmark), but opposition from a group of Eastern European countries led by Poland as well as from countries who were in favour of climate targets but opposed renewable targets, such as the Netherlands.[19] For the current revision, we expect that binding targets would suffer from a similar lack of political feasibility.

The political feasibility of the baseline option is less challenging, although the variant with the reinforced mechanism may be slightly less politically feasible than the other options.

[19] Monti, A. and Romera, B. M. (2020). Fifty shades of binding: Appraising the enforcement toolkit for the EU's 2030 renewable energy targets. Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/reel.12330

x. Coherence

The final assessment criterion for the options to address an ambition gap is the coherence between the EU target setting and the contributions of MSs. In particular, in case the contributions of MSs after the NECP revision do not add up to the EU target, the EU target could be considered as less credible, and the overall EU policy mix as less coherent. From this perspective, the more stringent options can be expected to deliver a better result as they leave less chance of an ambition gap.

Synthesis

f. Options for setting the level of the EU target

The assessment of the options for setting the level of the EU RES target can be broken down into two comparisons. The first one concerns the comparison against the baseline scenario of not raising the climate and renewable energy ambitions at all. The second one concerns the comparison against the other main policy instruments to reach the increased climate ambition: carbon pricing and energy efficiency measures. In this chapter we synthesize the findings for both comparisons and draw overall conclusions on the impacts of the different options related to raising the overall EU target.

Compared to the baseline scenario, the most significant impacts of raising the EU RES target are increased investor certainty, security of supply, innovation and GHG emission reductions (see Table 4-1). Raising the EU RES target has positive impacts on all those dimensions and is therefore preferable over the baseline scenario (no updates to the EU RES target).

Table 4-1 Summary table of impacts of options for raising the EU RES target

Dimension	Indicator	0. No updates (baseline)	1. Raise EU RES target to 38-40%
Economic	Cost-effectiveness	0	-
	Investor certainty	0	++
	Macroeconomic impacts	0	(not assessed in this paper - see modelling results presented in EC impact assessment)
	Security of supply	0	++
	Innovation	0	++
	Administrative burden	0	0
Social	Distributional impacts	0	0
Environmental	GHG emission reductions	0	++
Other	Political feasibility	0	0

+,++,+++ : positive impact (from moderately to highly positive)
0 : neutral or very limited impact
-, --, --- : negative impact (from moderately to highly negative)

Compared to the alternative policy measures of carbon pricing and energy efficiency measures a more nuanced picture emerges. Increasing the RES ambition may be slightly less cost-effective than carbon pricing and energy efficiency, while having better impacts for security of supply and innovation thanks to the resulting increase in domestic energy production and the associated market growth as well as the better support for emerging technologies and sectors through market formation, capacity building and improved consumer awareness. Furthermore, the impacts of increasing the RES target on low-income households and inequality are better than carbon pricing, but worse than energy efficiency, while depending to a large extent on the exact configuration of the support schemes and the way they are financed.

But overall, most projections indicate the need for accelerated progress on all dimensions (RES, EE, GHG) for meeting the overall climate ambitions. Hence, there is little room for energy efficiency measures to compensate for less RES deployment and vice versa, and both groups of measures are important to realise the ambition. Carbon pricing may deliver increased RES deployment, too, but is not as effective in addressing non-market barriers and does not stimulate innovation for less mature technologies as effectively as targeted RES policies.

g. Options for the nature of the target

The assessment of the options for the nature of the target in function of addressing an ambition gap reveals mostly moderate differences in impact (see Table 4-2) due to the observation that the current governance process (baseline) has been effective in addressing an ambition gap previously and may be effective for the upcoming revision, too. As a result, the more stringent options of adding a reinforced mechanism or establishing national binding targets are not expected to have a large impact on the eventual contributions put forward in the updated NECPs.

Still, there are benefits of implementing a more stringent approach to prevent an ambition gap in terms of higher investor confidence and better coherence with the overall EU RES and GHG targets. Additionally, the more stringent options would have better macroeconomic, security of supply and GHG emission reduction benefits to the extent that they would be effective in realising increased RES deployment. The main drawback of those options is the political feasibility, in particular for option 1 (establishing national binding targets).

Table 4-2 Summary table of impacts of options for avoiding an ambition gap between the raised EU target and the contributions of MSs

Dimension	Indicator	0. No updates (baseline)	0. + reinforced mechanism to solve ambition gap	1. Establish national binding targets
Economic	Cost-effectiveness	0	0	0
	Investor certainty	0	+	++
	Macroeconomic impacts	0	+	+
	Security of supply	0	+	+
	Innovation	0	0	0
	Administrative burden	0	0	0
Social	Distributional impacts	0	0	0
Environmental	GHG emission reductions	0	+	+
Other	Political feasibility	0	-	---
	Coherence	0	+	+

+,++,+++ : positive impact (from moderately to highly positive)
0 : neutral or very limited impact
-, --, --- : negative impact (from moderately to highly negative)

Annex B - Improve Energy System Integration

Annex B to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

Acronym	Full name
BEVs	Battery Electric Vehicles
BC	Book and Claim
CAPEX	Capital Expenditures
CBAM	Carbon Border Adjustment Mechanism
CCfD	Carbon Contracts for Difference
CCS / CCU	Carbon Capture and Storage / Carbon Capture and Usage
CPO	Charge Point Operator
CTP	Climate Target Plan
DHC	District Heating and Cooling
DSR/DR	Demand Side Response
EC	European Commission
eSMP	Electric mobility service provider
ETS	Emission Trading System
EVs	Electric vehicles
FCEVs	Fuel Cell Electric Vehicles
FT	Fischer-Tropsch
GO	Guarantee of origin
HFO	Heavy Fuel Oil
ICE	Internal Combustion Engine
MB	Mass Balance
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MS	Member State
NECP	National Energy and Climate Plan
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditures
RCF	Recycled Carbon Fuels
RED	Renewable Energy Directive
RES	Renewable Energy Sources
RFNBOs	Renewable liquid and gaseous transport fuels of non-biological origin
SAF	Sustainable Aviation Fuels
SMC	Supplier Managed Charging
SMR	Steam Methane Reforming
UCO	Used Cooking Oil
UMC	User Managed Charging
V2G	Vehicle to Grid
WHR	Wate Heat Recovery

Background

According to the EU Strategy for Energy System Integration (COM(2020) 299[20]), energy system integration refers to the planning and operating of the energy system "as a whole", across multiple energy carriers, infrastructures, and consumption sectors, by creating stronger links between them with the objective of delivering low carbon, reliable and resource-efficient energy services, at the least possible cost for society.

Energy system integration comprises three complementary and mutually reinforcing concepts:

1. A more 'circular' energy system, with energy efficiency at its core: reusing unavoidable waste streams for energy purposes.
2. **A greater direct electrification of end-use sectors**: renewable electricity can service a growing share of energy demand – for instance using heat pumps for space heating or low-temperature industrial processes, electric vehicles for transport, or electric furnaces in certain industries;
3. The use of renewable and low carbon fuels for end-use application where direct heating or electrification are not feasible, not efficient or have higher costs: in such cases, a number of renewable or low carbon fuels could be used, such as sustainable biogas, biomethane and biofuels, renewable and low carbon hydrogen, Renewable Fuels of Non-Biological Origin (RFNBOs) or synthetic fuels, offering solutions allowing to store the energy produced from variable renewable sources, exploiting synergies between the electricity sector, gas sector and end-use sectors.

Consumers playing an active role in energy supply is also part of a more integrated system (in a multi-directional' way). 'Vertically', decentralised production units and customers can contribute actively to the overall balance and flexibility of the system, and 'Horizontally', exchanges of energy increasingly take place between consuming sectors.

Linking the various energy carriers with each other and with the end-use sectors will allow the optimisation of the energy system as a whole, rather than decarbonising and making separate efficiency gains in each sector independently.[21]

This document provides input to the impact assessment for the revision of the Renewable Energy Directive (RED)[22]. Part of the revisions considered are a range of policy options to better align the existing and proposed regulatory framework with the objective of an integrated energy system in line with the Climate Target Plan and the EU Strategy for Energy System Integration. In particular they will consider the principles of circularity and energy efficiency first, the synergies between sectors and energy carriers, the role of energy markets and the optimisation of infrastructure planning.

In the next section we first introduce the problem definition for energy system integration. Next, we define and develop the policy options that are considered for addressing the problems and map their potential impacts. In the third section we assess the merits of each policy option per the most relevant assessment criteria.

[20] COM(2020) 299 final.
[21] idem.
[22] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.

Design

Problem Definition

A decarbonised energy system will require more sector integration going beyond electrification. In order to meet increased climate ambition, further deployment of renewable and low carbon fuels, notably clean hydrogen, will be needed which will require a suitable internal market framework. Today's energy system is still built on several parallel, vertical energy value chains, which rigidly link specific energy resources with specific end-use sectors. Market rules are largely specific to different sectors. This model based on separate silos, can lead to substantial losses in the form of waste heat and low energy efficiency.

The recent decline in the cost of renewable energy technologies, the digitalisation of our economy and emerging technologies in batteries, heat pumps, electric vehicles or hydrogen offer an opportunity to accelerate, over the next two decades, a profound transformation of our energy system and its structure. The uptake of these technologies has not yet started and the coordinated planning and operation of the energy system 'as a whole', across multiple energy carriers, infrastructures, and consumption sectors is still in its infancy. Consumers are starting to become more active (prosumers), but there are many opportunities not yet exploited by the current market design.

The **Clean Energy Package** provides a basis for better integration across infrastructure, energy carriers and sectors. The **revised RED** has also taken steps to incentivise electrification of end-use sectors as well as the use of renewable fuels.[23] However, regulatory and practical barriers remain, differing per sector and across MS. Without robust policy action, the energy system of 2030 will be more akin to that of 2020 than a reflection of what is needed to achieve climate neutrality by 2050.

The EU Strategy for Energy System Integration prescribes a list of concrete policy and legislative measures to address the identified barriers for energy system integration. Some of these actions are potentially expected to be addressed by the **revision of the RED** (see Textbox 0-1).

Some of the measures listed in the strategy are already being evaluated by other Annexes of this study due to their sectoral focus (e.g., setting stronger RES sectoral targets, establishing minimum mandatory green public procurement criteria) but we have identified a set of four key problems of Energy System Integration that can potentially be addressed via the revision of RED:

1. The underutilisation of waste heat;
2. A lack of integration between RES-based electricity in the heating and cooling (H&C) and transport sectors;
3. The scope of renewable energy certification systems is not adjusted to cover consumption of all renewable and low carbon fuels, especially hydrogen, in every end-use sector;
4. A lack of promotion of renewable and low carbon fuels across transport and H&C sectors.

These problems are further defined in the sections below.

[23] The RED provides incentives to electrification through the sectoral targets, and it incentivises the use of renewable fuels by introducing a target of 3.5% for the consumption of advanced biofuels and biogas in transport.

Textbox 0-1 Proposed measures outlined in the EU Strategy for Energy System Integration to be addressed as part of the revision of the RED.

The EU Strategy for Energy System Integration outlines a list of concrete policy and legislative measures to address existing barriers for energy system integration. The following explicitly mention the review of the Renewable Energy Directive:

- A key measure to build a more circular energy system is to **facilitate the reuse of waste heat** from industrial sites and data centres, through strengthened requirements for connection to district heating networks, energy performance accounting and contractual frameworks, as part of the revision of the Renewable Energy Directive and of the Energy Efficiency Directive.
- To further accelerate the electrification of energy consumption, develop more specific measures for the use of renewable electricity in transport, as well as for heating and cooling in buildings and industry, in particular through the revision of the Renewable Energy Directive, and building on its **sectoral targets**.
- **Propose a comprehensive terminology for all renewable and low carbon fuels** and a European system of certification of such fuels, based notably on full life cycle greenhouse gas emission savings and sustainability criteria, building on existing provisions including in the Renewable Energy Directive.
- Consider **additional measures to support renewable and low carbon fuels**, possibly through **minimum shares or quotas** in specific end-use sectors (including aviation and maritime), through the revision of the Renewable Energy Directive and **building on its sectoral targets** (June 2021), complemented, where appropriate, by additional measures assessed under the REFUEL Aviation and FUEL Maritime initiatives (2020). The support regime for hydrogen will be more targeted, allowing shares or quota only for renewable hydrogen.

- ***Problem 1: Underutilisation of waste heat and lack of recognition of its recovery***

As underlined in several works, such as in the EU project Heat Roadmap Europe or in the 2016 EU Heating and Cooling Strategy[24], the EU produces more waste heat than the demand of its entire building stock. Assuming District Heating and cooling (DHC) could cover 50% of H&C demand by 2050[25], waste heat could cover at least 25% of district heating supply[26]. In addition, there is significant heat recovery potential from unconventional waste heat sources, such as from data centres, metro stations, service sector buildings, and waste-water treatment plants, which corresponds to more than 10 % of the EU's total energy demand for heat and hot water.[27]

Tapping into waste heat recovery potential could displace a significant amount of primary energy demand for heating. It could form an essential component of a cost-effective energy transition to a smart integrated energy system, used alongside renewable energy solutions such as geothermal, large scale heat pumps, biomass or solar thermal in district heating networks.

Although the recovery of waste heat is not a new idea, especially in countries where district heating is well-developed (e.g., Finland & Sweden), waste heat recovery is far from reaching its full potential, due to a multitude of barriers. Most of these barriers are specifically linked to the deployment, but also access to DHC (all points are addressed under Annex D on H&C).

These are related to building codes & regulations (including unfavourable Primary Energy Factor or PEF), urban planning not integrating comprehensive energy planning, electricity tariffs not valuing

[24] COM(2016) 51 final.
[25] This is further developed in the Annex D on Heating and Cooling, based on the results of the HRE4 study. Heat Paardekooper,S. et al.(2018): Heat Roadmap Europe 4: Quantifying the Impact of Low-Carbon Heating and Cooling Roadmaps. Aalborg Universitetsforlag. Available at:http://vbn.aau.dk/files/288075507/Heat_Roadmap_Europe_4_Quantifying_the_Impact_of_Low_Carbon_Heating_and_Cooling_Roadmaps.pdf
[26] Heat Roadmap Europe 4. (2019). The Legacy of Heat Roadmap Europe 4: Scenarios, recommendations and resources for decarbonising the heating & cooling sector in Europe and complementing strategic long-term vision of the EU. Available at: https://heatroadmap.eu/wp-content/uploads/2019/02/HRE_Final-Brochure_web.pdf (accessed on 31.05.2021).
[27] Euroheat & Power. (2020). Draft Recommendation Paper – Making more of waste heat to decarbonise cities. Cours Saint Michel 30a Box E, 1040 Brussels, Belgium, June 2020. Available at https://www.euroheat.org/wp-content/uploads/2020/06/Recommendation.pdf

demand response, no level playing field with individual fossil systems maintaining relatively low oil and gas prices, the absence of a specific legal framework for DHC and its production facilities, little awareness on DHC and Waste Heat Recovery (WHR) benefits, heavy procedures, limited political willingness to undertake a local energy transition, limited human resources of Municipalities and empowerment of their teams, operators' state of mind in this relatively new paradigm (requiring higher cooperation), delays in building refurbishment programmes, and so on.

Treating all sources of waste heat equally, and with renewables would be beneficial to encourage MS to support waste heat recovery. As example, waste heat from sewage water is considered as ambient energy and thus as a renewable energy source. Waste heat from sewage can therefore be counted toward national renewable energy targets (under Article 7), while other waste heat sources are left out and cannot count for the national target.[28]

In addition, unconventional heat sources, such as from data centres, metro stations, service sector buildings, and waste-water treatment plants, are not clearly part of the waste heat definition (art 2(9)[29]).

The fact Article 23 of RED II imposes a higher renewable share increase percentage point per year when accounting waste heat (from 1.1 to 1.3), creates a discrepancy between renewables and waste heat, diminishing the attractiveness to incentivise its recovery.

- ***Problem 2: Lack of integration between RES-based electricity in H&C and transport Support roll-out and streamlining of recharging infrastructure for electric road mobility***

To keep up with the demand for charging infrastructure for the estimated 33 – 44 million electric vehicles in 2030, Europe needs to prioritise electric charging in line with the increasing demand for public and private charging points.[30] The EC estimates that the EV fleet may reach up to 13 million vehicles by 2025, which would require upscaling the number of publicly accessible charging points from 200,000 to at least 1 million.[31] A rapid growth in EVs and a growing share of renewable electricity pose substantial opportunities for MS to “use transport electrification as an attractive option to meet their targets under RED II”.[32] Currently, on any charging point, although they have the same supply of electricity to it, they may have different EMSPs treating the customer for that supply. The current Charge Point Operator (CPO), Electric mobility service provider(EMSP), and Original Equipment Manufacturer(OEM) constellations as well as the not fully developed standards, digital ecosystems,

[28] Euroheat & Power. (2020). Draft Recommendation Paper – Making more of waste heat to decarbonise cities. Cours Saint Michel 30a Box E, 1040 Brussels, Belgium, June 2020. Available at https://www.euroheat.org/wp-content/uploads/2020/06/Recommendation.pdf

[29] ‘Waste heat and cold’ means unavoidable heat or cold generated as by-product in industrial or power generation installations, or in the tertiary sector, which would be dissipated unused in air or water without access to a district heating or cooling system, where a cogeneration process has been used or will be used or where cogeneration is not feasible;

[30] Transport & Environment. (2020). Recharge EU: how many charge points will Europe and its Member States need in the 2020s. Available at: https://www.transportenvironment.org/sites/te/files/publications/01%202020%20Draft%20TE%20Infrastructure%20Report%20Final.pdf

[31] The European Green Deal – Sustainable Mobility. (2019). Available at: https://ec.europa.eu/commission/presscorner/detail/en/fs_19_6726

[32] Transport & Envronment. (2019). Using renewable electricity in transport to meet RED targets. Available at: https://www.transportenvironment.org/sites/te/files/publications/2019_10_Renewable_electricity_in_the%20RED_final.pdf

contracts and hence charging experience, potentially create a panoply of inefficiencies in Europe's attempt to electrify its transport.

- **Different treatment of EV-users:** In theory, there can be discrimination in the sense that an EV-users of OEM-Brand A gets better or worse treatment, i.e., different price, access, service compared to EV-user of OEM-Brand B, because the OEMs are affiliated to different EMSPs. There is a risk that this creates significant market distortions as OEMs affiliated with a large geographical scope of EV-infrastructure will have advantages in the regional vehicles sales as well. Furthermore, there is some confusion around prices due to the distinction between ad hoc and contract- based prices. In a consultation carried out under the sustainable transport forum "CPOs indignantly pointed to the fact that the issue is not so much that prices are not displayed at the station, but that prices on the bills may differ from those prices advertised due to different contractually agreed prices and the addition of non-transparent roaming costs. In other words, in reality the EMSP often determines the final price for the charging service, not the CPO, notably in the case of contract-based charging. This leads to the confusing situation where the consumer is not invoiced according to the price that he sees on the station and assumes to be his agreed transaction price, but according to a price that he agreed to when he concluded his EMSP contract. Some EMSPs by contrast complained that they cannot display their prices on stations they do not own or operate. It was also argued that the application by CPOs of a variety of tariff structures (time-based, kWh-based, flat rates, start-up costs, etc.) combined with variable costs such as EMSP transaction costs and additional roaming fees, makes it hard to offer a one-size-fits-all solution for charging. Moreover, EMSPs complained that the specific CPO tariffs are not always known by EMSPs in advance which makes it hard for them to properly inform consumers ahead of a recharging session;"[33]
- **Infrastructure deployment:** The charging infrastructure is, by definition, location specific. So, in popular or densely populated areas there is a risk of lacking availability of different EMSPs, which creates disadvantages for certain EV-users. If all stations are secured by only one EMSP, this presents a problem of infrastructure availability, as certain EV-EMSP-user groups may either face restrictions on how many charging stations they can access – and even if they can access them, they may then be treated on different (potentially worse) terms, compared to the locally dominant EMSP. It is unclear what effect this has on the duplication of electric charging infrastructure, potentially making the deployment of charging points less efficient, while distorting the market and slowing down the penetration of renewable energy;
- **RES-penetration and V2G:** Renewable energy in the form of electricity brings volatility in supply, which requires flexibility in the grid, which can be supplied by EVs. The key to using EVs in the energy system is smart charging. The virtual ecosystems are all connected and can aggregate EVs that are charging into pools of storages, which at the same time allows for a certain share of discharging, if required as flexibility reserves of the energy system to bring in more sustainable sources into the grid. Standardisation of the charging infrastructure and digital ecosystems is key for this, as is communicating the renewable energy share to consumers. At the moment, there is no single digital ecosystem that allows tapping into the possibilities of smart-charging across Europe, let alone a transparent communication of the renewable energy share in the electricity mix to EV-users and a flexible pricing mechanism

[33] Sustainable transport forum. (2020). Recommendations for public authorities on recharging infrastructure. Available at https://ec.europa.eu/transport/sites/transport/files/sustainable_transport_forum_report_-_recommendations_for_public_authorities_on_recharging_infrastructure.pdf

across CPOs and EMSPs that would incentivise users to charger their EVs when renewable energy is available. The strong fragmentation of market participants and the division of services between CPOs and EMSPs for recharging, complicates this. “Smart (re)charging requires the inclusion of a smart controller in the recharging point and back office with power steering algorithms, which must be standardised. Moreover, it requires compatibility and communication between recharging points, the electricity grid and the vehicles. In order for this communication to work effectively - independent of the specific CPO, vehicle manufacturer or recharging infrastructure developer - standards are required. Such standards should allow for an effective integration of EVs into the smart grid and should prevent any vendor lock-in by proprietary solutions. Currently, international standards and communication protocols for smart recharging have not yet been fully developed.” [34]

- ***Problem 3: The scope of renewable energy certification systems is not adjusted to cover consumption of all renewable and low carbon fuels, especially hydrogen, in all end-use sectors***

Promoting renewable and low carbon fuels, including hydrogen, is one of the six pillars of the EU System Integration Strategy. The strategy specifically mentions the use of these fuels in hard-to-decarbonise sectors, such as industry or transport sectors. The strategy identifies as a key action extending the scope of existing terminology and certification to all renewable and low carbon fuels. This would also enable introducing the second action proposed in the strategy, which is introducing minimum shares or quotas on renewable energy consumption in specific end-use sectors. The current RED II version has only specific quotas for transport sectors, but for example heating & cooling or industry could be considered as well (these measures are considered in other options).

In RED II, two systems for tracking the consumption of renewable energy exist in parallel. Guarantees of origin under the Book & Claim (BC) system serve for the information of final energy consumers, whereas the certification system based on mass balance (MB) serves for the purpose of demonstrating the compliance with sectoral obligations for transport fuels. In the RED II, the scope of the MB certification system was extended to cover also RFNBOs (in liquid and gaseous form, for the use in transport) and RCFs additionally, the RED II also requires that a centralised Union database is developed to track fuels in the mass balance system. This database will work in parallel with existing national databases.

However, extending the scope of MB system to RFNBOs used as transport fuel only is not sufficient. The consumption of hydrogen in other sectors than transport is not covered by the same detailed requirements on e.g., additionality of used renewable electricity, as mandated for transport fuels in Article 27.

In RED II, hydrogen was added also into the scope of BC system, which is sufficient for the purpose of disclosing information about renewable origin of energy to final consumers. However, the BC system does not by design take into account the intermediate steps of renewable energy value chain, and therefore does not cover the actual carbon footprint of produced hydrogen. These issues have to be addressed in order to facilitate hydrogen use in wider range of hard-to-decarbonise end uses.

[34] Sustainable transport forum. (2020). Recommendations for public authorities on recharging infrastructure. Available at: https://ec.europa.eu/transport/sites/transport/files/sustainable_transport_forum_report_-_recommendations_for_public_authorities_on_recharging_infrastructure.pdf

Since both BC and MB serve different purposes, their coexistence has so far not produced any significant problems. The addition of hydrogen to both MB and BC systems means that there are possible situations, where the two system might interact. The most relevant case of such interaction is cancellation of a GO issued for a fuel that is entering the MB certification system. In that situation, the information on renewable energy quality carried on the GO in the BC system is not sufficient for certification purposes; additional information is needed and has to be validated through audits, notably the sustainability criteria need to be validated. Moreover, the process of GO cancelation is not sufficiently addressed in RED II, although it is mentioned that: “No more than one guarantee of origin shall be issued in respect of each unit of energy produced.” However, there is no clear provision that GOs need to be cancelled for energies that enter the MB system. In such a situation, a GO and a certificate in the MB system can both be generated and used based on the same amount of renewable energy. This needs to be avoided.

Another problem is the fact that the national share of renewable energy in transport, as far as RFNBOs are concerned, is calculated on the basis of the national electricity mix. If, for example, a MS has a renewable share in the electricity mix of 45%, then 45% of hydrogen produced from the grid mix is renewable and counted towards the national target. For these quantities of renewable electricity, GOs may have been issued. Therefore, it would be necessary for avoiding the same units of energy to enter both BC and MB systems to require GO cancellation for all RFNBOs produced.

Mass balance system

Mass balance system is established on the basis of Article 30 of the RED II. It is applicable to biofuels, bioliquids and biomass fuels that are taken into account for:

- Contributing towards the Union target set in Article 3(1) and the renewable energy shares of MS;
- Eligible for being counted towards the target (specifically the numerator referred to in point (b) of Article 27(1) – the renewable transport target);
- Measuring compliance with renewable energy obligations, including the obligation laid down in Article 25;
- Eligibility for financial support for the consumption of biofuels, bioliquids and biomass fuels.

Unlike the BC system, the MB system requires the simultaneous transfer of the physical fuel together with the certificate disclosing the sustainability quality of the fuel. However, the sustainable fuel can be mixed with other fuels of the same physical quality (e.g., MB system does not require keeping biomethane separate from natural gas and segregated transport, storage or distribution is not required).

Article 30 of RED II also requires that the “information about the sustainability and greenhouse gas emissions saving characteristics remain assigned to the consignment”, and if the consignment is processed, “information on the sustainability and greenhouse gas emissions saving characteristics of the consignment shall be adjusted and assigned to the output”.

Furthermore, Article 27(3) requires that a framework for ensuring the additionality of renewable electricity consumed in the transport sector is developed. Specifically for the production of transport RFNBOs, the renewable electricity must be supplied via direct connection from a production facility that has come in operation after or at the same time as the installation producing the RFNBO.

Union database for tracking MB certificates

According to Article 28 of RED II, MS and the Commission shall increase cooperation between national systems tracking the renewable fuels in order to improve the data availability on the EU level and to minimise the risk of fraud and double counting of fuels. For that purpose, a Union database shall be set up for fuels that are:

- Eligible for being counted towards the target (specifically the numerator referred to in point (b) of Article 27(1) – the renewable transport target);
- Suitable for measuring compliance with renewable energy obligations;
- Eligible for financial support for the consumption of biofuels, bioliquids and biomass fuels.

The article also requires that the information includes "sustainability characteristics of those fuels, including their life-cycle greenhouse gas emissions, starting from their point of production to the fuel supplier that places the fuel on the market". Furthermore, MS can set up national databases, that are linked to the Union database and the entered information is instantly transferred between them. MSs shall also be responsible for verification of data entered into the Union database.

The scoping study[35] on the Union database clarified several technical details on the working of the database:

- The union database becomes the main central tracking tool; economic operators enter the information about fuels in the Union database. From there, the data can be exported to national databases that MSs may choose (or not) to operate in parallel;
- MSs may choose to accept the data from Union database or preform additional checks on their validity;
- The scope of the database should cover the whole supply chain, from the point of origin of the fuels via fuel manufacturers to fuel suppliers;
- There should be no limit on the size of installations included in the database.
- Within the current regulatory framework, the scope of fuels in the MB system is limited to renewable and low carbon fuels intended for the use in the transport sector. This could in theory include also electricity, but the scoping study suggest using the database for biofuels, biomethane, renewable fuels of non-biological origin and recycled carbon fuels. The study also suggests widening the scope to bioliquids and biomethane used in other sectors than transport (this might however change depending on the assessed option).

Book & Claim system

Article 19 of RED II mandates the guarantees of origin (GOs) for disclosing the origin of energy consumption, including the consumption of renewable gas. The purpose of GOs is to demonstrate to consumers the share of renewable energy in the consumed energy mix. GOs are not foreseen to be used for the purpose of calculating the share of energy from renewable sources according to the Article 7 of RED II, thus having no function in terms of a MS' compliance with Article 3 and with the sectoral obligations for transport in Article 25.

[35] Navigant. (2020). Scoping study setting technical requirements and options for a Union Database for tracing liquid and gaseous transport fuels. Available at: https://op.europa.eu/en/publication-detail/-/publication/f9325197-f991-11ea-b44f-01aa75ed71a1/language-sv.

The GO system, in contrast to the mass balance system, does not require a physical link between supply and consumption sites and GOs can be traded independently from the physical matter36. Hence, the GOs are issued directly at the point of production of renewable energy and traded and cancelled at the point of final energy consumption. Therefore, any intermediate steps in the value chain are not reflected in the information included in the guarantee of origin. This a lesser issue for renewable electricity, where there are only limited transmission and conversion losses of the energy, but in case of renewable gasses, there could be several intermediate steps that change the renewable characteristics of the consignment such as biogas methanation, production of hydrogen from biomethane by SMR, or even injection of hydrogen into methane grid (where the hydrogen is used afterwards the same way as methane and it would be difficult to separate hydrogen again).

The mandatory information included in a guarantee of origin is (in accordance with Article 19(7)):

- the energy source from which the energy was produced and the start and end dates of production;
- whether it relates to:
  - electricity;
  - gas, including hydrogen; or
  - heating or cooling;
- the identity, location, type and capacity of the installation where the energy was produced;
- whether the installation has benefited from investment support and whether the unit of energy has benefited in any other way from a national support scheme, and the type of support scheme;
- the date on which the installation became operational;
- the date and country of issue and a unique identification number.

The paragraph also states that simplified information requirements can be specified for installations of less than 50 kW output.

Limited scope of BC system

There are two main issues based on this definition. Firstly, the scope does not cover the whole scope of energy carriers: in particular RFNBOs (other than hydrogen) and RCFs. Liquid fuels are also not in the scope of Article 19.

Limited information content of GOs

Secondly, the GO does not include information on actual carbon footprint of the energy carrier, which is in particular relevant for renewable gases and hydrogen, which might have different carbon content, depending on the production pathway. Therefore, the additional value of fuels with lower carbon content cannot be valued properly on the market, creating a missed opportunity to facilitate production of renewable energy with the lowest carbon footprint. Furthermore, if the GO would be cancelled in order to prove renewable quality of consignment used to produce fuel within the mass balance system (e.g., biomethane GO used for production of hydrogen used as fuel in transport), the information included in the GO would not be sufficient to prove all the requirements put on fuels in the MB system.

[36] Ecofys. (2012). Analysis of the operation of the mass balance system and alternatives: Final Report (Task 1). https://ec.europa.eu/energy/sites/ener/files/documents/2013_task_1_mass_balance_and_alternatives.pdf

The paragraph 19(2) states that “No more than one guarantee of origin shall be issued in respect of each unit of energy produced”; and “MS shall ensure that the same unit of energy from renewable sources is taken into account only once”. Based on this, the MSs are responsible for oversight and prevention of fraud and double claiming of renewable energy consumptions. The MSs should also prevent the situation, where both a GO and MB certificate are issued for the same volume of renewably produced, although this is not explicitly mentioned in the directive.

- ***Problem 4: Lack of promotion of renewable and low carbon fuels***

Renewable and low carbon fuels are an essential pillar of an energy system which is compatible with the ambitious target of climate neutrality of the European Union by 2050. Energy carrier like renewable hydrogen and other gaseous and liquid fuels derived from it will be required for applications in different sectors, where direct electrification is not feasible from a technological or economical perspective. Sectors with such hard-to-abate emissions include specific transport sectors like specific heavy-duty vehicles, aviation and maritime as well as specific industrial processes where renewable or low carbon fuels are the only option for future decarbonisation progress.

Existing provisions for technology-specific support of renewable fuels under RED II across transport and heating and cooling sectors mainly focus on biofuels or renewable electricity. While the provisions for biofuels in transport as well as heating and cooling will be discussed in the respective sections, this section will therefore discuss options for renewable and low carbon fuels.

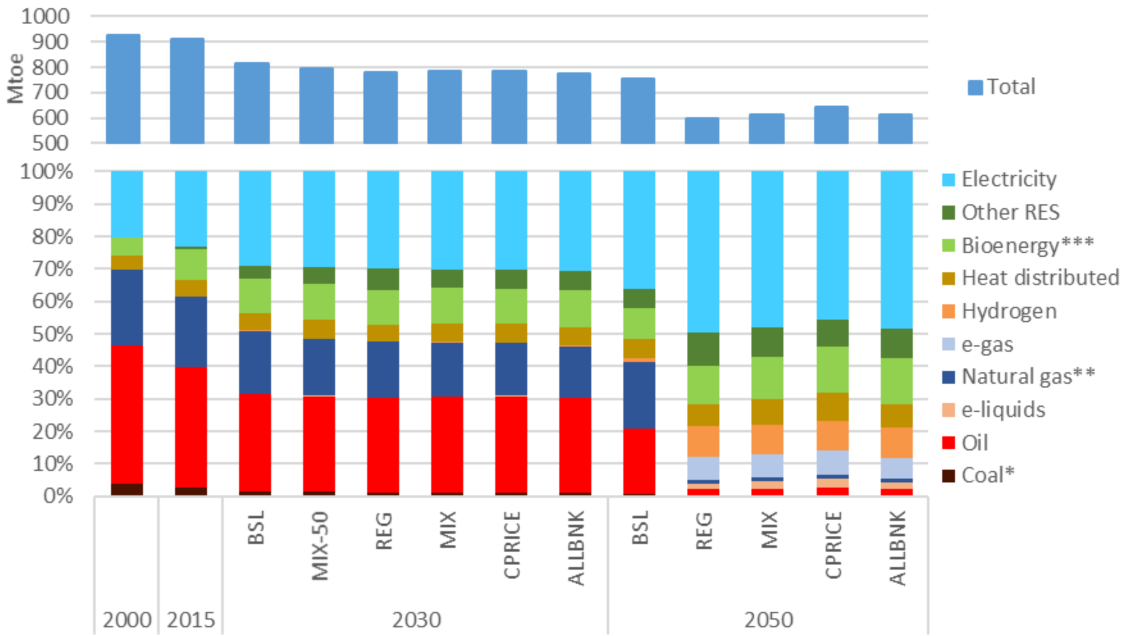
RFNBOs

RED II already includes specific provisions for electricity-based fuels in transport, the so-called RFNBOs. They are defined in Article 2(36) as “*renewable liquid and gaseous transport fuels of non-biological origin […], the energy content of which is derived from renewable sources other than biomass*”. Accordingly, the term comprises hydrogen produced from renewable electricity, as well as hydrocarbons like methane, methanol or other liquid fuels, based on this hydrogen. Given the high importance such fuels will gain also in hard-to-decarbonise industry processes, it seems necessary to extent this definition also other sectors than transport. For consistency reasons, the term RFNBOs will therefore be used in the following describing the consumption of hydrogen and its derivates as a fuel in all sectors.

While hydrogen is already today a significant feedstock for chemical and petrochemical industry, also its role in energy consumption (either direct or in form of RFNBOs or low carbon fuels) is expected to increase drastically until 2050. According to the impact assessment of the Climate Target Plan[37], hydrogen, e-gas and e-liquids will make for 17.9 to 19.4 percent (108-124 Mtoe or 1254 or 1447 TWh) of the final energy demand in Europe in the ambitious climate target scenarios by 2050 (see Figure 0-1).

[37] SWD(2020) 176 final.

Figure 0-1 Final energy demand by energy carrier (Source: SWD(2020) 176 final)



Despite the high future demand for RFNBOs and low carbon fuels by 2050, their role from a mid-term perspective will be rather limited. This is especially driven by high production costs for hydrogen connected to high conversion losses, which especially occur during production of liquid hydrogen-based energy carrier. Consequently, they are not competitive with conventional fuel (in transport or heating) or hydrogen production (in industry, mainly based on steam methane reforming).

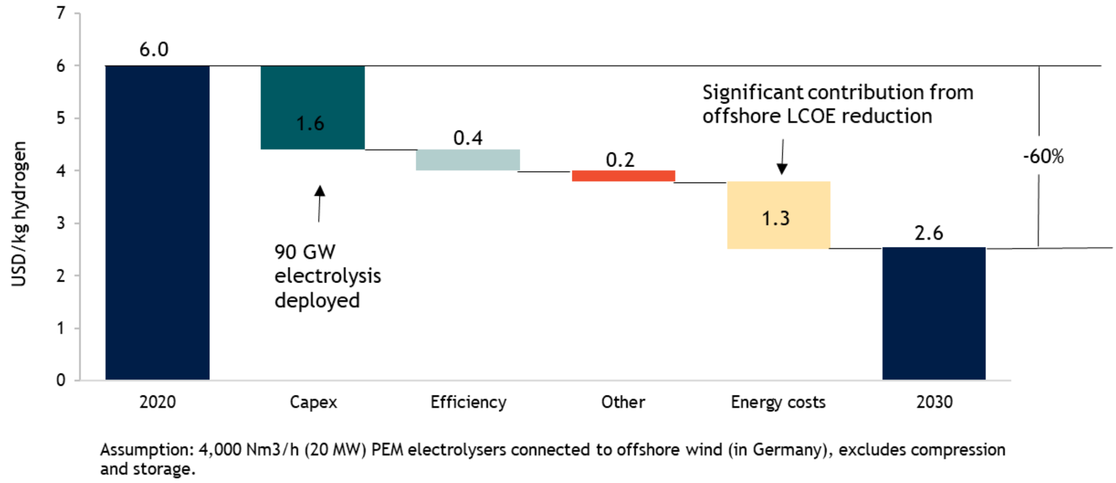
Accordingly, the creation of an early market is an important lever for RFNBOs (and low carbon fuels) to increase their competitiveness in the different sectors. The importance of such a measure can be estimated looking at the baseline scenario in the CTP impact assessment (Figure 0-1) compared to the more ambitious scenarios: One of its main results regarding RFNBOs was, that "*[…] new fuels such as hydrogen appear in all scenarios in significant quantities only post-2030 but are crucial in this time-frame to achieve climate neutrality […]*"[38]. Though their impact is described to be rather limited in the power and building sectors, the hard-to-decarbonise transport and industry sector require that RFNBO technologies "*[…] are demonstrated at scale during this decade to deliver increased reduction after 2030*". The report, however, clearly states that "*carbon price alone will […] not sufficiently trigger demonstration and deployment of clean technologies in transport (vehicles and fuels) and industry sector (e.g., hydrogen) at scale during this decade to deliver increased GHG reductions after 2030.*" This is also true for low carbon technologies: the EC's hydrogen strategy estimates that carbon prices in the range of 55-90 €/tCO_2 would be required, to reach competitiveness between fossil-based hydrogen with carbon capture and fossil-based hydrogen.[39]

It must be noted that the EC's target to increase the renewable hydrogen production capacity by the installation of at least 40 GW electrolysers by 2030 in the EU (and further 40 GW in neighbouring regions) as announced in the EC's hydrogen strategy in 2020 are not considered in these scenarios yet. Based on an analysis of the Hydrogen Council, significant cost reduction in renewable hydrogen

[38] SWD(2020) 176 final PART 1/2.
[39] COM(2020) 301 final.

production will be achieved, in case of technology development due to high deployment rates (in case of 90 GW globally by 2030).[40] Costs for renewable hydrogen from electrolysis have already fallen by 60% since 2010 to about 6 $/kg[41] hydrogen (average case, offshore wind) according to their conclusions. Large scale manufacturing as well as low cost for renewable electricity will further decrease the cost, enabling hydrogen production at about 2.6 $/kg[42] in 2030 in regions like e.g., Northern Europe with high wind potential (see Figure 0-2).

Figure 0-2 Estimated cost reduction for renewable hydrogen from offshore wind in Europe until 2030 (Source: LBST based on Hydrogen Council, 2020)



A detailed cost comparison of RFNBOs to conventional fuels and biofuels is provided in document F – Transport in chapter *Analysis*. The results support the assumption of a significant reduction in RFNBO costs until 2030, mainly driven by decreasing cost for renewable electricity, increased commercialisation and technology employment as well as lower transport and distribution distances in case of a high employment density.

Industry and stakeholders therefore face a trade-off today: on the one hand, these prospects of significant cost reduction in case of significant investments in the raising technologies today and on the other hand, low fuel and feedstock prices today on expense that those technologies might be much more expensive, when the hard-to-abate sectors require their immediate deployment.

Finally, an increased production and consumption of RFNBOs requires further adaptation of the existing provision under RED II. Beside an extension of the definition of RFNBOs to all sectors, as stated above, the calculation methodology for the Union target of renewable energies in Article 7 should be revised. Currently the energy content of domestically produced RFNBOs is not considered for the final consumption of energy from renewable sources in the transport sector in a MS (Article 7(1c)). Instead, the renewable electricity used for their production is considered for the electricity sector (Article 7(1a)). Following this approach, limited conversion efficiencies during the production and distribution of RFNBOs (about 61% for hydrogen via electrolysis and about 50% for further processing into synthetic

[40] Hydrogen Council. (2020). Path-to-Hydrogen-Competitiveness: A cost perspective. Available at: https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf
[41] Equivalent to about 5.40 €/kg or 16.3 ct./kWh, assuming an exchange rate of 1 $ = 0.9 €.
[42] Equivalent to about 2.34 €/kg or 7.1 ct./kWh, assuming an exchange rate of 1 $ = 0.9 €.

methane or 41% to liquid RFNBOs like PtL diesel) are neglected in the statistics.[43] This creates the risk that the requirement of additionality for RFNBOs, as laid out in recital (90), does not translate into additionality with regard to the target for renewable energy of a MS (so called "target additionality"). In other words, when renewable electricity for RFNBO production is fully accounted to the renewable targets, this reduces the otherwise required renewable electricity generation to a certain extent, although the energy is not usable for final consumption due to conversion losses.

Intra-European trade of liquid RFNBOs and the consumption in the transport sector in another country is also not taken into account, since the renewable energy is always only accounted in the RFNBO producing country. In contrast to that, the calculation of the 'minimum share' in transport (RES-T) includes the energy content of RFNBOs, as defined in Article 25(1) and Article 27.

Low carbon fuels

Hydrogen produced from non-renewable sources (e.g., grid-electricity, nuclear energy), steam methane reforming including carbon capture and storage technology, or pyrolysis are expected to play an important role (at least in the short- and medium-term) in replacing existing conventional hydrogen demand from chemical processes, conventional fuel production or other industry sectors. But also other fuels produced using low carbon hydrogen could potentially decrease greenhouse gas emissions from existing vehicle fleets or in hard-to-decarbonise sectors like aviation or maritime. Also heating and cooling applications could in the short-term achieve greenhouse savings applying low carbon technologies and for the industry sector, low carbon fuels could accelerate GHG emission reductions.

However, so far, recycled carbon fuels are the only non-renewable fuels, which may be considered by MS under RED II for the calculation of the RES-T (see B4 Option 0 and Article 25(1)). Following the explanation in recital 89: "*Since those fuels are not renewable, they should not be counted towards the overall Union target for energy from renewable sources*", they are, however, not part of the overall RES target in Article 3. Additionally, MS "may count waste heat and cold, subject to a limit of 40% of the average annual increase", when calculating the share of renewable energy in the heating and cooling sector (Article 23(2a)).

Unlike other directives, e.g., the Fuel Quality Directive (FQD)[44], the Renewable Energy Directive recast (RED II) focuses on renewable fuels and renewable electricity only, while other low carbon fuels are not covered. Following the Commission's assessments described e.g., in the EC's Hydrogen Strategy[45], low carbon fuels like hydrogen or synthetic fuels / e-fuels from non-renewable sources, however, will be needed in the short- and medium-term to achieve a rapid and cost-efficient greenhouse gas emission reduction in specific, hard-to-decarbonise areas.

In summary, the existing regulatory framework, including the current provision under RED II, do not provide the required support to foster a significant market ramp-up connected to a cost reduction of renewable and low carbon technologies.

[43] Well-to-tank analysis based on LBST & Hinicio. (2019). Future fuel for road freight. Available at: http://fondation-tuck.fr/upload/docs/application/pdf/2019-03/future-fuel-road-freight-report_lbst-hinicio_2019-02-19.pdf
[44] Please see Annex F (Transport) for a discussion of the relationship of FQD to RED II, notably in terms of renewable versus low carbon fuels.
[45] COM(2020) 301 final.

Objective Setting

- ***B1: Facilitate use of waste heat***

RED II requires MSs to endeavour implementing an increased share of renewable energy in heating and cooling by an indicative 1.3 percentage point (p.p.) per year in the period of 2021-2030, with up to 40% potentially to be fulfilled by waste heat and cold. As recalled by the CTP impact Assessment, the availability of local waste heat sources should also be taken into account in the urban and infrastructure planning. Energy audits have proven to efficiently identify potential for energy savings, but are not systematically identifying appropriate actions for waste heat recovery.

The objective is to facilitate the uptake of Waste Heat Recovery (WHR) potential, which can be combined with the deployment of district heating and cooling, and the promising perspective of increasing recovery potential especially with the deployment of low temperature solutions (such as the 5^{th} generation of DHC). The DHC aspects (including planning) are covered under Annex D on H&C.

To facilitate the uptake of WHR, EU guidance and the share of best practices will be a key determinant, to raise awareness, provide support, and increase the confidence of all involved parties (waste heat owner and final heat consumer). An appropriate accounting framework and recognition is required, ideally with equal treatment as renewable energy sources. Last but not least, based on high level guidance and best practice sharing, an in-depth support for the more complex contractual arrangements between the parties (waste heat owner, district heat operator, and heat consumer) would help developing the fundamentals for WHR project developers.

- ***B2: Promote RES-based electrification by better integrating RES electricity in H&C and transport***

All scenarios compatible with a 1.5°C target indicate that a better integration of the energy system in terms of energy carriers and between energy consumption sectors is required. Sectoral integration, storage, renewable energy share, and energy efficiency are key to achieve a fully decarbonised energy system. Electricity generation should be fully decarbonised around 2050, as it is one of the most important means for decarbonisation. This is particularly true for transport (e.g., through electric vehicles) and buildings (e.g., the use of heat pumps for heating), but also industry (e.g., the use of electric arc furnaces in the steel sector). The deployment of renewables (especially wind and solar) is substantial and should be rapid.

A large-scale deployment of renewable electricity generation technologies is at the centre of all credible pathways to decarbonise the European economy. Generating large volumes of renewable electricity enables to reduce GHG emissions via:

- the decarbonisation of the current end-uses consuming electricity;
- enabling a number of end-uses to switch to decarbonised electricity from fossil fuels (e.g., electric mobility, heat pumps, etc.) and;
- the production of hydrogen through electrolysis to decarbonise otherwise hard-to-abate sectors (potentially coupled with additional processes to produce methane or energy liquids).

The second and third options are often referred to as direct and indirect electrification. Whether a given end-use should rather pursue a path towards direct or indirect electrification depends on a number of factors, such as the availability of technological options, their efficiency, and their respective costs (from the individual investors' point of view, but also and perhaps more importantly from the overall system point of view).

In its recently released Strategy for Energy System Integration[46] the European Commission underscores the importance of accelerating electrification and a largely renewables-based power system. Indeed, in most cases, direct electrification is the most efficient way of using electricity when compared with the indirect electrification route (e.g., electric vehicle vs gas-based mobility; heat pumps vs gas boilers), and therefore requires less investment in electricity generation capacities.

Transport

The electrification of road transport is considered as a major building block to achieve a substantial improvement of energy efficiency of the transport sector - and in particular to increase the use of renewable energy in transport substantially. Although electric vehicles (EVs) have zero tailpipe emissions of GHG and air pollutants and allow the use of a wide range of primary energy sources via electricity, the contribution of EVs to reduce transport-related emissions is dependent on the type of electricity generation. Today, depending on the power generation mix of the country, avoided direct emissions through the electrification of vehicles can be associated with an increase of upstream emissions that are related to the additional electricity generation for EVs. To ensure a positive environmental impact of electric vehicles on transport-related emissions, the interaction of EVs with the energy system has to be investigated in greater detail on the European level. Beyond 2020, the development of a performant charging network must keep pace with the growing deployment of electric vehicles to maximize user convenience and flexibility, and to do away with range anxiety.

Results from a stakeholder survey suggest that there is strong support across stakeholders and the vast majority of countries within Europe to both harmonise the charging infrastructure and also communicate the renewable energy share when users are recharging their vehicle. Hence, more effort is needed to cater to the stakeholders' demand and ensure seamless and reliable charging within and across countries for EV-users. It is clear, also from a stakeholder perspective, that two milestones to advance the electrification of transport need to be 1) interoperability of charging infrastructure and 2) communication of the renewable energy share to users when charging. Only then can inefficiencies be resolved, market distortions reduced, flexible prices and V2G for improved RES penetration and grid flexibility fully tapped into. he results from the stakeholder consultation are a clear mandate to the legislation. Across stakeholders, 92% are in favour of interoperability of public recharging infrastructure and 85% would welcome it if information would be made available whether or not users are recharging their vehicle with renewable energy. Other objectives for the transport sector regarding energy system integration include tapping into advanced data analytics, which can enhance the value of the EV charging infrastructure. Next to physical installations, digital infrastructure around EVs will play an important role when it comes to resolving existing issues around accounting of renewable electricity in transport, including tracking and measurement of V2G or V2Home transfers, minimizing stress on public electricity grid, and staying competitive in the emerging markets around EV-infrastructure or autonomous driving. Currently there is no central database to track and manage EVs charging across the EU. For a fully-fledged V2G, the standardisation and integration of existing digital ecosystems or the creation of a new centralised, decentralized or distributed platform that allows for harmonized smart-

[46] COM (2020) 299 final.

charging is important. Lastly, the charging deployment and EV-sale should be equitably incentivised and offered across MS "to ensure all Europeans get the same chance to shift to zero emission mobility".[47]

Figure 0-3 Stakeholders' opinion on whether consumers should receive information on the renewable content of the electricity mix when charging

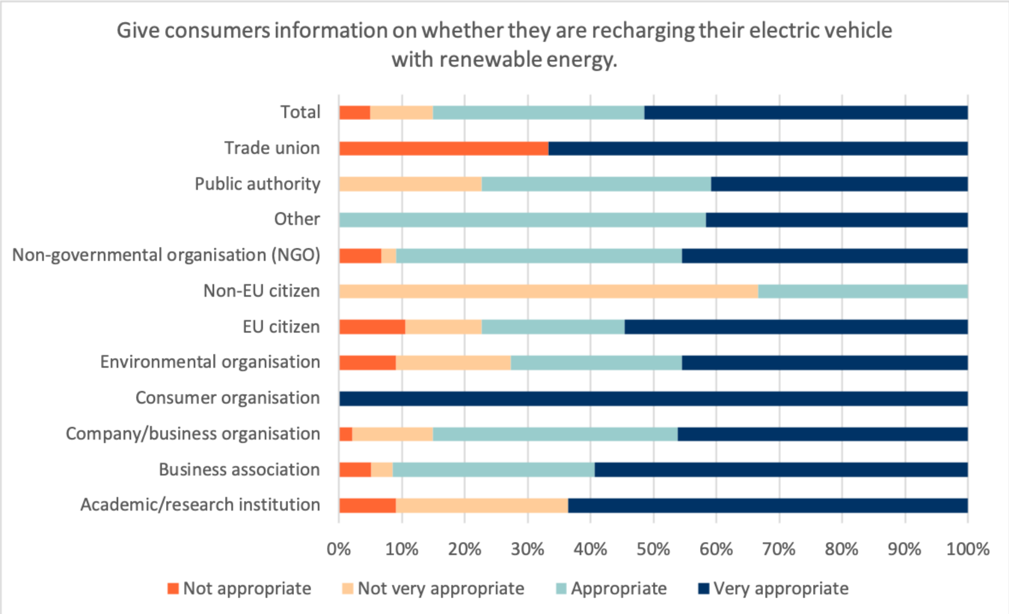
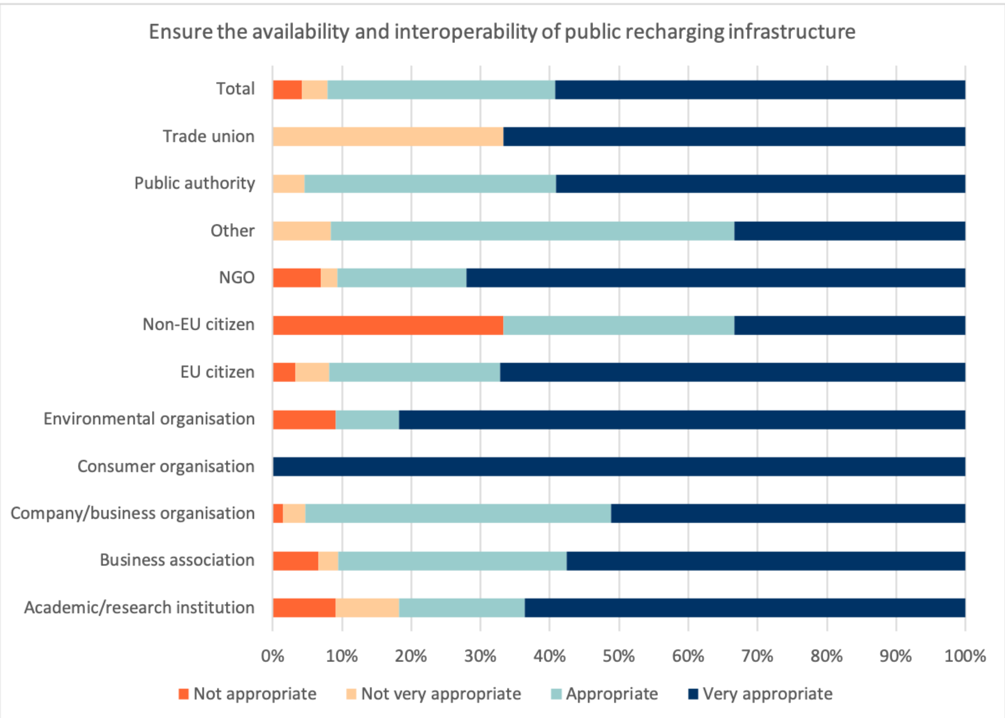


Figure 0-4 Stakeholders opinion on whether interoperability of public recharging infrastructure should be ensured



[47] Transport & Environment. (2020). Recharge EU: How many charge points will Europe and its Member States need in the 2020s. European Federation for Transport and Environment AISBL. Available at:https://www.transportenvironment.org/sites/te/files/publications/01%202020%20Draft%20TE%20Infrastructure%20Report%20Final.pdf

Heating and Cooling

According to the LTS, and also other relevant scenarios to 2050, a clear trend that emerges concerning the fuel mix in the building sector (already in the Baseline scenario) is that buildings will rapidly electrify to reach an important level. The share of electricity in services buildings will increase from 50% today up to around 80% by 2050 in the 1.5°C scenarios, as depicted in the Long Term Renovation Strategy (figure 42, page 103). In residential buildings, electricity which represents 25% today will grow up to 63% in 1.5°C scenarios. The deployment of heat pumps will therefore be a key pillar to decarbonise the building sector, but will also become a challenge to happen. Therefore, further promoting the electrification of building's heating needs to be shaped according to the challenge. The deployment of on-site renewable energy should also be considered (and is addressed under topic E on renewables in buildings).

The objective is to ensure an appropriate accounting framework for further electrification of the building's heat, as first lever, but also assess the role the heating and cooling sector can play in energy system integration, by providing flexibility services via demand response, on-site storage, flexibility in the use of heating systems (e.g., individual heat pumps, or larger DHC systems) or hybrid heating systems (e.g., hybrid heat pumps).

- ***B3: Certification of renewable and low carbon fuels***
  - Develop a comprehensive framework for hydrogen certification in all end-use sectors;
  - Clarify the interactions between MB and BC systems;
  - Streamline and harmonise the information offered to energy consumers and used to prove the renewable origin of energy for the purpose of demonstrating compliance with sectoral targets;
  - Integrate green energy certificate markets in Europe; increase demand for renewable fuels;
  - Level the playing field for all renewable and low carbon fuels by integrating them in the certification system;
  - Develop the union database for tracking renewable fuels;
  - Increase transparency and public trust in the green energy use claims;
  - Prevent the risk of fraud and double counting of renewable energy consumption.

- ***B4: Promotion of renewable and low carbon fuels across transport and H&C***

Promotion measures of renewable and low carbon fuels are required in the different sectors, to foster a market development in the short term, which would ultimately lead to a significant cost reduction.

Accordingly, provisions under RED II should be revised with regard to existing inconsistencies and disadvantageous formulations for RFNBOs: Firstly, the definition of RFNBOs should be extended to also cover other sectors than transport, especially with regard to its future role in industry and heating. Secondly, the different target calculation methodologies of how to take RFNBOs into account (either the renewable electricity consumed for their production or their own energy content) should be harmonised between Article7 for the Union target and Article 25 of the transport target, also considering aspects of the "efficiency first principle" as well as intra-European fuel trading. Finally, sub-mandates or sector-specific quotas might be one possibility to foster investment and provide a long-term investment security for RFNBOs and low carbon technology in hard-to-decarbonise sectors, like heavy-duty transport, aviation, maritime, and specific industries. Some results of the OPC with regard to hydrogen and RFNBOs are included in Annex F – Transport.

Low carbon fuels, on the contrary, are not covered under RED II, except for recycled carbon fuels. The integration of sector-related targets would enable technology-specific support in line with the overall motivation of RED II to reduce carbon emissions by the support of renewable and low carbon technologies. In this regard, it has however to be ensured that supporting low carbon technologies does neither result in a decreased deployment of renewable technologies, nor creates the risk of stranded assets in the future.

Development of policy options

This section presents a description of the four policy options considered for addressing energy system integration in the Renewable Energy Directive.

For each policy option, a table is presented with an overview of the options and sub-options to be analysed, organised by their order of departure from the current approach (e.g., option 0 is the baseline, option 1 are non-regulatory measures, etc.). After the table, a full description of the option is presented.

- ***B1: Facilitate use of waste heat***

The purpose of the measures under B1 is to facilitate the recovery of waste heat to supply District Heating and Cooling (direct heat recovery is considered under EED).

Table 0-1 Options for B1: Facilitate use of waste heat

Options	Description
Option 0 (baseline)	Maintain current policies under RED II
Option 1 (non-regulatory)	Facilitation of waste heat integration with non-regulatory measures, such as guidance and best-practice sharing (not through the Directive), including on Article (24(8)) implementation, funding of R&D, targeted financial support, raising consumer awareness and promoting consumer engagement with labelling
Option 2	Integrate accounting framework for waste heat/cold, clarify definition in Article 2(9) and application for key sources from industry, data centres and the tertiary sector. **Sub-option 2.1:** Obligation to count waste heat/cold in H&C target (covering industry and building applications too)
Option 3	Establish guidelines/template for purchase agreements between waste heat and cold suppliers and district heating and cooling system operators could be done and clarify the possibility of contracts to connect industrial sites, data centres, and other sources for waste heat suppliers and buyers, infrastructure providers and regulators (such as municipalities), indicating the main elements that could be included in such contracts.

B.1 - Option 0: No updates - Baseline scenario

The baseline scenario (Option 0) only considers non-regulatory measures, supporting the implementation of the existing provisions addressing waste heat under RED II.

- Article 2(9) defines ‘waste heat and cold’ as “unavoidable heat or cold generated as by-product in industrial or power generation installations, or in the tertiary sector, which would be dissipated unused in air or water without access to a district heating or cooling system, where a cogeneration process has been used or will be used or where cogeneration is not feasible”;
- Article 15(3) mainstreams waste heat and cold recovery when planning (incl. spatial planning) at national, regional and local levels. Article 15(4) allows the use of waste H&C to contribute buildings complying with their national building regulations and codes RES requirements;
- Article 15(7) obliges MS to carry out an assessment of waste H&C potential (together with RES), including spatial analysis (to be included in the second comprehensive assessment required by Article 14(1) EED). Article 20(3), when taking the necessary steps to develop district heating and cooling infrastructure, includes accommodation to use waste H&C;
- Article 23(1) fixes a RES target for the H&C, varying with the use of waste H&C. Article 24 on DHC systematically includes waste H&C.

B.1 – Option 1: Facilitation of waste heat integration with non-regulatory measures

Option 1 concerns the development of specific guidelines to support the required authorities to implement these provisions related to waste heat and cold recovery. Clear understanding of waste H&C definitions and potentials are still needed.

B.1 – Option 2: Integrate accounting framework for waste heat and cold

Option 2 aims to clarify officially the definition of waste heat. A basis could be the discussion paper of EuroHeat&Power and AIT (2020[48]), categorising waste heat into conventional[49] and unconventional[50], or the JRC study on Integrating renewable and waste heat and cold sources into district heating and cooling systems - Case studies analysis, replicable key success factors, and potential policy implications[51].

Article 7(3), for the calculation of the gross final consumption of energy from renewable sources in the heating and cooling sector (contributing to the gross final consumption of energy from renewable sources), does not currently include waste H&C. This is calculated as the quantity of district heating and cooling produced from renewable sources, plus the consumption of other energy from renewable sources in industry, households, services, agriculture, forestry and fisheries, for heating, cooling and processing purposes. The only exception is ambient energy, including waste heat to a certain extent, used for heating by means of heat pumps[52] and ambient energy used for cooling by means of district cooling. Including waste H&C in the accounting of renewable H&C needs first a clear definition, to agree on the precise scope, in order to only target unavoidable waste H&C.

Sub-option 2.1: Obligation to count waste heat and cold in H&C target

A variant to the option is the obligation to count waste heat/cold in H&C target (covering industry and building applications too).

B.1 – Option 3: Establish guidelines for purchase agreements for waste heat and cold

Option 3 in addition to option 2, aims to establish guidelines/template for purchase agreements between waste heat and cold suppliers and district heating and cooling system operators.

It will clarify the possibility of contracts to connect industrial sites, data centres, and other sources for waste heat suppliers and buyers, infrastructure providers and regulators (such as municipalities), indicating the main elements that could be included in such contracts.

[48] Euroheat & Power and Austrian Institute of Technology (AIT). (2020). Discussion Paper: The barriers to waste heat recovery and how to overcome them? Available at: https://ec.europa.eu/futurium/en/system/files/ged/20200625_discussion_paper_v2_final.pdf

[49] Especially energy intensive industries, i.e. glass, cement, paper and metal plants, etc. where waste heat is usually rather readily available, easy to identify and has a high temperature level.

[50] Includes data centres, tunnels and metro stations, as well as cooling from buildings (e.g., offices, hospitals, supermarkets, shopping malls), waste heat from power-to-gas processes, from sewage channels (from households and some industries like food processing) and wastewater treatment plants.

[51] Galindo Fernandez, M., et al.(2021): Integrating renewable and waste heat and cold sources into district heating and cooling systems. Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-29428-3, doi:10.2760/111509, JRC123771.

[52] Calculated in accordance with the methodology set out in Annex VII.

- ***B2: Promote RES based electrification by better integrating RES electricity in H&C and transport***

Table 0-2 Options for B2: Promote RES based electrification by better integrating RES electricity in H&C and transport

Options	Description
Option 0 (baseline)	No further actions / implementation of existing RED II measures and EU policies Including: EV charging market stays as is under AFID terms
Option 1 (non-regulatory)	Guidance on RED II electricity-related provisions related to H&C and transport. This may include: • Market design and market-based instruments, • Self-regulation & co-regulation, • Information and co-education
Option 2	Demand response measures: Include enhanced flexibility in pricing and grid electricity RES share % in real time, GHG emissions profile, as well as forecasting information where possible, in a near-real-time and interoperable manner, which can be used by all players, including EV users and those acting on their behalf, as well as devices connected to the network. • Objective: enable overall system optimization by allowing for demand response in H&C and electric transport • Topics: User-managed charging (UMC), supplier-managed charging (SMC), GOs with time stamp (e.g., on hourly basis)
Option 3	Better integration of renewable electricity into sectoral targets: • Sub-option 3.1 better integration of renewable electricity into the H&C sector, by accounting RES electricity to meet H&C targets (under Article 7(3)) • Sub-option 3.2 Credit mechanism electricity: Introduction of a credit mechanism under the fuel supply obligation rewarding supplying renewable electricity in public charging stations (broad scope, e.g., covering approaches such as the draft German transposition of RED II; including other charging stations (semi-public, private, for battery in rail; etc.)
Option 4	Stronger, more efficient and equitable integration of system users and electric mobility services into the grid through: • setting minimum requirements for the availability of intelligent infrastructure (intelligent charging and V2G) for the integration of electric vehicles in the electricity system • ensuring a level playing field in market of aggregation and electric mobility services

The foremost objective of policy instruments concerning the system integration must be to maximize the RES-share in transport as well as H&C. In this regard, three major areas for policy instruments stand out: improved demand response through communicating of the right signals, such as price or CO_2-content (option 2), minimum requirements for the availability of intelligent infrastructure for the integration of electric vehicles in the electricity system as well as ensuring a level playing field in the market of aggregation and electric mobility services (both option 4).

Demand Response

There is currently no substantial effort to adopt either user-managed charging (UMC) or supplier-managed charging (SMC). Through SMC networks, in addition to charging decisions, the EVs as well as stationary batteries can also discharge to meet local electricity needs or to mitigate the pressure on electricity demand during peak hours. Smart charging and V2G have the potential to move significant amounts of demand into hours with greater availability of renewables in the electricity mix (compare Figure 0-5). Introducing a more integrated system capable to do so builds on the presumption of an EU-wide standardized approach to demand response management and infrastructure availability. Most grid problems occur at distribution level and can be managed there and incentives for system users to balance the grid should be streamlined and standardized across Europe, including signals and reporting and transmission protocols across MS. This also serves the interoperability of charging infrastructure making it easier to roll out and ensure a harmonized approach across MS, hence creating a larger market and a more level playing field for all.

Figure 0-5 Schematic outline of daily load profiles with and without smart controlled charging and PV generation

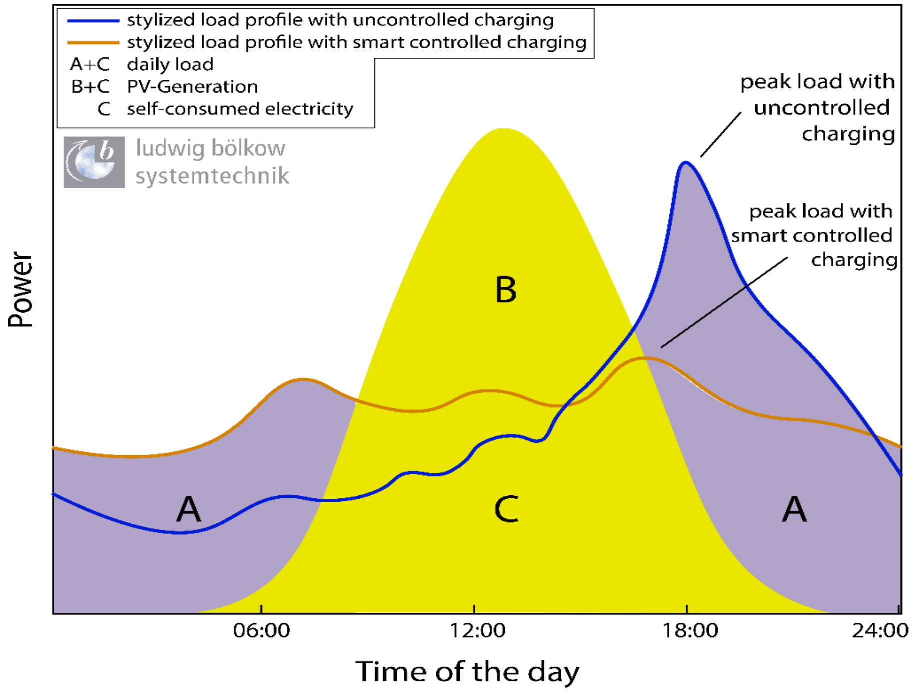
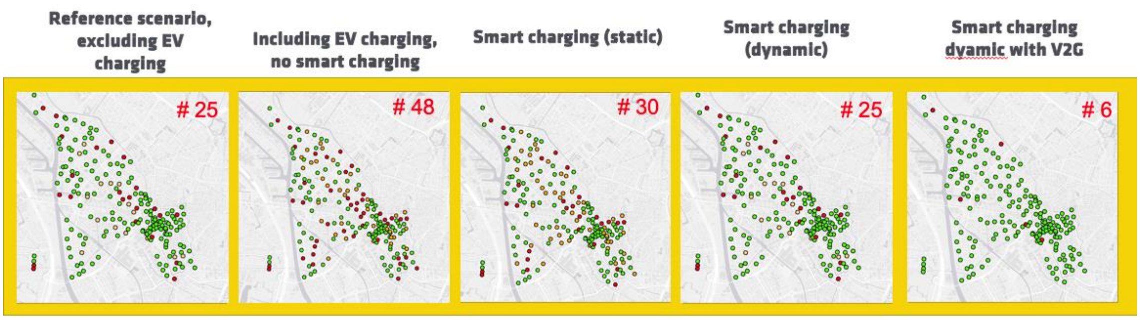


Figure 0-6 Stedin Scenario study for the city of Utrecht – 2035. Source: Utrecht Sustainability Institute and Stedin.net[53]



[53] Shared with consortium via stakeholder consultation with the Utrecht Sustainability Institute and Stedin.net

Notes: Numbers in red indicate the numbers of substations in overload, on a total of about 200 stations in the city; Dots in green (substation load <=80%); Dots in orange (substation load >80%, <100%), Dots in red (substation load >=100%)

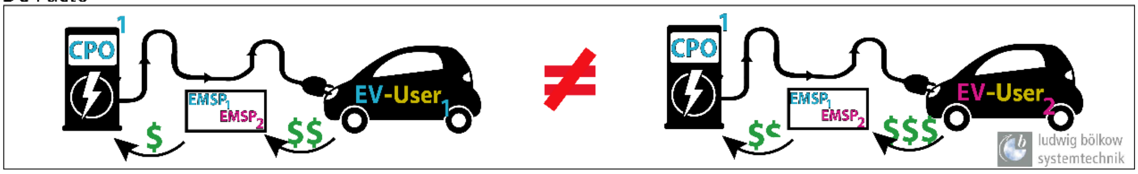
EV Charging Market

The EV charging market is currently it in a late consolidation phase. Over the next decade, a small number of big players is likely to emerge as margins will increase, business models sharpen and volumes rise. In order to become (more) profitable, most players are heading for scale, consolidations, and acquisitions. This process lowers the level of fragmentation but increases tension and – forces all players to evolve beyond their classic roles.

Currently, the charging market is regulated through the Alternative Infrastructure Directive (AFID), which allows charging operators to provide recharging services to customers on a contractual basis, including in the name and on behalf of other service providers, and obliged operators to offer charging services on an ad hoc basis with no prior contract (AFID §4 (8,9)). "MS shall ensure that prices charged by the operators of recharging points accessible to the public are reasonable, easily and clearly comparable, transparent and non-discriminatory" (AFID §4 (10)). There is no law that explicitly regulates the standards of service and specific roles of the different players in the market, including Charging Point Operators (CPOs), Electric Mobility Service Providers (EMSPs), eRoaming platforms, and Original Equipment Manufacturers (OEM). Prices charged to consumers at different recharging points are not necessarily comparable, transparent or non-discriminatory at the moment.

Figure 0-7 Scheme of current EV-User-EMSP-CPO set-up, which allows user discrimination

De Facto



B.2 - Option 1: Non regulatory measures

H&C

Pushing the deployment of individual renewable solutions, via building related instruments such as support schemes and/or mandatory building requirements will certainly pave the way for a large deployment of individual heat pumps, progressively electrifying the H&C sector, leading to more energy system integration. Also, large scale heat pump systems to supply district heating and cooling (DHC) will progressively take up, to decarbonise and increase RES share into existing DHC, and depending also on the deployment of new DHC, large scale heat pumps would become one of the leading technologies. Low temperature heat pumps will also emerge as a competitive and liable solutions for industrial applications, which deployment will depend on the industrial incentive to use renewables.

Additional non regulatory measures to further facilitate the electrification of H&C would start by creating awareness among all concerned stakeholders, such as final consumers, services providers, but also DSOs as they would need to address increasing electricity demand. Communication programs could play a key role in promoting efficient heat pumps. RD&I funding for pilot or demonstrations would also be helpful and support launching the market, aggregating small scale systems to provide flexibility services to the electricity system, or via DHC to provide the same flexibility services.

EV and charging

Non regulatory measures to push energy systems integration forward means first and foremost strengthening the electrification of transport to create a strong demand for integration of a substantial electric vehicle fleet into the energy system. Instruments to do so include many market-based, well-seasoned policy instruments that MS continue using, including subsidies or ownership taxes applied to commercial vehicles that include CO_2 emission levels in the final invoice. "This is particularly important because such vehicles are the most fuel demanding and the most responsible for CO_2 emissions when using internal combustion motors. Growth in e-commerce ought to lead to increasing use of EVs for parcel deliveries in urban areas. Measures to support EVs could be seen as a part of the effort required to meet the delivery services offered by e-retailers."[54] Similarly, vehicle registration fees could factor in vehicle CO_2 emissions. R&D and funding charging stations to facilitate electro-mobility are equally important. "In addition, communication programs could play a crucial role in promoting electro-mobility through two ways. First, misperceptions of the main advantages of EVs could be reduced through adequate information programs co-funded together with private companies. Second, remarkable efforts in communicating available public incentives could help to shift potential consumers to EVs from other, more contaminating options." [55]

B.2 – Option 2: Demand response measures

EV charging happens in two ways: 1) fast-charging (typically for less than 1h), typically in situations of concrete charging needs (e.g., on highways); in such a case there is theoretically little flexibility to shift the charging process. However, it is worth mentioning that drivers can opt to charge sooner than needed, in order to take advantage of lower price / higher res share. Similarly, today, drivers chose in which MS to add fuel on a long trip within EU, i.e., stop in Luxemburg before crossing the border (typically referred to as *fuel tourism*). 2) standard charging (2h-5h) when the car is parked at home (e.g., overnight) or at work (during working hours) for 6-14h hours and there is actually an opportunity to shift charging in time. It could be expected that it is not the consumer itself, but the charging infrastructure that is smart enough to act on pre-set consumer any preferences (e.g., price, RES share, time) or optimizes the charging process based on a price (or other) signal received by the supplier/grid operator, i.e., indirect consumer empowerment.[56] This is understood to apply within a singular home charging system that integrates appliances, EVs, and H&C.[57]

H&C installations are stationary systems that provide a relatively high load shifting potential. When equipped with thermal storage or when building can play an active role storing energy similar to the EVs, the functioning of the H&C (notably of heat pumps) could be optimised by the EMS based on a price/RES signal from the supplier/TSO and in compliance with consumer preferences (cheapest vs greenest vs least-carbon supply).

This option aims at assessing the contribution of demand-response measures (or signal to consumers) to enhance the integration of renewable electricity. It should be considered in a broader context for the promotion of RES-E use in transport, heating and cooling, charging of home battery storage, as well as

[54] Cansino J.M., Sánchez-Braza A., Sanz-Díaz T. (2018). Policy Instruments to Promote Electro-Mobility in the EU28: A Comprehensive Review. *Sustainability*. 2018; 10(7):2507.
[55] Cansino J.M., Sánchez-Braza A., Sanz-Díaz T. (2018). Policy Instruments to Promote Electro-Mobility in the EU28: A Comprehensive Review. *Sustainability*. 2018; 10(7):2507.
[56] It is to be noted that the modelling of EV demand response with METIS (as detailed in Section ¤) is restricted to the standard charging, disregarding fast-charging and fuel tourism.
[57] With respect to EVs, smart charging infrastructure could also become available for public curbside/roadside charging in the medium term, featuring similar characteristics.

other electricity end consumers featuring such demand side flexibility, including industry with a potential market for green products produced from minimum shares of green energy and compliant with EU taxonomy regulation, for example. Both the electricity price and RES-E share information are available in nearly real time in the electricity market system as auctions are cleared every 30 minutes and TSOs dispose of this data. Buildings' Energy Management Systems and Smart Charging infrastructure for EVs could be configured in a way that they do not only consider the hourly price signal, but also information on the RES-E share. Shifting power demand into hours with high RES-E share would thus favour the use of renewable electricity. This is important for incentivising the absorption of RES in real time.

The assessment will make use of the EU energy system model METIS to analyse the impacts of RES-optimised consumer behaviour in the transport and H&C sector. The METIS model was developed by Artelys on behalf of the European Commission. It is a multi-energy model covering the entire European energy system at high granularity, i.e., in time and technological detail. It also represents each Member State of the EU and relevant neighbouring countries. METIS represents explicitly electric vehicles (EVs and PHEVs, being charged at home or at work) and heat pumps (HPs, considering the deterioration of the COP in function of the outdoor temperature; potentially configured as hybrid power-gas assets) as national fleets. Based on arrival/departure timeseries for EVs and heat demand timeseries (derived from hourly national temperature timeseries) for heat pumps, it allows to optimise the behaviour of these consumers with respect to total system costs (i.e., considering some kind of real-time pricing (RTP) mechanism).

For the present option, we assess several demand-response strategies and their impact on the system. These strategies would be modelled as horizontal sensitivities deriving from the MIX-55 scenario (which would be integrated into METIS; scenario selection being subject to further discussion with A4), meaning that no other parameter of the system except the demand-side-response (DSR/DR) strategy would change from a model run to another. It enables to capture solely the impact of the DR strategy, without interfering with assumption changes on other aspects.

The strategies cover smart-charging of electric vehicles (passenger cars, both charging-at-work and charging-at-home), and domestic heating based on heat pumps.[58] Electric vehicles may offer vehicle-to-grid (V2G) capabilities, enabling to use the EV battery as a storage to cover system flexibility needs. Appliances and other domestic consumption areas may provide additional flexibility capabilities, yet it is rather ambitious to assume that these end uses feature a significant flexibility potential by 2030. Therefore, they are not accounted for explicitly in the model. Similarly, the industry mostly offers load shedding capabilities, that help in managing unexpected generation failures or peak demand, yet they offer limited services for the purpose of RES integration – thus they are not modelled explicitly either. Nevertheless, these two uses should be integrated in the qualitative assessment, in particular with respect to the additional potential they would bring assuming increased social acceptance (most probably after 2030).

[58] The modelling of heat pumps with METIS properly reflects the fact that the heat pump's efficiency deteriorates at decreasing temperatures. For further information see Artelys (2018): METIS Technical Note 8. Available at: https://ec.europa.eu/energy/sites/default/files/documents/t8_-_metis_demand_and_heat_modules.pdf

The assessment will be carried out via a joint dispatch and capacity optimisation, first analysing to what extent the optimisation of EV/HP operation patterns[59] may affect the overall power mix, primary energy demand, RES curtailment and total costs; and second how an optimisation of flexibility capacities can avoid investments (thereby reducing overall system costs). In this regard, the capacity optimisation covers peak generators (OCGT/CCGTs), storage technologies (PHS and batteries) and interconnectors.

The following runs are considered:

- **Baseline (no DR)**: In this scenario, no demand response is considered, meaning that cars charge immediately when they are connected to the charging point and heat pumps operate when heat demand occurs (no heat storage is considered). This option is expected to be costly for the system, which will need to invest in additional flexibility means to facilitate the electrification of transport and H&C.
- **Medium demand-response (medium DR)**: In this scenario, 30% of EVs' and heat-pumps' demands are assumed to be flexible, their operation being based on the hourly electricity price (reflecting real-time pricing, RTP). Demand may be shifted within a 24h time window (in case of EVs, subject to connection of the EV to the charging infrastructure). The remaining demand does not feature any flexible operation, similar to the Baseline scenario. This share reflects what is understood as the minimum level of flexibility required to achieve the CTP level of ambition.[60]
- **High demand-response (high-DR).** This model run features a higher flexibility share, as 70% of EVs and heat pumps feature flexible demand. This strategy is expected to reduce further the system costs, and help integrating renewables.
- **High demand-response with vehicle-to-grid (high-DR-V2G).** In this model run, in addition to 70% flexible demand of EVs and heat pumps, we also consider that EVs can use the energy stored in their batteries to inject electricity in the grid (vehicle-to-grid). It provides an additional flexibility potential to the system.
- **Demand-response to a combined price and vRES signal (high-DR-V2G_vRES-share).** This model run considers that 70% of heat pumps and EVs respond to a signal combining the electricity price and a second price component based on the real-time share of vRES in electricity generation. In order to better reflect consumer behaviour in response to a renewable signal, the latter is modelled as hourly guarantee of origins, featuring an increasing price as the vRES share decreases and hourly GOs become scarcer. The modelling of consumer-response to hourly GOs is detailed in the following section.

Detailed description of the hourly GO option

By purchasing guarantees of origin, a consumer receives information on the renewable component of the electricity he consumes. In order to foster renewables integration, supplying GOs at an hourly granularity would help consumers to adapt their electricity consumption patterns to times featuring higher renewable generation.

As a tradeable certificate on electricity markets, hourly GOs feature a market price resulting from the balance of supply and demand. When renewable generation decreases, competition for GOs increases

[59] The MIX55 scenario data indicates some 20% of 2030 transport activity of private cars (incl. LDVs) is related to plug-in hybrid and full electric vehicles. Applying this share to the total number of private cars (159 M) gives some 32 M EVs in 2030 in EU27. In METIS, figures are slightly different (33 M) as we assume different daily demand levels.

[60] It is highly unlikely that no DR will take place by 2030. The impacts of immediate charging for EVs in particular might have a strong impact on power markets and grids. It is thus assumed that even without further regulation some DR will occur.

and their prices rise. As consumers are exposed to this hourly price, they adapt their consumption patterns to minimise their electricity bill (including GO payment). On the opposite, a high vRES generation would supply the market with large amounts of GOs, which could lead to a fall in the GO price (and ultimately to an oversupply). Under such an hourly GO pricing scheme, flexible consumers tend to shift their electricity consumption to times of abundant renewable power generation as it would decrease their total electricity bill.

In order to account for consumers' response to the hourly vRES share in electricity generation, an indirect representation of hourly GOs and its associated price is integrated into METIS.

In addition to the hourly electricity price, the consumer is exposed to the hourly GO price, which is assumed to vary as a piecewise linear function of the hourly vRES share. When the vRES generation exceeds a given threshold, the GO price falls to 0 due to oversupply conditions. The threshold is set at a 30% RES share in power generation in this analysis. However, when renewable generation is lower than the specified threshold, offtakers are competing for GOs. For this model run, the price is assumed to rise linearly with the decrease in vRES generation, until reaching a maximum when almost no renewable generation is available. For this exercise, this maximum is called *scarcity price*.

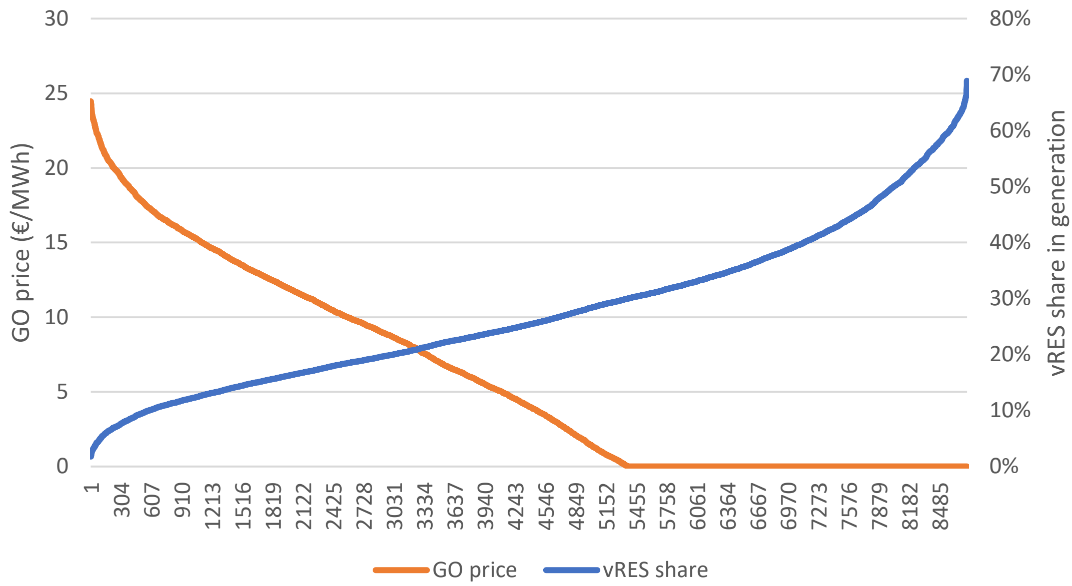
Setting this scarcity price defines the overall shape of GOs price curve against renewable generation. Considering the hourly vRES share extracted from the high-DR model run, one can compute the average GO price over the year. This annual GO price is expressed in comparable terms with respect to current GO prices (which typically range between 0.1 and 2 €/MWh, reaching up to 10 €/MWh in selected cases), which can be cancelled within a year. In total, three model runs are considered in which the scarcity price varies in order to reach different average GO prices. The average GO prices equal 2, 4, and 10 €/MWh, in contrast to the mean wholesale electricity price of 46 to 50 €/MWh under the MIX55 scenario in 2030.

Table 0-3 scarcity and average GO price per demand scenario[61]

	Low demand	Medium demand	High demand
Scarcity price	13 €/MWh	26 €/MWh	65 €/MWh
Average price	2 €/MWh	4 €/MWh	10 €/MWh

[61] The EU27 average electricity price in the MIX55 scenario is between 46 and 50 €/MWh.

Figure 0-8 vRES share against GO price duration curve - FR - medium demand scenario



Setting a GO-price reflecting the hourly vRES share on top of the electricity price provides a financial incentive for the consumer to operate at hours that benefit the most to the system in terms of renewables integration. In particular, as displayed on the load duration curves in Figure 0-8 and Figure 0-9, some hours feature the same electricity price, indistinctively of the actual vRES share, therefore the electricity price alone does not provide the appropriate signal to a consumer trying to identify hours with higher vRES shares. Setting a GO price on top of the electricity price provides a complementary signal that favours renewables consumption (cf. Figure 0-10).

However, it should be noted that adding a renewable signal on top of the electricity price could shift the consumer operation to hours featuring higher electricity prices, instead of relying on cheap electricity generation, e.g., from nuclear energy. This consumption pattern modification may increase renewables integration at the expense of the overall system costs.

Figure 0-9 vRES share against electricity price duration curve - FR - without GO price signal

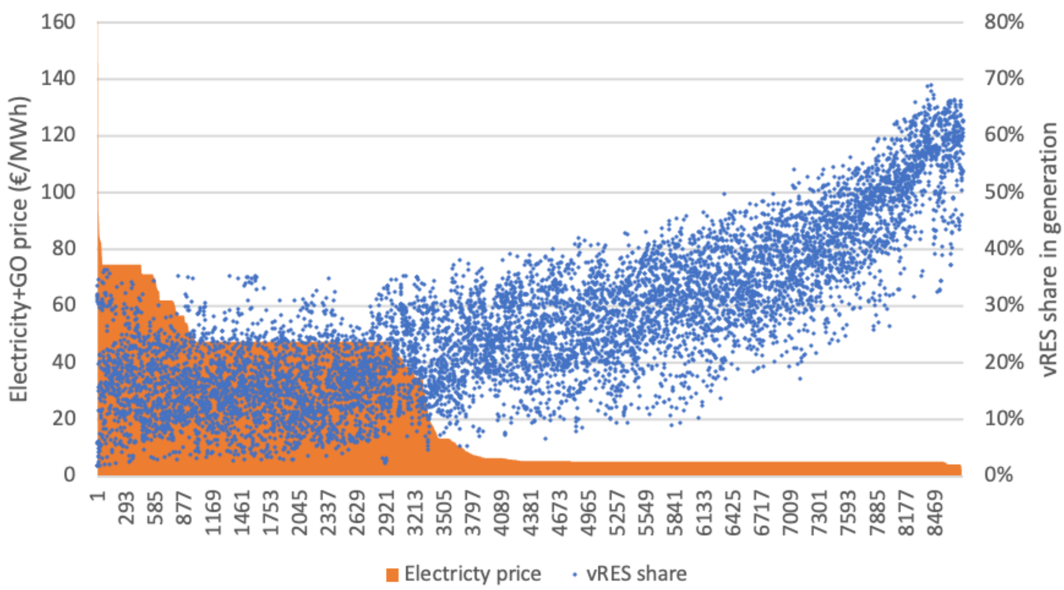
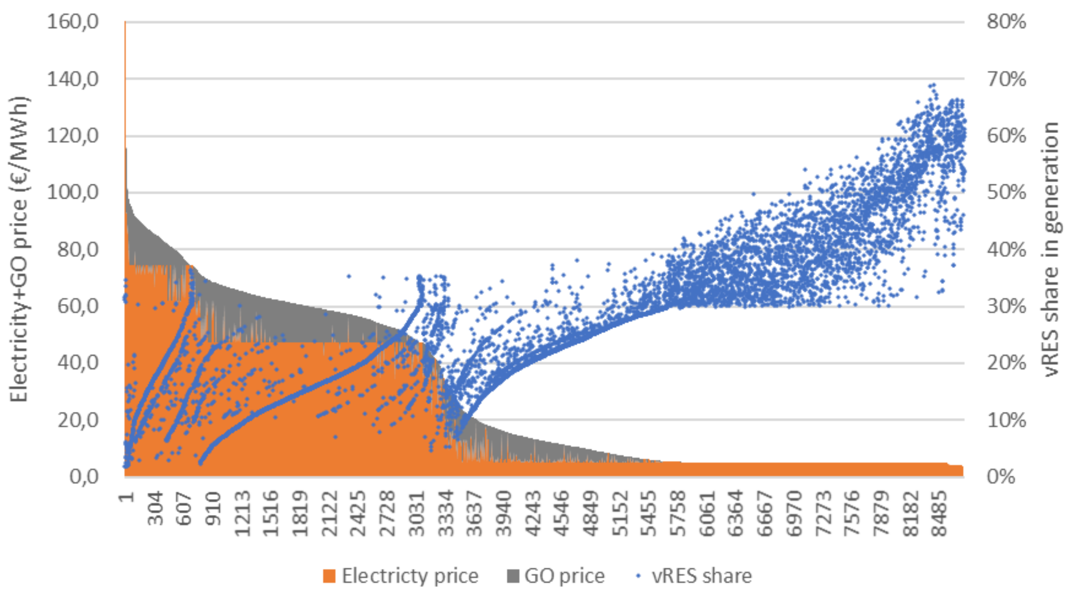


Figure 0-10: vRES share against total electricity price (incl. GOs) duration curve - FR - medium demand scenario



B.2 - Option 3: Better integration of renewable electricity into sectoral targets

Sub-Option 3.1 Accounting RES electricity to meet H&C

The calculation of the share of energy from renewable sources (Article 7 RED) takes into account ambient and geothermal energy used for H&C by means of heat pumps and district cooling systems (Article 7(3)) for the purpose of determining the gross final consumption of energy from renewable sources in the heating and cooling sector. The quantity of H&C should be calculated in accordance with the methodology set out in Annex VII of RED, while the renewable electricity used to produce heat is accounted under the production of electricity (Article 7(2)).

This option would:

- Add renewable electricity used to produce renewable heat to the H&C target under Article 7(3), by inserting “Renewable electricity used for heating and cooling by means of heat pumps and district cooling systems shall be taken into account for the purposes of point (b) of the first subparagraph of paragraph 1”;
- Extract the same amount of electricity from the renewable electricity accounting, by inserting to the first paragraph of Article 7(2) “excluding the production of renewable electricity used for heating and cooling by means of heat pumps and district cooling systems and accounted under Article 7(3)”.

In order to promote the use of renewable energy in the heating and cooling sector, the RED requires MS to increase the share of RES by 1,3% (1% without considering waste heat) as annual average (Article 23(1) RED). Although the target is indicative, extending its scope by including renewable electricity used for H&C purposes would promote technologies like heat pumps to contribute to the Article 23 target. Heating and cooling consumption to be accounted for this target should be calculated in accordance with the methodology set out in Article 7 (while the transport has its own calculation methodology).

Sub-Option 3.2 Credit Mechanism Electricity

The fuel supply obligation as defined in RED II Article 25 is designed for this option so as to reward supplying renewable electricity to transport through a credit mechanism. Electricity suppliers to transport would thus not be obligated parties affected by the fuel supply obligation directly but would be able to generate credits that could be transferred to obligated parties. These would then be able to use them to fulfil their obligation. The accuracy as well as extent of covering all renewable electricity supplied to transport escalates from variant 1-3. A credit mechanism could be designed various ways:

1. Operators of public electric charging stations for transport would measure and calculate the quantities or renewable electricity based on provisions of RED II and the relevant delegated acts. Either the renewable share of grid electricity of the prior two years is multiplied by the share of electricity supplied to transport, or the amount of electricity supplied to transport is counted as 100% renewables if the relevant criteria are met. Credits are awarded to the operator according to such calculation, which can be sold or otherwise transferred to obligated parties under the fuel supply obligation. Actors that deliver electricity to transport and that have connections to the grid for that purpose would be eligible to generate credits.
2. Another approach, a variant of which is currently proposed by the German government for transposition of RED II into national law, would cover all the renewable electricity used in transport including quantities supplied via public and non-public charging stations. The quantity of renewable electricity consumed by battery-electric vehicles (BEV) is estimated by multiplying the number of registered BEVs in the country with the average annual electricity consumption of BEVs and with the renewable share of grid electricity two years before. These quantities would either be claimed by economic operators having exclusive contractual relations to the vehicle owners (e.g., through an electricity supply contract), or would be assigned to the government, and subsequently auctioned to obligated parties. Plug-in hybrid-electric vehicles (PHEV) would be excluded from this approach as current experience shows that electric charging is difficult to estimate as vehicle owners have very diverging charging strategies, including not to charge electricity at all.
3. A third approach would consist of a detailed data monitoring mechanism of the electricity externally charged to BEVs and PHEVs. Such an approach is in place in China, where it is used to determine eligibility for subsidies for BEVs and PHEVs. Data privacy would have to be ensured. The quantity of renewable electricity is calculated by multiplying the electricity thus measured with the renewable share of grid electricity two years before. The renewable electricity quantities could either be assigned to the vehicle owners (possibly to be valorised by aggregators) or to the government which would auction them to obligated parties.

These variants of a credit mechanism increasingly cover electricity consumed in transport. The focus here is on road transport as this is the most complex sector to cover; however, this should also be applied to rail transport and direct electricity consumption in water-borne transport.

B.2 – Option 4: Stronger, more efficient and equitable integration of system users and electric mobility services into the grid

With smart charging, electric vehicles can function as flexible and intelligent storage buffers for the grid. As a result, the grid is stabilized, renewable energy utilization is maximized and electromobility is financially more affordable for everyone as electricity is consumed when it is cheapest. This is absolutely crucial if EVs are going to play a key role in achieving climate targets in line with the EU's Green Deal. The demand response measures outlined in Option 2 that help electric mobility service providers to integrate charging points effectively inter alia through incentivizing EV-users to charge their vehicles when electricity is greenest and cheapest, rest on the assumption of sufficiently available intelligent charging infrastructure. To ensure this adequate availability for the best integration of electric vehicles in the system means first and foremost setting minimal requirements for infrastructure availability in buildings. For residential buildings, this should complement existing EPBD provisions. Different considerations as to the extent of such requirements in certain areas, e.g., public or commercial parking spaces can be evaluated.

While a lot can already be achieved with unidirectional charging if the load is simply moved to the correct time of the day, a more ambitious provision would be to set requirements for infrastructure that is capable of V2G. This would allow to fully tap into intelligent load management. There is a sense that a V2G friendly regulatory framework is necessary for EVs to be fully integrated into the energy system, meaning that one should incentive charging when there is green energy available in the system and make mobile (or stationary) storage accessible via aggregators when necessary.

What is lacking for a wide V2G adoption and roll-out is an adequate regulatory framework that ensures universal access through greater interoperability of public charging infrastructure and minimization of price discrimination, according to stakeholders. The charging infrastructure is, by definition, location specific. So, in buys or densely populated areas there is a fundamental challenge of providing enough charge points and also the risk of poor interoperability when only certain service providers or aggregators are able to work a charging point in a smart way, which may create disadvantages for certain EV-users. The latter may happen with single OEM-aggregator-DSO bundles and is to be discouraged. If all stations are secured by only one aggregator or service provider, this presents a problem of infrastructure availability, as certain user groups may either face restrictions on how many charging stations they can access - and even if they can access them, they may then be treated on different terms or not contribute the same value to a fully-fledged V2G system because their service provider or OEM is incompatible with the aggregator providing V2G functionality at the respective charging point. It is unclear what effect this has on the duplication of electric charging infrastructure or inefficiencies in V2G in general. Another component is the payment settlement process when charging, as the payment modalities may vary from one service provider to another. Regulation may consider making a minimum selection of commonly accepted payment options at charging points mandatory. There needs to be a focus on infrastructure investment next to ensuring interoperability across all stations. As laid out in Figure 0-4 **Error! Reference source not found.**above on the objective settings, e nsuring interoperability between charging stations has strong support across stakeholders with over 90% in favour.

In light of an efficient system integration of transport, it is equally important to ensure a level playing field for the supply side of electric mobility, including OEMs, aggregators and other related electric mobility service providers. This implies, next to ensuring that stationary and mobile (battery) devices are treated equally by network operators, also that e.g., vehicle data that is necessary for smart charging, such as battery state of health and state of charge information, are openly accessible to independent third-party aggregators and service providers. In this regard, there are several ways to implement V2G. Either through communication with the vehicle through the charger or through the backend of the automaker. However, to exchange some safety information that is not accessible through the backend of the automaker, a protocol for bidirectional power flows is pivotal. There is substantial value in adopting such a protocol (ISO 15118), and the international body of standardization is on its way to establishing the standard, with nearly all major manufacturers endorsing it. However, it is important to emphasize that OEMs should be disincentivized to see vehicle data and user data as a product that they can sell. This creates not only privacy concerns but hurdles on the way to openly accessible data necessary for system integration. Working towards wider adoption of V2G also means facilitating not only physical infrastructure but also the (digital) user experience through easy to understand user interfaces and accessible user experiences. This should translate into easy processes for charging in the form of standardized interfaces for all vehicles and charging points to ensure interoperability, user uptake, and economies of scale.

- ***B3: Certification of renewable and low carbon fuels***

Table 0-4 Options for B3: Certification of renewable and low carbon fuels

Options	Description
Option 0 (baseline)	Continue to apply the mass balance system to ensure compliance with the sustainability and greenhouse gas saving criteria, and to account renewable fuels towards the renewable energy targets, and maintain the current GO system for consumer information.
Option 1 (non-regulatory)	No non-regulatory option
Option 2	Develop the basis for a fully-fledged certification system for all RES and low carbon fuels by: • Extending the scope of the Union database to all gaseous and liquid fuels (used transport, H&C, and power sectors) as well as to feedstock with high fraud risk (e.g., UCO from the point of collection to the consumption of the biofuel). • Extending the scope of certification to low carbon fuels and waste heat. • Extending the scope of definitions of RES and low carbon fuels in RED II.
Option 3	Further develop and harmonise the GO system across the EU for electricity and gas (including H2) and H&C to include sustainability information on carbon footprint (production & use).
Option 4	Apply the Union database as main traceability tool for all energy carriers except RES electricity
Option 5	Apply the Union database as main traceability tool for all energy carriers including RES electricity.
Option 6	Apply the GO system as main traceability tool for renewable and low carbon gases and waste heat/cold. • Sub-option 6-1: Limit the use of the book and claim system to the transfer across the grid • Sub-option 6-2: Use of the book and claim system to determine the place of consumption of renewable gases
Option 7	Require electricity GOs issuing and cancellation to be “real-time” (hourly or quarter-hourly) • Sub-option 7-1: Only require close-to-real-time stamp for electricity GO issuing

B.3 - Option 0: Baseline

The mass balance system will be applied to ensure compliance with the sustainability and greenhouse gas saving criteria, and to account renewable fuels towards the renewable energy targets. The current GO system would be maintained solely for the purpose of consumer information, with no change to the design of the system.

The current RED II version already foresees the creation of the Union database for MB tracking system. Therefore, even in the Option 0, the MB system would be eventually centralized to a large extent. Nonetheless, the certification process is still separate from the Union Database. Certification is carried out by national (currently only in Austria) or voluntary schemes (currently 14 acknowledged by the Commission).

Next to the integration of certification system in the Union database mandated by the RED II, there are also some initiatives of the private sector to integrate markets in both BC and MB systems. The recent launch of the *CertifyHy* scheme for European trade of renewable and low carbon hydrogen GOs can serve as an example of the trends in the industry[62].

The figures provided by the Association of Issuing Bodies (AIB) in the 2019 annual report[63] illustrate that the volume of traded energy certificates (notably electricity) is also increasing. In this case, the volume of issued electricity GOs within the European Energy Certificate System increased by around 75% between 2015 and 2019, and the volume of cancelled GOs increased by 63%. There is no clear trend on the share of expired GOs. One reasons for GO expiring is probably the low price on the GOs, but could also be explained by that some buyers of GO just let them expire without actually cancelling them[64].

The price of GOs has now also slightly increased to 0.75-0.85 EUR/MWh in 2019[65], from a level around 0.15-0.30 EUR/MWh in 2017[66]. Even the 2019 price level, however, reaches only 2-3% of wholesale electricity market prices (if we assume the price fluctuates between 30-50 EUR/MWh).

B.3 - Option 1:

There is no non-regulatory option for this section.

B.3 - Option 2: Develop the basis for an EU-wide certification system for all RES and low carbon fuels

Extending the scope of definitions of RES and low carbon fuels in RED II

To equally cover all emerging alternative fuels, new definitions to all RES and low carbon fuels beyond the scope of RED II should be introduced. This would ensure fine-tuning and readjusting the scope of the legal basis in terms of energy carriers in line with the objective of decarbonisation (i.e., defining RFNBOs, adding definitions for low carbon hydrogen). Optimising the legal scope of RED II would allow to fully deploy the decarbonisation options of all energy carriers and this way enrich the opportunities MSs have to deploy the optimum energy mix to reach the decarbonisation objectives most cost-effectively. This would be achieved by:

- adding the required definitions under Article 2;

[62] CertifyHy. (2020). CertifHy enters into phase 3 to build a H2 GO market as well as a H2 certification scheme for RED II. Available at: https://www.certifhy.eu/9-uncategorised/176-certifhy-enters-into-phase-3-to-build-a-h2-go-market.html
[63] AIB. (2020): Annual report 2019. Page 5. Available at: https://www.aib-net.org/news-events/annual-reports?year=2020
[64] AIB has provided the information that: "some very large consumers want to cancel GOs in order to cover for their local consumption in a certain country, but are not allowed to do so directly due to national legislation. Therefore they purchase GOs for the amount of their consumption in that country and let those deliberately GOs expire on their accounts in that country."
[65] ECOHZ. (2019). The European market for renewable energy reaches new heights. Available at: https://www.ecohz.com/press-releases/the-european-market-for-renewable-energy-reaches-new-heights/
[66] Öko-Institut. (2017). Green public procurement of electricity: Results of study on possible GPP criteria for RES-E. Available at: https://ec.europa.eu/environment/gpp/pdf/2017-04-05_GPP%20Electricity.pdf

- adding the missing fuels and gases to the list of fuels under Annex III (ENERGY CONTENT OF FUELS).

Extending the scope of MB certification system to low carbon fuels and waste heat
To enable effective tracking of energy losses through value chain and proper disclosure of carbon footprint, the scope of the certification system should be extended to cover low carbon fuels and waste heat. This would be mainly achieved by:

- extending the list of fuels and gases under Annex V RED II (on the RULES FOR CALCULATING THE GREENHOUSE GAS IMPACT OF BIOFUELS, BIOLIQUIDS AND THEIR FOSSIL FUEL COMPARATORS);
- expanding the scope of sectors to H&C under Annex IX RED II (Part A. Feedstocks for the production of biogas for transport and advanced biofuels, the contribution of which towards the minimum shares referred to in the first and fourth subparagraphs of Article 25(1) may be considered to be twice their energy content);
- amending the list of fuels allowed for the purpose of calculation of minimum share in transport sector in Articles 25 and 27.

Extending the scope of the Union database
The scope of energy carriers covered by the MB system in the Union database would be extended from covering transport fuels to:

- All types of gaseous and liquid fuels used in transport, H&C and power sectors;
- The scope of the Union database would also be extended to be able to track waste heat and cold;
- The scope of covered supply chain would be extended to cover also feedstocks for energy carrier production that have high-fraud risk (UCO from the point of collection to the consumption of the biofuel).

A pre-condition for any amount of fuel to enter the Union database will be the existence of a sustainability certificate. Therefore, extending the Union database to all types of fuels in the above sectors will make sure that any RES fuels used in these sectors and counted towards the targets are covered by the certification system (national or voluntary schemes).

This would be done by adding those missing carriers under Article 29 (on Sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels), under Article 30 (on Verification of compliance with the sustainability and greenhouse gas emissions saving criteria), and moving the provisions on union database from Article 28 (which only concerns transport sector) to Article 30 (which describes the MB system).

Functioning of MB systems in networks
In order to enhance the functioning of the mass balance systems, physically interconnected gas and heat grids would be considered as a single logistical facility, similarly to the proposed ERGaR scheme[67]. Therefore, cross-border trade could be enabled without the need to book cross-border interconnection capacity. The main condition would be a proof that same volume of energy was injected before the energy carrier is taken out of the grid. The Article 30 states that the balance between injected and withdrawn consignments must be “achieved over an appropriate period of time”, which would translate

[67] ERGaR, The core principles of the ERGaR RED MB scheme. Available at: http://www.ergar.org/mass-balance/

in maximum time of 3 months between injection and outtake of the energy consignment from the grid. This would have impact especially on methane networks, as hydrogen grids currently exist mainly in separated local clusters and district heating systems exist only on a local scale due to high transmission losses. However, the hydrogen strategy foresees creation of an interconnected European hydrogen network by 2030.

The scope and purpose of BC system stays the same

The scope of current BC system would stay the same, e.g., covering electricity, gases (including hydrogen) and H&C. The existing GO schemes would remain in operation in parallel with the mass balance system and serve exclusively for the purpose of customer information. The only necessary change would be clarifying that GOs have to be cancelled when the related energy enters the Union database, and thus the MB system.

Clarifying the cancellation of GOs when the related energy enters the Union database

The requirement to cancel the GO when the related energy enters the Union database, and thus the MB system, should be codified in Article 19. In practice, this would also require an additional auditing step in the MB system to verify that the economic operators cancelled the concerned GO when entering the information in the Union database. It would, nonetheless, remain necessary to verify all necessary information (sustainability requirements, etc.) about the energy carrier for the MB system tracking, which is notably not fully possible from the current information included in the GO.

Table 0-5 Scope of the fuel tracking systems in Option 1

	Book & Claim (GO)	Mass Balance (certification for the Union DB)
Information to users (or any other use)	RES electricity; All types of renewable/low carbon gases, hydrogen; H&C	/
Accounting (traceability)	Cancelation of GOs issued in previous supply chain steps when they will be used for accounting	• Biofuels including all biogases (from all biological sources, incl. UCO); • Low carbon gases and liquid fuels; • Recycled carbon fuels (RCF); • RFNBOs; • Waste Heat

B.3 - Option 3: Further develop and harmonise the BC system across the EU for electricity and gas and H&C and to harmonise the GO content with MB system requirements

This option is based on measures developed under Option 2. In addition, the BC system would be further developed and harmonised across the EU MS to ensure better interconnectivity and facilitate development of GO markets.

Moreover, information content of GOs for electricity, gas (especially hydrogen) and H&C would be extended to include sustainability information on carbon footprint and previous steps of value chain. This would ensure that when an energy carrier enters the Union database, the information from the GO can be used instead of verifying previous value chain steps, as in Option 2. This is especially relevant for hydrogen, which can be directly used as a transport fuel.

Harmonisation of GOs with MB system

The information required by MB system and missing in the content of GOs is:

For electricity used in production of transport RFNBOs, it is necessary to prove that the directly connected renewable electricity sources (meaning also via grid) have been put into operation at the same time or later than the RFNBO production facility. Information on the start date of operation is included in the GO, so this would be possible. However, guarantees of origin as such do not have any provisions regarding the origin of renewable energy that would ensure its additionality.

GOs also only include information on the original source of renewable energy, not on its concrete carbon footprint. For example, in case of biomethane there is no indication of real emissions connected to the production pathway of the particular volume of biomethane. Therefore, it is only possible to rely on approximate benchmark values.

Therefore, the information content of GO would have to be amended to include:

- Real carbon footprint of the energy carrier; This information should be based on energy content of the carrier [gCO_2e/MWh][68], in order to ease the tracking of the energy content through various energy carrier conversions. An annex establishing the Calculation methodology would have to be set up, including benchmark base values. Annex V.C of RED II (RULES FOR CALCULATING THE GREENHOUSE GAS IMPACT OF BIOFUELS, BIOLIQUIDS AND THEIR FOSSIL FUEL COMPARATORS) would, together with delegated acts, serve as basic methodology;
- Information on previous steps of value chain – this could be done by copying the information, or providing a link to GOs issued in previous supply chain steps. However, the compatibility of existing GO systems is limited;
- Provisions on additionality of the produced energy.

Harmonisation of BC systems across MS

Beyond harmonisation of GOs with MB system, the harmonisation across different GO schemes could be also enhanced to facilitate the certificate market development. Within the FaStGO project, following measures were considered[69]:

- Harmonisation of residual mix calculation across MSs: currently the calculation is within the competence of MSs. This could be enhanced by introducing a unified calculation methodology (as the one proposed by AIB), or by introducing a single EU-level residual mix;
- Improved IT infrastructure for cross-border exchange of GOs;
- Further harmonisation (or centralisation) of GO scheme standards so the scrutiny of foreign GO systems is easier;
- Setting up forum of gas GO certification bodies (similar to AIB), that would facilitate discussions about system development and further harmonisation of practices across different GO schemes. Information exchange and discussions should also happen across schemes for different energy carriers, to move closer to a unified framework for all GO schemes;
- Simplifying the administrative steps for GO conversion in cases of energy carrier conversion.

Table 0-6 Scope of the fuel tracking systems in Option 3

	Book & Claim (GO)	Mass Balance (certification for the Union DB)
Information to users (or any other use)	• RES electricity; • All biogases; • Recycled carbon fuels (RCF); • Renewable and low carbon hydrogen	/

[68] Verwimp et al. (2020). Technical support for RES policy development and implementation. Establishing technical requirements & facilitating the standardisation process for guarantees of origin on the basis of Dir (EU) 2018/2001. Available at: https://www.aib-net.org/news-events/aib-projects-and-consultations/fastgo/project-deliverables
[69] AIB. (2020). FaStGO Task 1.3 Mapping GO system management challenges. Available at: https://www.aib-net.org/news-events/aib-projects-and-consultations/fastgo/project-deliverables

Accounting towards targets and supplier obligations	Cancelation of GOs issued in previous supply chain steps when they will be used for accounting	• Biofuels including all biogases (from all biological sources, incl. UCO); • Low carbon gases and liquid fuels; • Recycled carbon fuels (RCF); • Transport RFNBOs; • Waste Heat

B.3 - Option 4: Apply the Union database as main traceability tool for all energy carriers except RES electricity

This is an alternative to Option 3, where the Union database would be used as main traceability tool for all energy carriers except RES electricity. This would mean that for all other energy carriers (gas, hydrogen, and H&C) the existing GO schemes would have to be abolished or transformed into certification schemes in the MB system. This would streamline the whole energy carrier tracking system, as it would apply only one tracking method to each sector and the duality issues from the previous options would be removed. The only interaction between GO and MB system that would still need to be addressed is cancelling electricity GOs when they are used for RFNBOs production (or in any other intermediate value chain step tracked within the MB system).

Cancelling electricity GOs

The BC system will cover only the sector of RES electricity and will be used for consumer information only. Under this option, the existing BC schemes for renewable gases would have to be abolished/transformed into MB systems compatible with the Union database. In this option it would be still necessary to apply the policy measures from Option 2 that ensure cancellation of previously issued electricity GOs when the energy carrier enters the Union database. However, the necessary information required by MB system (carbon content, additionality) would not be transferred from the GO information, but rather verified by a relevant certification body in an additional certification step that would also verify that the previously issued GOs would be cancelled. However, this procedure would be probably required less administrative costs, as the value chain of renewable electricity is effectively limited to electricity networks.

Table 0-7 Scope of the fuel tracking systems in Option 4

	Book & Claim (GO)	Mass Balance (certification for the Union DB)
Information to users (or any other use)	RES electricity;	• All biogases; • Recycled carbon fuels (RCF); • Renewable and low carbon hydrogen
Accounting (traceability)	Cancelation of electricity GOs issued in previous supply chain steps when they will be used for accounting	• Biofuels including all biogases (from all biological sources, incl. UCO); • Low carbon gases and liquid fuels; • Recycled carbon fuels (RCF); • RFNBOs; • Waste Heat

B.3 - Option 5: Apply the Union database as main traceability tool for all energy carriers including RES electricity.

This Option would take further the Option 4 by applying the Union database would as main traceability tool for all energy carriers, including RES electricity. This would be achieved by adding electricity under Article 30 (on Verification of compliance with the sustainability and greenhouse gas emissions saving criteria) and changing the Article 19 to state that the information disclosed to the consumer should be based on the MB certification data, and that data from the Union database should be used by electricity suppliers to inform their customers about the electricity mix composition as mandated by Article 18(6) and Annex I of the Electricity Market Directive[70] (the Annex I itself would have to be changed to remove reference to GOs).

This option would lead to full coverage of the RES and low carbon fuels in the Union database, facilitating the traceability of sustainable fuels through the whole value chain.

The functionality of the Union database would have to be significantly enhanced from the currently proposed scope, to be able to account for and verify flows of energy in the electricity networks in a near to real-time timeframe (probably on quarter-hour or hourly basis, to reflect the energy the traded energy flows). The MB certification system on national level would still be needed to provide the reliable data inputs for the database, and MSs would still be responsible for verification of data correctness.

Table 0-8 Scope of the fuel tracking systems in Option 5

	Book & Claim (GO)	Mass Balance (certification for the Union DB)
Information to users (or any other use)	/	• RES electricity; • All biogases; • Recycled carbon fuels (RCF); • Renewable and low carbon hydrogen
Accounting (traceability)	/	• RES electricity; • Biofuels including all biogases (from all biological sources, incl. UCO); • Low carbon gases and liquid fuels; • Recycled carbon fuels (RCF); • RFNBOs; • Waste Heat

B.3 – Option 6: Apply the GO system as main traceability tool for renewable and low carbon gases and waste heat/cold transported via networks.

This is an alternative to Option 3. The sectoral scope of the BC system would remain the same as in RED II (electricity, gases including hydrogen, H&C) but for gases it would be broadened to include all types of gases and to include information on carbon footprint of the consignment.

Broadening the gas BC system to all types of gases

An obligation would be set to issue GOs for all renewable, low carbon, and non-renewable gases that are injected into the gas grid. This would require adapting Article 19(1) and impose issuing of GOs to all injected gases. In order to ensure the differentiation between different types of fuels and sustainability characteristics, this would require including the information on carbon footprint of GOs and harmonising the information included in gas GOs with the requirements of gas MB schemes, in the same way as in Option 3.

[70] European Commission. (2019). Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU. Available at: http://data.europa.eu/eli/dir/2019/944/oj

Disclosing the origin of gas and its carbon content to final customers

All suppliers of gas would be obligated to disclose to consumers in their bills the origin of supplied gas and its carbon content, the same way as it is currently working in the electricity sector. This would require amending the Gas Market Directive[71] by adding the requirement into the Article 3. Additionally the Article 19 (of RED II) would have to be amended to specify the process.

Applying BC system to all transfers of gas via networks

The application of mass balance system for renewable and low carbon gases would be limited to the point where they are injected into or extracted from the gas grid. This would require clarifying in Article 30 that mass balance system shall not be applied for tracking the energy carrier through gas networks. In other cases, where gases are not transported via networks, MB system would apply to the whole supply chain, including the cases of "last mile" supply chain, where the gas is extracted from the grid and transported to the point of final consumption by other means (e.g., transport in tracks to fuel stations).

A dedicated BC scheme would be established to handle these grid transfers. It would have to include an interface with the Union database to ensure that:

- GOs are issued and cancelled at the injection and extraction point;
- The information needed for further tracking of consignments within MB system is conserved. This could be done by linking the GO to the information on previous value chain stored in the Union database.

Using gas GOs for sectoral obligation accounting

After the injection of gas previously tracked in the Union database MB system to the gas grid and subsequent issuance of a GO, the final consumption of the renewable energy carrier could be proved in two ways. These constitute two sub-options:

Sub-option 6-1: Limit the use of the book and claim system to the transfer across the grid

In this option, the GO would have to be cancelled and the information on the energy consignment would have to be entered back to the union database. This would constitute an additional certification step.

Table 0-9 Scope of the fuel tracking systems in Option 6.1

Option 6.1	Book & Claim (GO)	Mass Balance (certification for the Union DB)
Information to users (or any other use)	• RES electricity; • All types of gases; • RFNBOs gases; • Waste heat and cold.	/
Accounting (traceability)	/	• Biofuels including all biogases (from all biological sources, incl. UCO); • Low-carbon gases and liquid fuels; • Recycled carbon fuels (RCF); • Transport RFNBOs; • Waste Heat • Fuels transported other way than via gas grids

[71] To mirror the Electricity market Directive.

Sub-option 6-2: Use of the book and claim system to determine the place of consumption of renewable gases

The alternative is enabling the economic operators to use GOs to demonstrate their compliance with sectoral obligations. However, the condition would be that the GO includes information on all steps of value chain, as required in the MB system. This would in practice mean that only GOs connected[72] to gases previously tracked via MB system would be eligible for the demonstration.

In cases where the final consumption of energy carriers would happen directly at the extraction point form the grid, this sub-option would decrease the administrative burden by removing the additional administrative step of cancelling the GO and entering the information back to the Union database.

This sub-option would require changing the Article 19 to clarify that GOs can be used for the purpose of sectoral obligation accounting, provided that they include additional information on previous value chain steps, as required by Article 30.

Table 0-10 Scope of the fuel tracking systems in Option 6.2

Option 6.2	Book & Claim (GO)	Mass Balance (certification for the Union DB)
Information to users (or any other use)	• RES electricity; • All types of gases; • RFNBOs gases; • Waste heat and cold.	/
Accounting (traceability)	• Biogases (from all biological sources, incl. UCO); • Low-carbon gas (RCF); • RFNBOs (based on RES electricity GO).	• Liquid fuels; • Other energy carriers transported other way than via gas grids

B.3 - Option 7: Require electricity GOs to be "real-time" (hourly or quarter-hourly)

This option includes the following elements:

1. Requiring through an amendment of Article 19 in RED II, that electricity GOs are issued with a close to "real-time" stamp (hourly or quarter-hourly, but exemptions may be applied for small scale installations below x kW);
2. Requiring through amendment of the Electricity Market Directive (done through the RED II amendment), that suppliers on an hourly or quarterly basis, match the energy they have sold to their consumers under renewable energy supply contracts with cancellation of the corresponding GOs for the same timeframe (e.g., hour, quarter hour). This matching shall take place within the existing disclosure period of Article 19 (4). As a variant, the existing disclosure period in Article 19 (4) may be shortened.
3. Requiring regulators to oversee the above.

[72] Connected by linking them to the information saved in the Union database, as suggested above.

Sub-option 7-1 Only require close-to-real-time stamp for electricity GO issuing

In this sub-option, only the first point from the list would be required. The producers issuing GOs would thus have to add a more detailed timestamp, but no system for matching GO issuance and cancelling would be developed or required.

- ***B4: Promotion of renewable and low carbon fuels across transport and H&C***

Table 0-11 Options for B4: Promotion of renewable and low carbon fuels across transport and H&C

Options	Description
Baseline scenario and non-regulatory measures	
Option 0	• No further actions / implementation of existing RED II measures and EU policies: RES fuels accounted for sectoral targets (except RFNBOs, only counted for transport), and recycled carbon fuels accounted for transport.
Option 1	• Promotion of renewable e-fuels and low carbon fuels with non-regulatory measures such as guidance and best-practice sharing, funding of R&D, targeted financial support for renewable and low carbon fuels as well as raising consumer awareness.
Extension of scope of accounting	
Option 2	Accounting of **RFNBOs** to comply with RED II targets and sectoral sub targets. • Sub-option 2.1: Start accounting RFNBOs beyond transport in heating and cooling and industry sector • Sub-option 2.2: Option 2.1 + Start accounting RFNBOs for the overall target for renewable energy in the MS where they are consumed (instead of the electricity they are produced from), and ensure the electricity for their production is deduced from the electricity consumption in the RFNBOs producing country.
Option 3	Option 2 + accounting of **low carbon fuels** to comply with sectoral targets (not counted for overall target).
Creation of specific sub-targets	
Option 4	Creation of sub-targets for RFNBOs in hard-to-decarbonise sectors such as maritime, aviation and industry
Option 5	Creation of combined targets for RFNBOs and low carbon fuels

B.4 - Option 0: Baseline scenario

The baseline option covers the implementation of existing measures in RED II and other EU policies.

As described in the problem definition, the definition of RFNBOs under RED II currently is limited to their application in transport. While the consumption of RFNBOs as transport fuel or intermediate product in the production of conventional fuels shall be taken into account when calculating the "minimum share" of renewable energy in transport (also referred to as RES-T) (Article 25(1)), there is no such provision for the accountability of RFNBOs in other sectors. The overall Union target in Article 3, however, does not consider the energy content of RFNBOs consumed. Instead, the renewable electricity required for their production is taken into account (see Art 7(4a)), neglecting conversion losses or intra-European energy trading.

With regard to low carbon fuels, RED II also allows that MS "*may take into account recycled carbon fuels*" when calculating RES-T (Art 25(1) third subparagraph). However, as stated in recital 89: "Since those fuels are not renewable, they should not be counted towards the overall Union target for energy from renewable sources". Besides that, RED II does not cover other low carbon fuels which are not produced from renewable sources as e.g., low carbon hydrogen and synthetic fuel production technologies like methane steam reforming including CCUS, pyrolysis, or electrolysis using non-renewable electricity.

RFNBOs in transport

RED II already defines specific criteria with regard of the required GHG emissions savings for RFNBO: according to Article 25(2), these "shall be at least 70% from 1 January 2021". With this, grid electricity-based RFNBO production with a high CO_2 footprint shall be prevented. However, additional demand for electricity may lead to some of the supply coming from fossil-based electricity or increase fossil or nuclear electricity in the conventional consumption sectors. Requirements as in Article 27 (3), subparagraph 7, are meant to resolve this and ensure that additional electricity demand from the transport sector does not lead to increasing emissions in the power sector. This required additionality of renewable electricity to be consumed in transport or to be used for hydrogen or other RFNBO production for transport use is so far unresolved. It is currently not defined by which rules producers of RFNBOs can provide evidence that they are using fully renewable electricity. Such provisions shall however be laid out in form of a delegated act to be adopted by the Commission by the end of 2021, according to Article 27 (3), subparagraph 7. RED II recital (90), emphasizes the importance of additionality, "meaning that the fuel producer is adding to the renewable deployment or to the financing of renewable energy". A study[73] commissioned by DG ENER is currently working on methodologies to resolve this issue.

While an additionality requirement is also described for renewable electricity in transport: "Options should be explored to ensure that the new demand for electricity in the transport sector is met with additional generation capacity of energy from renewable sources" (see recital (87)), RED II imposes additional requirements for RFNBO production. Following recital (90), an upcoming delegated act should describe a "*reliable Union methodology*" for the case that RFNBOs are produced with grid electricity, ensuring "*that there is a temporal and geographical correlation between the electricity production unit […] and the fuel production*". It can be argued that these provisions shall foster RFNBO production near renewable electricity production to minimize additional congestions in the electricity grid by transporting RFNBOs via pipeline or trailer to the end consumer. However, especially in the short-term, these requirements may significantly limit or restrict the number of possible locations for RFNBO production. This will prevent the ramp up of RFNBO production especially in areas where i) already high renewable electricity production capacities are installed (not additional) or ii) the regional RES potential is not sufficient or limited due to political reasons, but RFNBO production based on grid electricity would be unlikely to result in additional grid congestion or even support the electricity system (e.g., via storage and buffering services).

Transport-related provisions under RED II do also include fuel-specific sub-mandates for renewable fuels (i.e., for advanced biofuels produced from feedstocks listed in Annex IX part A) (Article 25(1) RED II) as well as caps for conventional biofuels (i.e., biofuels produced from food or feed crops) (Article 26(1) RED II). In addition, the contribution of biofuels produced from feedstocks listed in Annex IX part B are only considered up to a certain cap when calculating RES-T (Article 27(1b) RED II). Biofuels produced

[73] Guidehouse Energy Germany GmbH. (2020). Technical assistance to assess the potential of renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs) as well as recycled carbon fuels (RCFs), to establish a methodology to determine the share of renewable energy from RFNBOs as well as to develop a framework on additionality in the transport sector 1st interim report | Task 3 Develop a framework on additionality in the EU transport sector

from feedstocks listed in Annex IX can be considered with twice their energy content when calculation the “minimum share” in transport, based on Article 27(2). In addition, fuels supplied to the maritime and aviation sector can be counted with a factor of 1.2, in case they are not produced from food or feed crops (Article 27(2)).

This latter definition would also include the consumption of RFNBO in the maritime and aviation sector, while the consumption in other sectors, e.g., renewable hydrogen for heavy-duty vehicles or trains, or as intermediate product in the production of transport fuels, is not supported via a multiplier or sub mandate. The grouping of hydrogen and e-fuels under the definition of RFNBOs also neglects, that the consumption of hydrogen in a fuel cell has a significantly higher overall efficiency (more than twice) than applying hydrogen or e-fuels for combustion applications (e.g., ICE vehicles, turbines, H&C applications)[74].

Provisions for low carbon fuels

Non-renewable fuels are currently not within the scope of the Renewable Energy Directive. The only exceptions are recycled carbon fuels (RCFs) in the transport sector and waste heat and cold in the heating and cooling sector.

Following Article 25(1), MS may consider RCFs in the calculation of RES-T. Following the explanation in recital 89: “Since those fuels are not renewable, they should not be counted towards the overall Union target for energy from renewable sources”, they are, however, not part of the overall RES target in Article 3. In heating and cooling, MS “may count waste heat and cold, subject to a limit of 40% of the average annual increase”, when calculating the share of renewable energy in this sector (Article 23(2a)).

B.4 - Option 1: Non regulatory measures

Non-regulatory measures to promote renewable fuels (mainly RFNBOs) and low carbon fuels, include guidance and best-practice sharing, R&D funding programmes, targeted financial support (CAPEX and OPEX), as well as programs to increase consumer awareness.

Guidance and best-practice sharing are already an important part of FCH JU’s funding process, with the yearly ‘programme review days’ and ‘programme review reports’ providing information about finalised projects. In 2020, this format has been extended to a virtual hydrogen conference during the “Europe Hydrogen Week”, a platform for the presentation of the results of over 250 funded projects.

R&D funding programmes like the European ‘Horizon 2020’, remain an important pillar of strategic support for RFNBOs and low carbon fuels. Between 2013 and 2020, a total budget of €464 million has been provided for research activities for advanced biofuels and other renewable sources.[75] R&D programmes will especially be tailored to those technologies, whose competitiveness is not foreseen in the near future, although they will be an essential part of a greenhouse gas neutral energy system (i.e. RFNBOs, sustainable aviation fuels, low carbon industry processes like carbon-free steel production). Although the volume of R&D programs might decrease with the maturity level of technologies, the

[74] Please see Annex F (Transport), option 2, for a discussion of a more targeted support of hydrogen instead of all RFNBOs.

[75] European Union Aviation Safety Agency. (n.d.). Sustainable Aviation Fuels. Available at: https://www.easa.europa.eu/eaer/climate-change/sustainable-aviation-fuels

support of continuous technology development will remain a fundamental basis for Europe's future economic strength.

Possible measures for targeted financial support have already been outlined in the EC's Hydrogen Strategy: One of those are (national or EU-wide) carbon contracts for difference (CCfD), being an important element for investors in RFNBO or low carbon technologies. With these contracts, the difference between the actual CO_2 price and the necessary CO_2 price for low carbon technologies, competing with their conventional counterparts, would be covered. Especially in industry, such a CCfD-mechanism would enable companies to do future investments in low carbon technologies, despite of the higher current prices, reducing financial risk associated carbon price development. Whereas currently most financial supporting schemes focus on CAPEX support only, this CCFD system would allow creating sustainable business models for RFNBOs and low carbon fuels.

Another element to minimize the disadvantages of European companies arising from the high carbon reduction ambitions is the so-called Carbon Border Adjustment Mechanism (CBAM). Especially in industry, such a mechanism would ensure fair competition by placing a carbon prices on specific good from outside the EU (e.g., steel) (see also Section G – Industry). This would also increase the pressure on non-EU countries to implement stricter emission regulations, reducing the overall risk of carbon leakage into non-EU countries.

Consumer awareness of RFNBOs and low carbon fuels can help to overcome hurdles of a price premium for low carbon products. Transparent labelling and certification are essential elements in this regard, providing customers with all necessary information of the lower product emissions. With regard to the automotive sector, certification for 'green steel' can support the creation of a market for new hydrogen-based steel technologies. Similar developments could support the automotive or aviation industry (see also section B3 Certification).

B.4 – Option 2: Accounting of RFNBOs to comply with RED II targets and sub targets

Sub-option 2.1: Accounting RFNBOs beyond transport in heating and cooling and industry sector

By definition, RFNBOs are "transport fuels", as Article 2(36) refers to "*renewable liquid and gaseous transport fuels of non-biological origin*".[76] Therefore, following the wording, these fuels can only account for the renewable target in transport. However, especially renewable hydrogen and synthetic methane produced from it, may become an important energy carrier or feedstock in the heating and cooling as well as industry and other hard-to-decarbonise sectors, replacing fossil natural gas.

Hence, the definition of RFNBOs in Article 2(36) would be extended to enable their application in sectors other than transport, replacing Article 2(36) by "*'renewable liquid and gaseous fuels of non-biological origin' means liquid or gaseous fuels other than biofuels or biogas, the energy content of which is derived from renewable sources other than biomass*".

The existing sectoral sub-targets under RED II would need to be adapted. For heating and cooling, the target for renewable energy as defined in Article 7(3), would be extended accordingly, to account for the energy consumed in form of RFNBOs in the heating and cooling sector, inserting at the end of

[76] 'Renewable liquid and gaseous transport fuels of non-biological origin' means liquid or gaseous fuels which are used in the transport sector other than biofuels or biogas, the energy content of which is derived from renewable sources other than biomass.

subparagraph 1 of Article 7(3) "*including renewable liquid and gaseous fuels of non-biological origin*", as these RFNBOs are implicitly comprised under "other energy from renewable sources in industry, households, services, agriculture, forestry and fisheries, for heating, cooling and processing purposes".

However, in order **to avoid double counting** under renewable electricity target and heating and cooling target, specific adaptions in Article (7) are required. A possibility could be to mirror Art 7(4), by inserting a subparagraph between 3rd and 4th subparagraphs of Article 7(3), precising "*renewable liquid and gaseous fuels of non-biological origin that are produced from renewable electricity shall be considered to be part of the calculation pursuant to point (a) of the first subparagraph of paragraph 1 only when calculating the quantity of electricity produced in a Member State from renewable sources*". This would exclude RFNBOs to be accounted for the purpose of H&C if the renewable electricity is produced in the concerned MS.

It is therefore suggested to have a coordinated approach to account for the use of RFNBOs in the end-use sectors (transport & heating and cooling), under option 2.2.

Sub-option 2.2: Option 2.1 + Start accounting RFNBOs for the overall target for renewable energy in the MS where they are consumed (instead of the electricity they are produced from), and ensure the electricity for their production is deduced from the electricity consumption in the RFNBOs producing country.

The existing rules for accounting RFNBOs towards the Union target in Article 3 include some discrepancy with the overall approach within RED II. As defined in Article 7(4a), *"Final consumption of energy from renewable sources in the transport sector shall be calculated as the sum of all biofuels, biomass fuels and renewable liquid and gaseous transport fuels of non-biological origin consumed in the transport sector. However, renewable liquid and gaseous transport fuels of non-biological origin that are produced from renewable electricity shall be considered to be part of the calculation pursuant to point (a) of the first subparagraph of paragraph 1 only when calculating the quantity of electricity produced in a Member State from renewable sources."*

This means that the energy content of RFNBOs is not considered for the final consumption of energy from renewable sources in the transport sector in a MS (Article 7(1c)). Instead, the renewable electricity used for their production is taken into account only for the electricity sector (Article 7(1a)). In case of intra-European trading of RFNBOs, they will only be considered in the producing country (in terms of the renewable electricity required) instead of the importing country, where RFNBOs are consumed. This is in contrast to provisions under Article 27, since RFNBOs can be included in the numerator of the target for renewable energy in transport RES-T (Article 25(1)). As laid out by Guidehouse et al.[77], this creates a risk that the requirement of additionality for RFNBOs does not translate into additionality with regard to the target for renewable energy (so called "target additionality")." In other words, when renewable electricity for RFNBO production is fully accounted to the renewable targets, this reduces the otherwise required renewable electricity generation to a certain extent, although the energy is not usable for final consumption due to conversion losses.

[77] Guidehouse Energy Germany et al. (2020). Technical assistance to assess the potential of renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs) as well as recycled carbon fuels (RCFs), to establish a methodology to determine the share of renewable energy from RFNBOs as well as to develop a framework on additionality in the transport sector 2nd interim report | Task 2 Methodology to determine the share of renewable energy, Chapter on Target additionality.

This sub-option 2.2 therefore changes this methodology, by clearly defining that RFNBOs are to be accounted with the energy they carry towards a MS's final consumption of energy according to Article 7(1b) for heating and cooling (see also sub-option 2.1) or Article 7(1c) for transport. At the same time, it requires that the renewable electricity used for their production is excluded or deduced from the final consumption from renewable electricity (Article 7(1a)) when calculating the RES target, e.g., via revision of Article 7(4) cited above.

As discussed in the options for updating the certification system (B3), all RFNBOs used in transport would be covered by the mass-balance certification system under the Article 30, and the data would be centralised in a Union database according to Article 28. Therefore, the data necessary for calculation of the electricity consumption could be extracted from this source. This would also ensure coherence of the calculations across the MSs.

For the practical calculation of the share of renewable electricity used, RED II describes three pathways for RFNBO production (see Article 27(3) fourth to sixth subparagraph): i) applying the average national RES share two years before, ii) via a direct connection with a RES production facilities or iii) applying grid electricity with some other kind of demonstration, ensuring the renewable character of the electricity as well as other appropriate criteria and no double counting (details for case 3 to be laid out in a delegated act by the end of 2021).

GOs would be the easiest way to prove the renewable character of electricity by the cancellation of an adequate quantity of GOs. This would also allow for international trade of GOs, as MS "*shall recognise guarantees of origin issued by other MS in accordance with this Directive exclusively as evidence of the elements referred to in paragraph 1 and points (a) to (f) of the first subparagraph of paragraph 7*." Article 11 also extents that possibility to non-EU countries. The requirement to prevent double counting is also defined in Article 19(2): "*MS shall ensure that the same unit of energy from renewable sources is taken into account only once.*"

However, the main purpose of GOs is, according to Article 19, the disclosure of information about renewable origin of energy to final consumers. Therefore, the need to cancel the GOs when the related electricity is used to produce transport fuels tracked within the mass balance certification system needs to be specified in detail in the directive. Furthermore, an additional certification step that will verify the suitability of renewable electricity for RFNBO production (e.g., specific requirements on additionality) will be required. These measures are discussed in detail in options for certification system (B3).

The extension of the definition of RFNBOs to the heating and cooling sector (see sub-option 2.1) also transfers this problem for heating application. In any case, the implementation should be the same for both sectors. Following the provision in Article 7(3), all energy from renewable sources used in the different segments for heating and cooling application should be considered for the gross final consumption in H&C according to Article 7(1b). Electricity, e.g., for heat pumps, however, is not included in this list and is accounted towards gross final consumption of electricity according to Article 7(1a). Options to overcome this inconsistency are discussed in B2 – Option 3.

For the industry sector, a sectoral target does not yet exist in RED II, and would be introduced through this option as heating and cooling would only cover the industry (the building sector is excluded). The assessment of this option needs to include the interrelation of such an industry target with other policy instruments, most notably the EU Emissions Trading System (ETS). This is addressed under option 4.

B.4 – Option 3: Accounting of low carbon fuels to comply with sectoral targets

This option focusses on the effect on renewable and low carbon technologies, when specific provisions are included in RED II to allow for counting specific or all low carbon fuels towards the sectoral targets in heating and cooling but only for the industry (Article 23 addresses the whole H&C sector), and transport (Article 25). The general idea is to allow for low carbon fuels to be accounted towards sectoral targets in the same way as, RFNBOs are eligible (see B4 Option 2.2 above). Due to their non-renewable character, low carbon fuels, however, shall not be considered for calculation of the overall Union target (Article 3).

In general, different variants for such an approach are possible:

1. Whether to include low carbon fuels on a voluntary or mandatory approach. The voluntary option would follow the current provision for recycled carbon fuels (transport) or waste heat and cold (H&C), allowing MS to include low carbon fuels for the sector target calculations.
2. Whether to limit the accountability to specific fuels, based e.g., on their greenhouse gas emission saving. Respective rules should be formulated following the existing Article 25(2) second subparagraph, which requires the EC to adopt a delegated act "*in accordance with Article 35 to supplement this Directive by establishing appropriate minimum thresholds for greenhouse gas emissions savings of recycled carbon fuels through a life-cycle assessment that takes into account the specificities of each fuel*". Similar thresholds have already been implemented for biofuels (Article 29(10)) or RFNBOs (Article 25(2)) in transport. Another alternative could be to limit the admissible low carbon fuels based on other criteria like cost, technology readiness level, pollution or overall quantitative potential.
3. Whether to limit the target compliance of their consumption to specific sectors only (i.e. transport or industry H&C) or not.

B.4 – Option 4: Create sub-targets for RFNBOs in hard-to-decarbonise sectors such as maritime, aviation and industry

So far, RED II does not contain any targets on sector or sub-sector level for RFNBOs. However, comparable to the obligation on MSs to require fuel suppliers to ensure a minimum share of advanced biofuels and certain biogases, such a measure might "encourage continuous development" of the technology (see Recital 85). In contrast to the sub-target for advanced biofuels in the transport sector (Article 25(1) fourth subparagraph), a target designed specifically for certain sectors such as maritime, aviation, or industry, cannot just be incorporated into the methodology following the calculation methodology of RES-T in transport. The reason is that aviation and maritime sectors are not included in the calculation of the denominator of RES-T, meaning that only the renewable energy consumption in both sectors are considered, while the overall energy consumption is neglected. Instead, MSs should be obliged to set an appropriate obligation on the respective fuel suppliers in these sectors to ensure that such targets are met (see approach in Article 25(1) for transport). A respective approach is currently being discussed in Germany for the national implementation of RED II: supplier for aviation fuels shall be obligated to increase the share of RFNBOs to 0.5% in 2026, 1% in 2028, and 2% in 2030.[78]

[78] See Draft for BImSchG, §37(4a). German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (2021): Kabinettentwurf eines Gesetzes zur Weiterentwicklung der Treibhausgasminderungs-Quote. 29. January 2021. Available at: https://www.bmu.de/gesetz/kabinettentwurf-eines-gesetzes-zur-weiterentwicklung-der-treibhausgasminderungs-quote/

Industry to a relevant part is subject to the EU Emissions Trading System (ETS). For industry installations falling under the ETS, the use of hydrogen in industrial processes as energy carrier (or as feedstock) would be counted as low-carbon emission, independent of the emissions of the hydrogen production process. Instead, it would only depend on the hydrogen production process (renewable electricity or fossil-based with CCSU). On the other hand, large hydrogen production facilities would fall under the ETS depending on certain criteria such as capacity and GHG emissions. The GHG emissions related to the consumption of carbon-containing RFNBOs would, however, be fully counted towards the ETS. A target for RFNBO use in industry would provide an additional incentive notably for renewable hydrogen use in ETS industries and specific sectors. The combination of the two instruments could provide sufficient incentive to trigger market uptake, if the RFNBOs target is designed to fit for specific sectors where no other low-carbon alternatives would be available to decarbonise. For industrial processes having various solutions for their decarbonisation, such as electrification, biomethane, or other biomass-based energies, it would be restrictive to fix a specific RFNBOs targets where these alternative would also fit.

For non-ETS industry, less hard-to-decarbonise sectors, these alternatives are even more extended than for ETS industries, as they usually use lower temperature heat, which could be supplied with additional renewable sources and technologies (geothermal heat, heat pumps, soler heat, etc.). Therefore, such RFNBOs target for the non-ETS would force the use of these fuels although more efficient alternatives would be more relevant.

On the other hand, industry sectors in strong international competition may not be able to bear the additional costs, or pass them on to customers (carbon leakage). Industry sectors listed on the so-called “carbon leakage list“ receive free allocations of emission allowances. All other emission allowances have to be acquired in the auctions by the European Commission.

The ETS carbon leakage list for phase IV (2021-2030) includes, among others, the following sectors, which are generally understood to be “hard-to-decarbonise sectors”[79]:

- Manufacture of refined petroleum products (NACE code 1920);
- Manufacture of other organic basic chemicals (NACE code 2014);
- Manufacture of fertilisers and nitrogen compounds (NACE code 2015);
- Manufacture of basic iron and steel and of ferro-alloys (NACE code 2410).

For such sectors, economically speaking, receiving emission allowances for free, which they can sell on the market if they use hydrogen instead of fossil fuels, is equivalent to other industry sectors (not receiving free allowances), avoiding the purchase of allowances because of emissions reductions based on hydrogen use. However, for industries on the carbon leakage list, an obligation would still deteriorate their international competitiveness; here, other instruments such as a CBAM or public funding, e.g., through CCfD seem more appropriate, as additional costs would be supported by the public, or taxpayers, and not by the industry.

The assessment of these policy options has to focus on the design and the effect of such measures and their interactions are mainly outside the scope of RED II.

[79] European Commission. (2019). ANNEX to the Commission Delegated Decision supplementing Directive 2003/87/EC of the European Parliament and of the Council concerning the determination of sectors and subsectors deemed at risk of carbon leakage for the period 2021 to 2030. Brussels, 15 February 2019, C(2019) 930 final.

B.4 – Option 5: Creation of combined targets for RFNBOs and low carbon fuels

This option considers the possibility to create a combined target for RFNBOs and low carbon fuels under RED II, which are independent of the existing targets for renewable energy, i.e., the overall Union target in Article 3 and Article 7, and the provisions for the transport sector (Article 25). A sectoral target for industry would be newly introduced, as Article 23 addresses the whole H&C sector, including the building sector which should not be considered for RCF.

While purely renewable-based fuels like renewable electricity, biofuels or RFNBOs should remain the dominant element in RED II, creation of a combined target for RFNBOs and low carbon fuels independent of the existing targets for renewable energy could create some positive impacts on the overall renewable and low carbon fuel market, fostering investments in low carbon technologies and creating sector-specific and cost-efficient pathways towards climate neutrality in 2050. At the same time, such a policy needs to bear the necessary support for renewable energies in mind as well as the risk of stranded investments in non-renewable technologies. One important question relates to a possible accountability of hydrogen produced from grid electricity (i.e. not fulfilling criteria listed in recital 90, RED II), which could contribute to a rapid scale-up in installed electrolysis capacity in a transition phase until enough renewable electricity is available to meet the demand for low cost renewable hydrogen.

As discussed for Option 3, different variants for introducing a combined target for RFNBOs and low carbon fuels might include:

1. Having an indicative target, which supports MS in promoting specific low carbon fuels or their application in specific sectors. Alternatively, a mandatory obligation for low carbon fuels for all MS would create a pre-defined demand-pull for the respective technologies.
2. Limiting the support via RED II to specific low carbon fuels based on specific criteria, e.g., on their greenhouse gas emission saving. Such requirements could follow the existing approach implemented for biofuels (Article 29(10) or RFNBOs (Article 25(2)) in transport. Another alternative could be to limit the admissible low carbon fuels based on other criteria like cost, technology readiness level, pollution or overall potential.
3. Support the consumption of more competitive low carbon fuels (compared to RFNBOs) in specific sectors only, e.g., industry or maritime and aviation, which are very price sensitive due to a strong international competition, and would also be able to consider alternatives, or just because they would like to consider the valorisation of their own waste stream.

Possibilities of implementations are to create a target, requiring MS to implement measures which ensure that a certain percentage of the overall existing hydrogen consumption to be covered by RFNBOs or low carbon technologies or that a certain percentage of the Union's gross final consumption of energy is covered by low carbon fuels. This target has, however, to be additional and independent of the existing targets for renewable energies. In case of the increased ambition formulated in line with the Climate Target Plan, a combined target for RFNBOs and low carbon fuels could be added to an increased target for renewable energies, in order to achieve the required greenhouse gas emission savings in a more cost-efficient way.

Mapping of potential impacts

This section presents an overview of the potential economic, environmental and social impacts identified for the different policy options to be assessed, summarising the following criteria as follows:

- **Direction:** Positive or negative;
- **Magnitude:** limited or significant;
- **Horizon:** Short to long term;
- **Affected parties:** following categorization indicated below.

B1: Facilitate use of waste heat

Table 0-12 Option B1 impacts map

Option B1 – impacts map	economic	environmental	social
Option 0 (baseline)	D: positive M: limited H: long term A: still too many barriers to attract WH owners	D: positive M: very limited H: long term A: still too many barriers to attract WH owners & no environmental benefit	D: positive M: very limited H: long term A: still too many barriers to attract WH owners
Option 1 (non-regulatory)	D: positive M: medium H: long term A: waste heat owners (urban & industry), DHC operators, end consumers, local authorities	D: positive M: medium H: long term A: waste heat owners (urban & industry), DHC operators, local authorities	D: positive M: medium H: long term A: end consumers, local authorities
Option 2 (incl. obligation to count)	D: positive M: significant H: long term A: waste heat owners (urban & industry), DHC operators, end consumers, local authorities	D: positive M: significant H: long term A: waste heat owners (urban & industry), DHC operators, local authorities	D: positive M: significant H: long term A: end consumers, local authorities
Option 3	D: positive M: medium H: middle term A: waste heat owners (urban & industry), DHC operators	D: positive M: medium H: middle term A: waste heat owners (urban & industry), DHC operators	D: positive M: medium H: middle term A: local authorities

- *B2: Promote RES-based electrification by better integrating RES electricity in H&C and transport*

Table 0-13 Option B2 impacts map.

Option B 2 - impacts map	economic	environmental	social
Option 0 (baseline)	D: negative M: limited H: mid term A: all stakeholders	D: negative M: limited H: mid term A: all stakeholders	D: negative M: limited H: mid term A: all stakeholders
Option 1 (non-regulatory)	D: positive M: limited H: mid-term A: all stakeholders	D: positive M: limited H: mid-term A: all stakeholders	D: positive M: limited H: mid-term A: all stakeholders
Option 2	D: positive M: significant H: long-term A: Grid, H&C, Transport	D: positive M: significant H: long-term A: Grid, H&C, Transport	D: positive M: significant H: long-term A: Grid, H&C, Transport
Option 3.1	D: positive M: limited with a global RES target, significant with H&C target H: long-term A: HP manufacturing, building professionals and users	D: positive M: limited with a global RES target, significant with H&C target H: long-term A: HP manufacturing, building professionals and users	D: positive M: limited with a global RES target, significant with H&C target H: long-term A: HP manufacturing, building professionals and users
Option 3.2	D: positive M: limited H: long-term A: all fuel suppliers	D: positive M: limited H: long-term A: all fuel suppliers	D: negative M: limited H: long-term A: all fuel suppliers
Option 4	D: positive M: significant H: short-term A: CPOs, EV-Users, EMSPs	D: positive M: significant H: long-term A: transport	D: positive M: significant H: short-term A: EV-Users, Urban residents

▪ ***B3: Certification of renewable and low carbon fuels***

Table 0-14 Option B3 impacts map.

Option B 3 – impacts map	economic	environmental	social
Option 0 (baseline)	D: positive M: limited H: short term A: RFNBO and RCF supply chains; MB schemes	D: positive M: limited H: long term A: RFNBO and RCF producers	D: negative M: limited H: long term A: energy consumers; general public
Option 1 (non-regulatory)			
Option 2	D: positive M: significant H: short term A: sustainable gases supply chains	D: positive M: limited H: long term A: sustainable gases supply chains	D: positive M: limited H: short term A: energy consumers; general public
Option 3	D: positive M: significant H: short term A: sustainable gases and RFNBO supply chains	D: positive M: limited H: long term A: sustainable gases and RFNBO supply chains	D: positive M: limited H: short term A: energy consumers; general public
Option 4	D: negative M: limited H: short term A: sustainable gases and RFNBO supply chains	D: positive M: limited H: long term A: sustainable gases and RFNBO supply chains	D: positive M: limited H: short term A: energy consumers; general public
Option 5	D: negative M: significant H: short term A: sustainable gases, renewable electricity and RFNBO supply chains	D: positive M: limited H: long term A: sustainable gases and RFNBO supply chains	D: positive M: limited H: short term A: energy consumers; general public
Option 6.1	D: negative M: limited H: short term A: sustainable gases and RFNBO supply chains	D: positive M: limited H: long term A: sustainable gases and RFNBO supply chains	D: positive M: limited H: short term A: energy consumers; general public
Option 6.2	D: negative M: limited H: short term A: sustainable gases and RFNBO supply chains	D: negative M: limited H: short term A: sustainable gases and RFNBO supply chains	D: negative M: limited H: short term A: energy consumers; general public
Option 7	D: negative M: limited H: long term A: competent authorities, issuing bodies, regulators,	D: positive M: limited H: long term A: renewable electricity producers	D: negative M: limited H: long term A: electricity consumers

	electricity suppliers, electricity consumers		

- *B4: Promotion of renewable and low carbon fuels across transport and H&C*

Table 0-15 Option B4 impacts map.

Option B4 – impacts map	economic	environmental	social
Option 0 (baseline)	D: positive M: significant H: short and mid-term A: Fuel suppliers (transport)	D: positive M: limited H: short and mid-term A: Fuel suppliers (transport)	D: N/A M: N/A H: N/A A: N/A
Option 1 (non-regulatory)	D: positive M: significant H: short to mid-term A:Suppliers of RFNBOs and low carbon fuels	D: positive M: medium H: mid to long term A: transport and H&C sector	D: positive (RFNBO and low carbon fuel industry) M: medium H: short term A:Job creation along RFNBO and low carbon fuel supply chain
Option 2.1	D: Positive (RFNBO industry) M: limited H: time horizon of RES-H&C target A: industry, RFNBOs supply chains	D: positive (RFNBO industry) M: limited H: middle term A: H&C in industry	D: Positive (RFNBO industry) M: medium H: middle term A: Job creation along RFNBO supply chain
Option 2.2	D: positive M: increasing with share of RFNBOs H: mid to long-term A: RES electricity producers	D: positive M: increasing with share of RFNBOs H: mid to long-term A: National administrations	D: positive M: increasing with share of RFNBOs H: mid to long-term A: Job creation along RFNBO supply chain
Option 3	D: positive M: medium H: short to mid-term A: suppliers of low carbon fuels	D: Negative (risk to substitutes renewable fuels) M: medium H: short-term A: Industry (e.g., refineries), transport sector	D: Positive (job creation) M: limited H: short-term A: Fossil- and non-renewable sectors
Option 4	D: Negative (aviation, maritime, industry) M: Medium to significant (industry) H: Short term A: Domestic aviation, maritime and industry sector	D: positive M: increasing H: N/A A: Domestic aviation, maritime and industry sector	D: Positive (RFNBO industry) M: medium H: short term A: Job creation along RFNBO and LC fuels supply chains, distributional effects within EU

Option 5	D: positive M: Medium1 H: short to mid-term A: suppliers of low carbon fuels	D: Negative (risk to substitutes renewable fuels) M: medium H: short-term A: Industry, transport sector (e.g., refineries)	D: Positive (job creation) M: limited H: short-term A: Fossil- and non-renewable sectors

Option 0 (Baseline): The effect of the baseline option under RED II on renewable and low carbon fuels can be summarised as followed:

- Target achievement of overall target and sectoral targets
- Support for renewable fuels mainly limited to biofuels, e.g., multipliers for biofuels from feedstocks Annex IX, sub-mandate for advanced biofuels (Annex IX part A)
- No specific support for RFNBOs, except accountability towards RES targets (transport and overall).
- Low carbon fuels not supported via RED II, with exceptions for recycled carbon fuels (transport) or waste heat and cool (H&C)

Option 1 (Non-regulatory measures): Non-regulatory measures to promote renewable e-fuels and low carbon fuels would mainly focus on the ramp-up of the existing supply chain of renewable hydrogen and other RFNBOs, but also low carbon fuels. Especially targeted financial support (not limited to CAPEX support) is an important requirement for the implementation of several projects in the proposed project pipeline. CCfD as well as carbon border adjustment mechanisms would create a level-playing-field for renewable and low carbon fuels compared to their conventional alternatives. As long as there is no market for renewable e-fuels and low carbon fuels, i.e. as long as the respective technologies are not cost-competitive with reference technologies, financial support is required. Increasing technology deployment as well as a high carbon price under the EU ETS will increase their competitiveness in the future.

Option 2 (Accounting of RFNBOs to comply with RED II targets and sub targets): The effect of this option – independent from the sub-options – is an increased support for RFNBOs. However, the magnitude of the effect and the affected parties is different for the three sub-options:

- **Sub-option 1** allows RFNBOs to be accounted towards the renewable target in the heating and cooling sector, creating a slight demand pull for RFNBOs like hydrogen or synthetic methane for heating applications. Since the H&C sector faces a large challenge in decarbonising the natural gas supply for heat application, the admixture of hydrogen to the natural gas grid or the injection of synthetic methane is being discussed as a short-term emission reduction measure. In the long term, the repurposing of the natural gas grid into a dedicated hydrogen grid seems to be the preferred option of European Transmission System Operations (TSOs).
- **Sub-option 2.2** can mainly be considered as a purely administrative improvement, eliminating inconsistencies in the accounting of RFNBOs and the renewable electricity used to produce them. As a consequence, their energy content (based on its calorific value) will be accounted as energy consumed in H&C or transport, taking efficiency losses during the production process into account. At the same time, the renewable electricity used to produce RFNBOs which are imported will no longer also be accounted towards renewable electricity production of the exporting country. This will reduce its RES-E share, incentivising further supporting measures for RES electricity producers. On the contrary, RFNBOs will increase the RES share in transport

in the importing country, creating an incentive for additional supporting measures in that MS to create a market for hydrogen. This is also connected to distributional economic effects between both MS. To prevent double counting, renewable electricity consumption for the production of RFNBOs needs to be statistically subtracted from the gross final consumption of electricity from renewable sources in Article 7(1a). To do so, a mass balancing system (e.g., in form a Union database), as discussed in section B3 – certification, needs to be implemented.

Option 3 (Accounting of low carbon fuels to comply with sectoral targets): The option to allow (all or specific) low carbon fuels being considered when calculating the sectoral targets could, on the one hand, create a market demand for such fuels with the possibility to support specific low carbon fuels (e.g., hydrogen from grid electricity or SMR including CCS) over others. On the other hand, the impact of such measures by providing energy with low carbon fuels which otherwise would have been consumed as renewable fuels, i.e. substituting them, need to be prevented (e.g., via increasing the sectoral targets).

Low carbon fuels are an important alternative, especially in price-sensitive industry processes. In case, an appropriate greenhouse gas emissions savings threshold is implemented, low carbon fuels will therefore contribute to a short-term reduction in greenhouse gas emissions. They, however, do not enable carbon neutrality in the long term.

Option 4 (Creation of sub-targets for RFNBOs in hard-to-decarbonise sectors such as maritime, aviation and industry): In this option, sector-specific targets for RFNBOs in hard-to-decarbonise sectors such as maritime, aviation, and industry are introduced. This will create an early market for RFNBOs, increasing the technology ramp-up. At same time, it will impose additional cost on sectors, which face a strong international competition, which, at least in the short term, will not be balanced by savings from the EU ETS.

Option 5 (Creation of combined targets for RFNBOs and low carbon fuels)
In contrast to option 4, combined targets for RFNBOs and low carbon fuels which are independent of the sectoral or overall target for renewable energies would allow the promotion and ramp up of a hydrogen, RFNBO and low carbon fuel markets while keeping the risk low that RFNBOs and low carbon fuels compete with each other in the same markets. Since low carbon fuels are expected to have a cost advantage in the short term, the allocation of investments in the technologies could be driven by short term motives increasing the risk of stranded assets in the future. Low carbon fuels can – however – provide a cost-efficient way of decarbonisation in industry sectors which are in strong (international) competition, while the consumption of RFNBOs might focus on those sectors with strong renewable energy targets and/or RFNBOs sub-targets. The option would also allow adjusting the combined target on the one hand and the renewable targets on the other hand independently, such that market distortion or unwanted incentives are minimised.

Analysis

The assessment of impacts in this section and the next discuss each group of options separately.

Semi-quantitative and qualitative assessment

- ***Options for B1 to Facilitate the use of waste heat***

Economic impacts

EU guidance & best practices sharing are needed to support waste heat recovery, hence option 1 would be essential. It would represent a one shot cost at EU, and no additional cost for MS or economic actors involved. Option 2 would represent a slight additional cost for MS or economic actors involved to monitor new energy (and waste) streams.

Option 1 would provide technical, economical, but also institutional support, and would therefore ease the process of implementation, reducing the costs for national authorities responsible for the implantation of the provisions, and certainly accelerate the process at regional and local levels, and among economic actors. Option 2 would be an additional incentive for the uptake of waste H&C recovery.

Option 2 variant 1, with the obligation to count waste heat could, for very specific waste streams, become complicated and even not feasible. Therefore obliging to account waste H&C may lead to significantly increasing the cost.

Option 3 would significantly ease contractual arrangements, which are one of the main obstacles to the recovery of waste heat.

Even though the technology itself is not new the **maturity of the installations** is considered an important barrier. There are few proven installations to learn from and the maturity of the existing solutions varies. Stakeholders[80] consider the replicability is very important. Before the concepts have been proven replicable their spread will be limited. Guidelines and best practices would also facilitate the access to finance, and accelerate the spread of technical and economical knowledge.

The main challenge for waste heat recovery is to find a suitable location matching waste heat and demand. On the heat owner side, the gap of employees with the competency to understand the heat recovery process is also important. Urban and industry waste heat recovery investments are tailor made solutions making the replication of the cases difficult. Option 1, including best practices and training material, would support identifying all these barriers and risks.

Option 1 would reduce administrative costs for MS and local authorities, and option 3 for waste heat owners, DHC operators and local authorities. Option 2 would lead to increased administrative costs, due to an increased scope, and data to monitor (for official reporting under Article 7). Option 2 could also increase the risks of misinterpretation given the difficulty to precisely define waste H&C (many industrial cases are specific situations).

[80] The majority (63%) of stakeholders in the ReuseHeat. Tractebel Engineering. (2019). Market and stakeholder analysis (WP 2 - Task 2.1 - Deliverable 2.1). Available at: https://www.reuseheat.eu/wp-content/uploads/2019/03/D2.1-Market-and-stakeholder-analysis.pdf

The value of the heat recovered is a critical point to arrive at a business deal. The uncertain value is related to the lack of measurement & verification skills. A bad estimate of the resource is one of the main reasons for not implementing the project. Sharing best practices, foreseen in option 1, would support building success stories, and raise confidence, and skills to manage the risks. The guidance would also cover risk assessment and management. This is key to leverage the potential of waste H&C expected by RED II, even if not yet quantified. Urban and industrial waste heat recovery lowers energy, maintenance costs, improve the productivity of DH network, industrial processes, energy efficiency of equipment.

Option 2, through a clear definition & the inclusion in the target, would require precise measurement and verification capacities, and would therefore support fixing a value on waste H&C (and possibly deploy a market, with indicators), accelerating the economic interest and uptake of waste H&C recovery.

Purchase agreements guideline under option 3 would be supportive to identify risks, and manage them accordingly (e.g., it is difficult to make a contract with the waste heat owner if the demand is not secured - a “chicken or egg problem”).[81] This could be tackled in such agreement by setting the framework and contractual conditions to help manage the risk.

DHC operators would be positively affected by option 1 (support to value waste H&C, contracts), by option 2 (references and facilitation to value waste H&C), and option 3 (support manage all risks). Policy makers would be positively affected by option 1 (dissemination, and guidance to identify/address regulatory barriers (e.g., taxes)), by option 2 (ease monitoring and planning), and option 3 (guidance to address regulatory barriers).

Investors would be positively affected by option 1 (support to advocate for regulatory changes (at national level)), by option 2 (references and facilitation to value waste H&C), and option 3 (support manage all risks).

Customers would be positively affected by option 1 (limited knowledge (not directly concerned)), by option 2 (limited knowledge (not directly concerned)), and option 3 (support manage all risks).
urban and industrial waste heat owners would be positively affected by option 1 (increase skills and understanding), by option 2 (increase understanding, support planning), and option 3 (support manage all risks, particularly for those owners that have no knowledge about the recovery of their waste H&C (e.g., urban)).

There is no legal framework in place to manage urban waste heat sources/ make efficient contracts. Option 1 guidance would also address this for national authorities.
From an economic point of view, the feasibility of waste heat recovery is related to the level of taxation, the cost of producing energy, as well as the price at which this recovered energy will be sold. An investor is ensured if there is a long-term contract, moral engagement of both parties (energy generator and final consumer). Again, guidance would provide support, while additional instruments may be needed (risk management), but at national level.

[81] Dr.-Ing. Ralf-Roman Schmidt, Ing. Roman Geyer MSC, and Pauline Lucas (2020): Discussion Paper: The barriers to waste heat recovery and how to overcome them? Austrian Institute of Technology (AIT) & Euroheat & Power. Available at: https://ec.europa.eu/futurium/en/system/files/ged/20200625_discussion_paper_v2_final.pdf

Efficient district heating and cooling systems (4th Generation District Heating, 4GDH) allow the use of significant amounts of waste heat. New business models and regulations need to be developed to encourage the use of unavoidable waste heat. 4GDH as a technical concept focuses on lowering district heating temperatures to increase efficiency and the use of low-temperature sources. However, in doing this, the concept challenges conventional energy system regulation and will, in some regards, constitute a paradigmatic change towards an energy system which is more integrated in both technical and regulatory terms.[82]

Option 2 would support to objectivise the advocacy to adapt instruments (and possibly barriers) according to the needs, such as energy taxation, or even support schemes where relevant. Option 2 would support to contractual arrangements & risk management (better view on the recovery potential), technical support to recover different temperature levels according to well defined definition and rules.

Option 2, by obliging to account for waste H&C, would harmonise the scope at EU, and make it comparable between MS.

Option 1, 2 & 3 would positively affect the resilience of the energy system (more integration & exchanges), increases energy independence, while it could possibly create long term contractual links and interdependences between waste heat owners (which depend on long term needs to value waste and recover the investment) and final users (which depend on the supply), which is hampering flexibility and deep industrial changes.

Environmental impacts

The proxy used to measure the potential environmental impact is directly linked to the H&C fuels it would replace, which is not yet quantified (based on potential assessment).

Significant amounts of excess heat are available throughout Europe, and brings direct energy savings. According to the analysis of the research paper Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country (Elsevier, 2018)[83], the estimation of the total waste heat potential in EU is about 300 TWh/year.[84] In France only, the Multi Annual Energy Plan[85] is based on estimating the potential of industrial waste heat at more than 30°C to be 109TWh (Ademe). However, a very limited portion is recoverable (based on spatial potential assessment). In the past, excess heat has been politically neglected. Excess heat recovery from various industrial processes, power production and commercial facilities is key to an efficient and resilient H&C

[82] Mathiesen, B. V., et al. (2019). Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy. Aalborg University. Available at: https://www.euroheat.org/wp-content/uploads/2019/12/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

[83] Papapetrou, M., et al. (2018). Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country. Applied Thermal Engineering, Volume 138, 25 June 2018, Pages 207-216. Available at: https://doi.org/10.1016/j.applthermaleng.2018.04.043

[84] One third corresponding to temperature level below 200 °C, which is often referred to as low-temperature waste heat, another 25% in the range 200–500 °C and the rest above 500 °C (mostly in the range 500–1000 °C). More than 55% of this potential comes from the iron and steel sector, and about 25% from the non-metallic minerals (cement and lime) as second sector.

[85] Ministère de la Transition Écologique et Solidarité (n.s.). (2020). French Strategy for Energy and Climate: Multiannual Energy Plan 2019-2023, 2024-2028. Available at: https://www.ecologie.gouv.fr/sites/default/files/0-PPE%20English%20Version%20With%20Annex_0.pdf

sector, and has the potential to support local industries, economies and employment. These sources could potentially cover at least 25% of the district heat production (in a scenario with a minimum share of DHC above 40% to cover heating demand).[86]
However, new business models and regulation needs to be developed to encourage the use of unavoidable waste heat while at the same time not encouraging business and industries to increase their excess heat production because it becomes profitable (4GDH allows to avoid this).

Option 1 would guide the identification of waste heat recoverable, and recommend to strictly limit the use of unavoidable waste heat.

Option 2 with a clear definition would also support raising awareness among waste H&C owners, given the significant amounts of excess heat throughout Europe. Recovery directly leads to energy savings. Option 2, by including waste H&C in the official accounting of renewable H&C, may encourage MSs (or any responsible party, public authority or private organisation) make excess heat profitable, leading to distort the concept of unavoidable waste H&C. The definition should be very clear setting the boundaries.

The term "unavoidable" is difficult to define since it could relate to technical or economic feasibility. It could also pose difficulties looking into the medium- and long-term future of the waste heat owner, i.e., future technologies might change the process and what was unavoidable to the current state-of-the-art might be avoidable with new technologies (e.g., upcoming of high temperature heat pumps). [87]
The uptake of waste H&C should avoid hampering these decarbonisation options (which could have a longer payback time than profitable waste H&C valorisation).

From a high-level and policy-making perspective, such as for decarbonisation strategies on a national or local level, the identification of waste heat sources can be a challenge. Data may not be available, especially for unconventional waste heat sources and smaller industries.[88] To overcome the challenge, the starting point is to have a clear definition, which requires appropriate monitoring, covered under option 2.

Urban and industrial waste heat recovery minimise emissions of air pollutants and also improve the productivity of industrial processes, and energy efficiency of equipment.

Recovering heat often has positive effects on the cooling system. The more heat is recovered and reused, the less it needs to be cooled off after the process steps. Hence, recovering waste heat may lead to decrease water cooling needs (e.g., industrial processes using river water).

[86] Heat Roadmap Europe 4. (2019). The Legacy of Heat Roadmap Europe 4: Scenarios, recommendations and resources for decarbonising the heating & cooling sector in Europe and complementing strategic long-term vision of the EU. Available at https://heatroadmap.eu/wp-content/uploads/2019/02/HRE_Final-Brochure_web.pdf
[87] Dr.-Ing. Ralf-Roman Schmidt, Ing. Roman Geyer MSC, and Pauline Lucas. (2020). Discussion Paper: The barriers to waste heat recovery and how to overcome them? Austrian Institute of Technology (AIT) & Euroheat & Power. Available at: https://ec.europa.eu/futurium/en/system/files/ged/20200625_discussion_paper_v2_final.pdf
[88] Ibid.

Social impacts

Option 1 would positively affect the level of education and training outcomes, and the number of jobs (e.g., in waste heat owners). Option 2 would positively affect the uptake of waste H&C recovery and would increase the level of education and training outcomes, and the number of jobs (e.g., in waste heat owners). Option 3 would positively affect the level of education and training among the owners with limited energy expertise and owning waste H&C (mainly urban and small industry owners, as it is assumed major industrial players have the required energy knowledge to handle all contractual issues). This will provide risk management guidance to tackle contracts.

Option 1 would positively affect the countries with heavy industry located in the vicinity of heat consumption areas (for short distance DHC), or with large urban waste potential. It could possibly negatively affect countries with limited industries and/or with industries located far from consumption areas[89]. Option 2 would positively affect the countries with heavy industry located in the vicinity of heat consumption areas (for short distance DHC), or with large urban waste unconventional potential (e.g., data centres, tunnels and metro stations, cooling from buildings (e.g., offices, hospitals, supermarkets, shopping malls)), waste heat from power-to-gas processes, from sewage channels (from households and some industries like food processing) and wastewater treatment plants). It could possibly negatively affect countries with limited industries and/or with industries located far from consumption areas. Option 3, through purchase agreements, would support tackling all players concerns (including vulnerable households), and manage all risks on equitable distributional rules.

Table 0-16 Overall impacts of B1.

	Overall impact		
	Economic	Social	Environmental
Facilitate the use of waste heat			
Option 0 -	0	0	0
Option 1 - guidance & best practices	++	++	++
Option 2 - clarify definition in accounting framework	++	++	++
Option 2.1 - obligation to count	0	0	0
Option 3 - purchase agreements	+	+	0

- ### *Options for B2 to Promote RES-based electrification*

The different options to be analysed under B2 differ in their scope to such an extent that they are analysed separately and independently from one another.

B.2 - Option 1: Non-regulatory measures

Non-regulatory measures can have important impacts, which, generally speaking, will be limited and most probably not achieve the increased ambition level for 2030. As such, they should be considered as a complement to the other policy options described below, but would not be sufficient to achieve the new 2030 target.

The impacts of non-regulatory measures related to transport overlap to some extent with what is discussed in Annex F-Transport.

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[89] But those may have other options to value their waste heat, by sharing directly with neighbourhood industries (industrial symbiosis). Such waste heat recovery is accounted under EED (not RED).

The impacts of non-regulatory measures related to Heating and Cooling overlap with discussions in Annex D-Heating and Cooling, Annex E-Buildings, and Annex G-Industry.

General non-regulatory measures related to overall Renewable Electricity are discussed under Annex C-Renewable Electricity.

B2 – Option 2

Option 2 assesses the contribution of demand-response measures (or dedicated RES-based signals to consumers) to enhance the integration of renewable electricity. It should be considered in a broader context for the promotion of RES-E use in transport, heating and cooling, charging of home battery storage, as well as other electricity end consumers featuring demand side flexibility.

Both the electricity price and RES-E share information are available in nearly real time in the electricity market system as auctions are cleared every 30 minutes and TSOs dispose of this data. By addition in RED II (possibly Article 20: Access to and operation of the grids), TSOs and DSOs make available information on the RES-share and GHG emission profile of the electricity supplied by the grid in a near-real-time manner, aligned with the clearance time intervals of the wholesale market. This information is available digitally in an interoperable manner which can be utilised by suppliers, consumers and end-users, as well as network related devices such as smart meters, electric vehicle charging stations and energy management systems.

Building' Energy Management Systems and Smart Charging infrastructure for EVs could be configured in a way that they do not only take into account the hourly power market price signal, but also information on the RES-E share. Shifting power demand into hours with high RES-E share would thus favour the use of renewable electricity. This is important for incentivising the absorption of RES generation in real-time.

EV-Charging

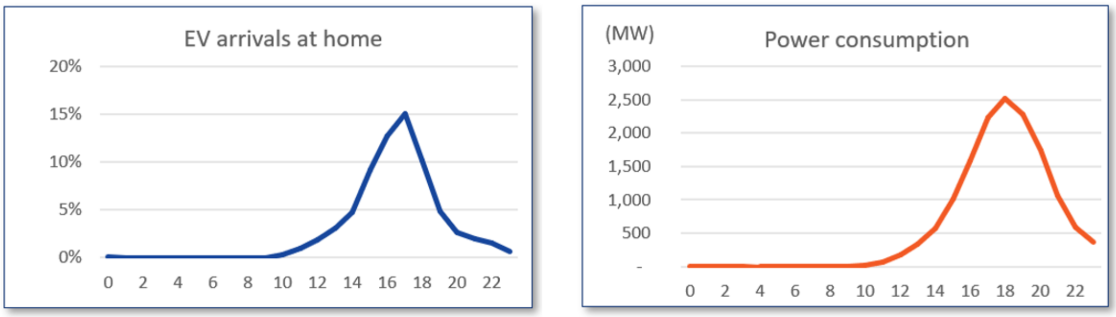
The modelling of electric vehicles in METIS focusses on private electric road passenger cars. Four types of electric vehicle assets are distinguished, representing battery as well as plug-in hybrid electric vehicles that may be charged at home or at work. Each electric vehicle asset represents the national fleet of vehicles of the respective category. Two different charging behaviours are considered for electric vehicles:

1. Immediate charging implies that vehicles are charged immediately after their arrival at the charging infrastructure (which may be at home or at work).
2. Optimised charging enables that the scheduling of the EV charging is jointly optimised with the overall power system dispatch. That is, EV charging reacts to the endogenously determined market price and contributes to the actual price setting. Upon selection, the optimised charging may include grid-reinjection into the grid, in the following referred to as vehicle-to-grid (V2G) behaviour.

Immediate charging

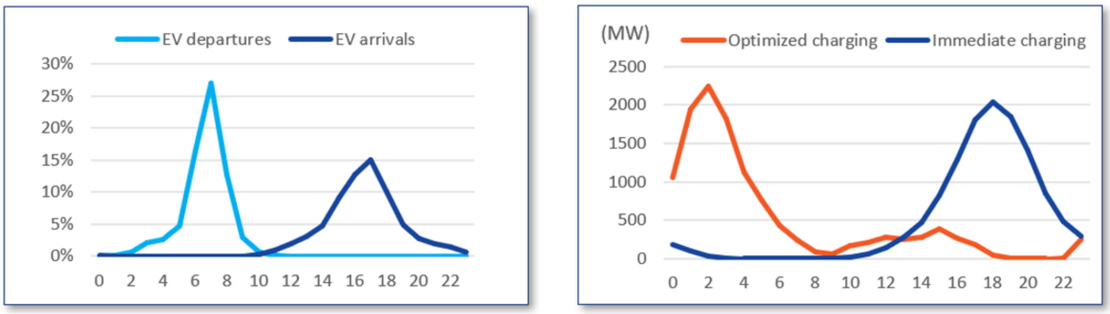
The electricity load profile related to immediate EV charging is primarily driven by the overall vehicle stock (total number of EV), the arrival timeseries (percentage of EV arriving at terminal, which states which share of the vehicle stock arrives at the charging infrastructure at every hour of the year), the average charging capacity (in kW/EV) and the mean charging duration (in h/cycle). Figure 3 illustrates how EV arrivals translate into a load curve.

Figure 0-11 Translation of EV arrivals (at home) into power consumption (Source: METIS Technical Note 8)



In the scenarios delivered with the METIS demand module, data on vehicle stock and overall annual EV demand builds upon the EC scenario data. This results in a mean daily electricity demand per vehicle (*Average journey discharge*). It is assumed that compared to weekdays, during weekend days only two-thirds of all vehicles are circulating. The charging duration depends on the assumed charging capacity. For the charging capacity, a conservative estimate of less than 4 kW was made, avoiding additional system stress for distribution grid infrastructure and assuming that charging may take place via (potentially reinforced) household connections. Based on the previous assumptions, the arrival time series may be translated into hourly national EV load profiles.

Figure 0-12 Schematic representation of optimal vs immediate charging (right) considering the arrival and departure time series (left) (Source: METIS Technical Note 8)



Optimised charging

Optimised charging is subject to a number of constraints. Upon arrival at the charging infrastructure, each vehicle is discharged by a constant level of energy, the average journey discharge. Each vehicle must be totally charged before leaving the charging infrastructure. Vehicle charging may not exceed the charging capacity of the individual vehicle. This implies that the charging moment of a vehicle may be freely scheduled between the moment of arrival and the moment of departure. Figure 0-12 illustrates that the electric load from optimal charging may differ substantially from immediate charging.

In addition, EVs may optionally reinject electricity into the grid. In this case the EV batteries may be used as storage facility for the power system. The V2G utilisation is constrained by the average discharging capacity (which is supposed to equal the charging capacity), the maximum discharging level (limited to the level of the average journey discharge, meaning that the batterie charging level should never be below the level at the return of EVs to the charging infrastructure), the EV discharging efficiency (reflecting conversion losses, in the present case 90% based on (Artelys, 2018)) and costs related to V2G (which may also reflect costs related to accelerated battery ageing).

H&C

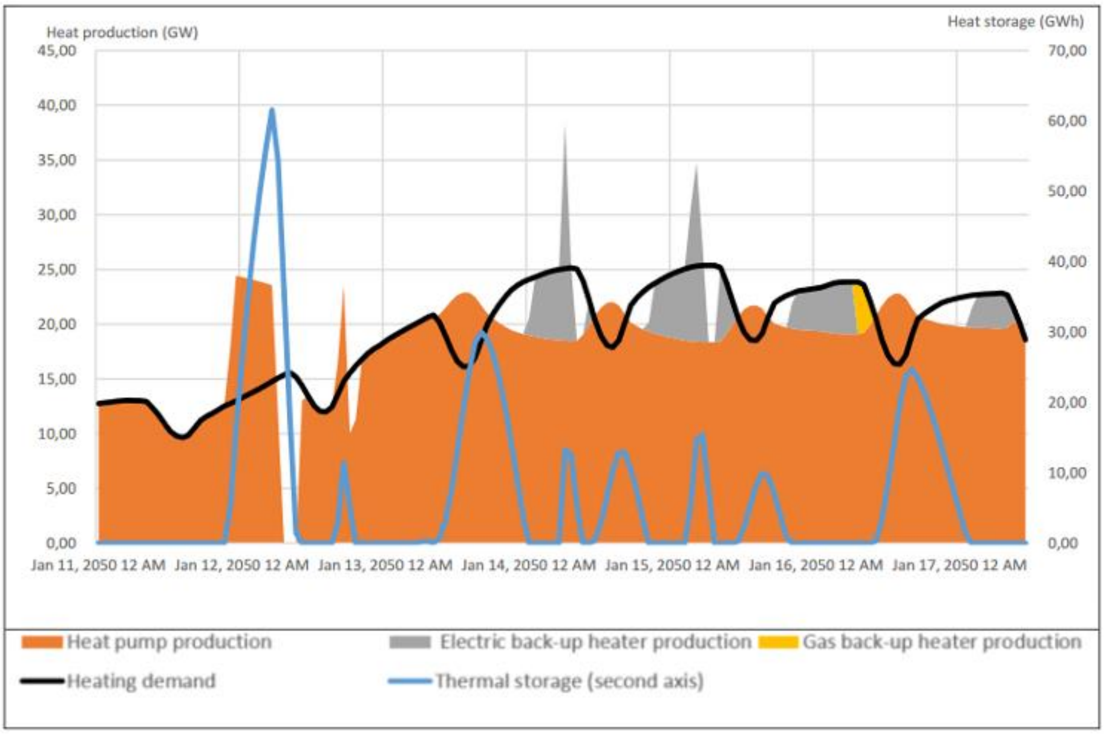
The power demand for residential heat pumps is modelled as being flexible. In addition to a 2-hour heat storage, heat pumps are equipped with backup boilers able to supply peak heat demand. The first option allows for the provision of daily flexibility by shifting the electric load to hours with less stress on the power system (e.g., larger local vRES generation or available imports). The second option enables heat pumps to mitigate peak power demand that occurs when low air temperature impairs the heat pump's coefficient of performance (which may go below 1) and output capacity while exacerbating electricity demand.

A water tank is often used as a buffer between the output of the heat pump and the household's central heating system, in order to provide a more reliable heat and to smooth the heat pump operation. Combined with smart meters and time-varying electricity prices, a storage device can provide flexibility with respect to the operation of the heat pump which allows consuming electricity in advance (and at lower prices), store the heat and then release it when required.

In METIS, the storage of the heat pump asset is dimensioned with the objective to store the equivalent of two hours of heat production at full capacity. In normal operation mode, the thermal storage temperature is rather constant over time, but the temperature slightly changes depending on the ambient temperature. In order to store energy, a signal is sent to increase the working temperature of this storage. During this time when the storage temperature is above normal, thermal losses increase. In the METIS tool, these losses are represented with a loss rate per hour, of 6%/hour. The heat loss is expressed as a percentage of the stored thermal energy.

As covering heat demand peaks exclusively with heat pumps would imply a costly over-dimensioning of the equipment and higher investments costs, low CAPEX back-up heaters are installed (covering 5% of demand). In the following model runs, an electric backup heater is considered.

Figure 0-13 Typical heat pump operation in winter



Modelling Results and Assessment

System Integration Impacts

The following results are extracted from the different model runs based on the MIX55 scenario. All results are displayed for the EU27 scope. When not specified, the high-DR-V2G_vRES-share results are provided for the medium demand case.

Flexible operation of EVs and heat pumps

In solar countries especially, in order to achieve a cost-efficient integration of renewables, consumers provide flexibility by adjusting their EV or heat pump withdrawal schemes to hours of large renewable generation within the day. Figure 0-14 displays the average generation profile in a country with high PV shares. In particular in summer, electricity generation is significantly higher in day-time than during the night due to large PV generation.

Figure 0-14 Average daily generation profile in a country with high PV shares, in summer

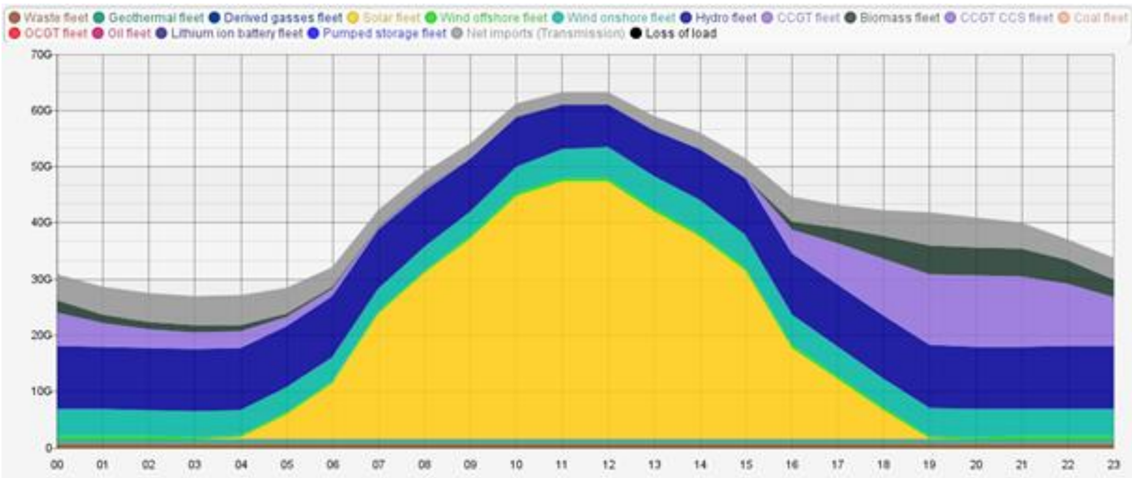
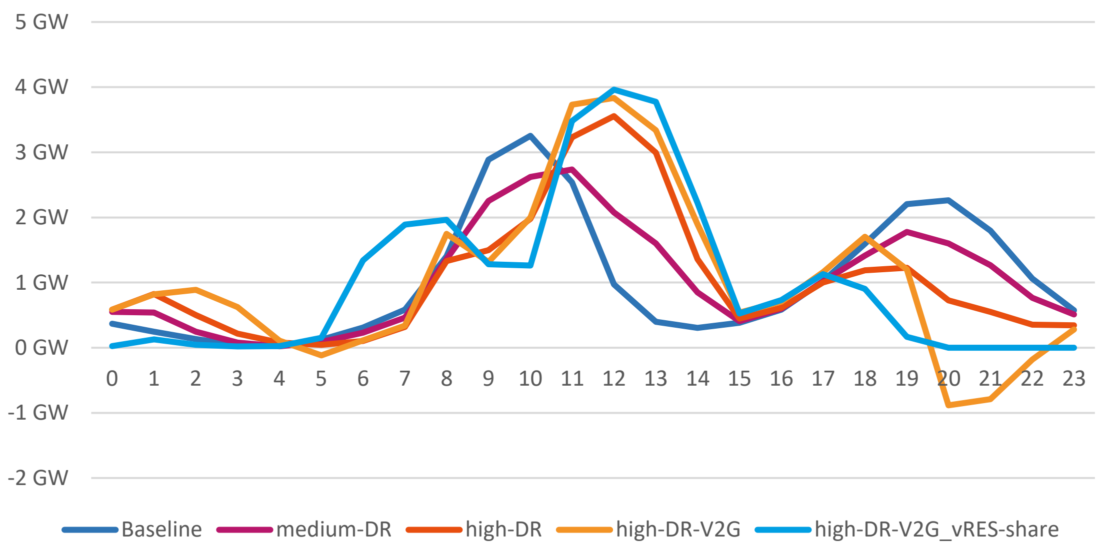


Figure 0-15 displays average EV daily consumption patterns for the different model runs. It is recalled that in the Baseline no flexible demand is considered, meaning that the consumption pattern reflects a static charging strategy, i.e. EVs charge when they connect to the charging point. Under this strategy, EVs plugged-at-work do not match the PV peak generation and charge slightly earlier. Charging-at-home EVs peaks at 7pm, when they return from work.

Increasing the flexibility share in the high-DR model run enables EVs to shift their consumption pattern to match PV peak generation. EVs featuring V2G are able to integrate further PV generation at mid-day, and return electricity to the grid at night when flexibility needs are stronger due to low renewable generation.

Eventually, EVs exposed to GO prices feature slightly different consumption patterns, as they tend to favour the early morning (in comparison with the other strategies) when the renewable share in power demand is high (as power demand remains low in this period of the day), at the expense of night-charging when both demand and renewable generation are low. This strategy helps to integrate further renewables into the system; however, it can come at a higher cost as electricity generation is often cheap during the night due to available nuclear and lignite power generation.

Figure 0-15 Average Daily EV consumption profile in a country where heat pumps do not operate in summer, for different DR strategies. Country with high PV shares, summer



It should be noted that the strategy is significantly different in winter, as PV generation remains low and is never marginal on electricity markets. Therefore, consumption patterns of high-DR and high-DR-V2G remain rather flat, with only a slide decrease in the early evening to cope with peak demand. The GO price-based consumption strategy favours further mid-day consumption, increasing the risk to rely on expensive gas-based marginal generation, as Figure 0-16Figure 0-14 displays some OCGT generation at mid-day.

Figure 0-16 Average daily generation profile in a country with high PV shares, in winter

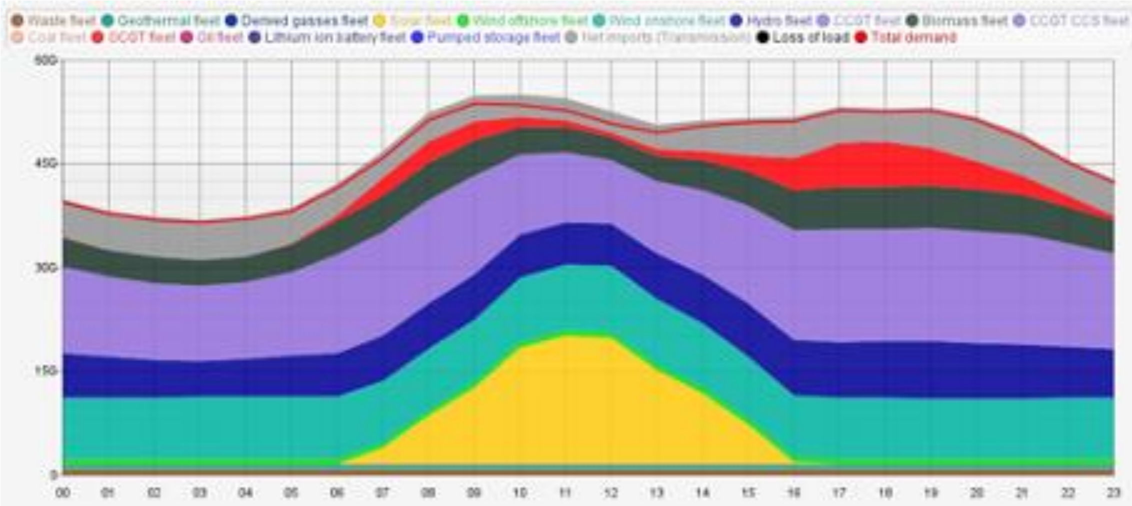
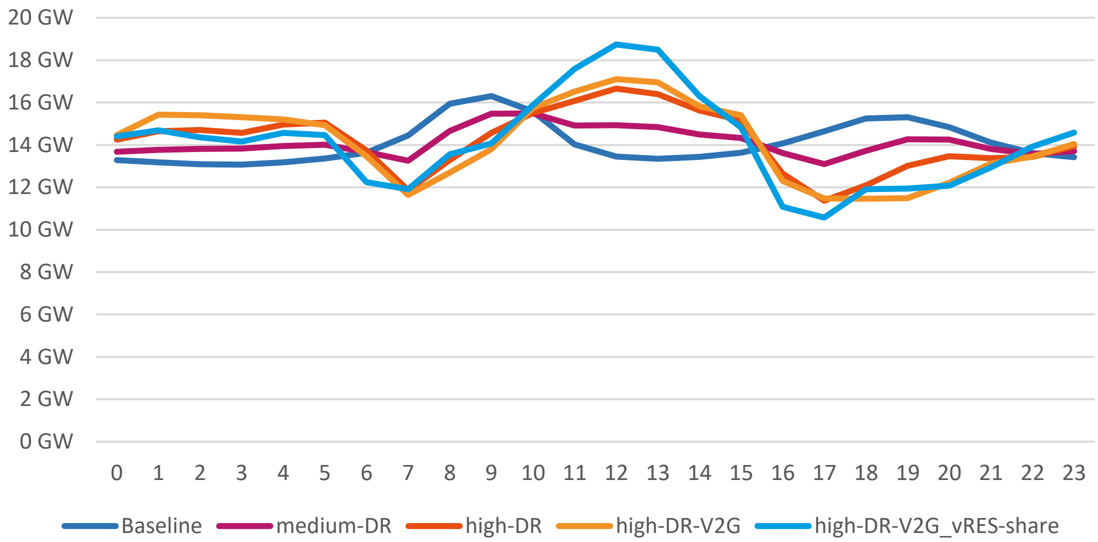
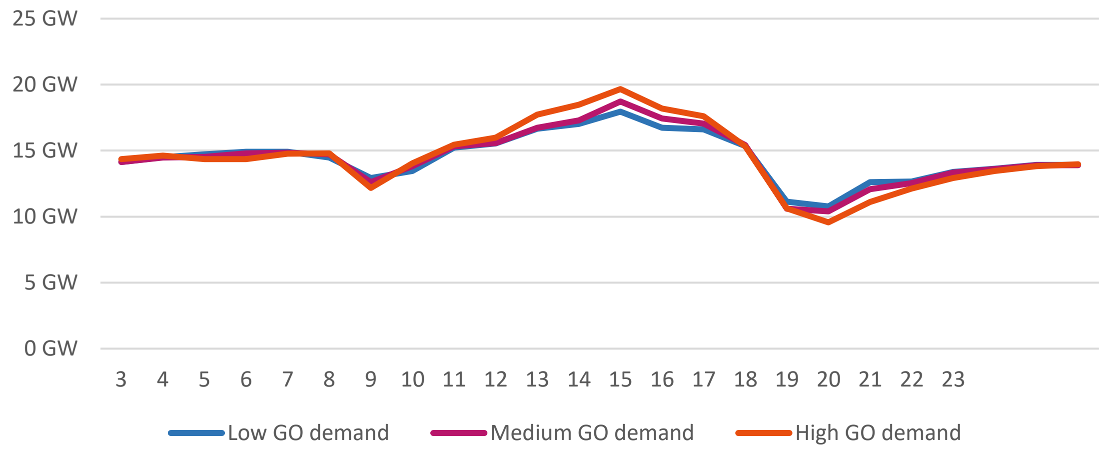


Figure 0-17 Average cumulative EV and heat pump daily consumption profile, for different DR strategies. Country with high PV shares, winter.



In order to capture the impact of the GO pricing strategy (used in the high-DR-V2G_vRES-share model run), three sensitivity analyses have been included in the assessment, corresponding to low, medium, and high GO demand levels, which were translated into different scarcity levels and GO prices. The optimised consumption patterns of EVs and heat pumps based on these pricing strategies are displayed in Figure 0-18. The pricing strategy only marginally affects the consumption pattern, by exacerbating the tendency to consume electricity when renewable generation is at its highest. The largest deviation on the average profile, between the low and high demand scenarios, is of 15% at mid-day.

Figure 0-18 Average EVs and heat pumps daily consumption profiles, for different GO pricing strategies

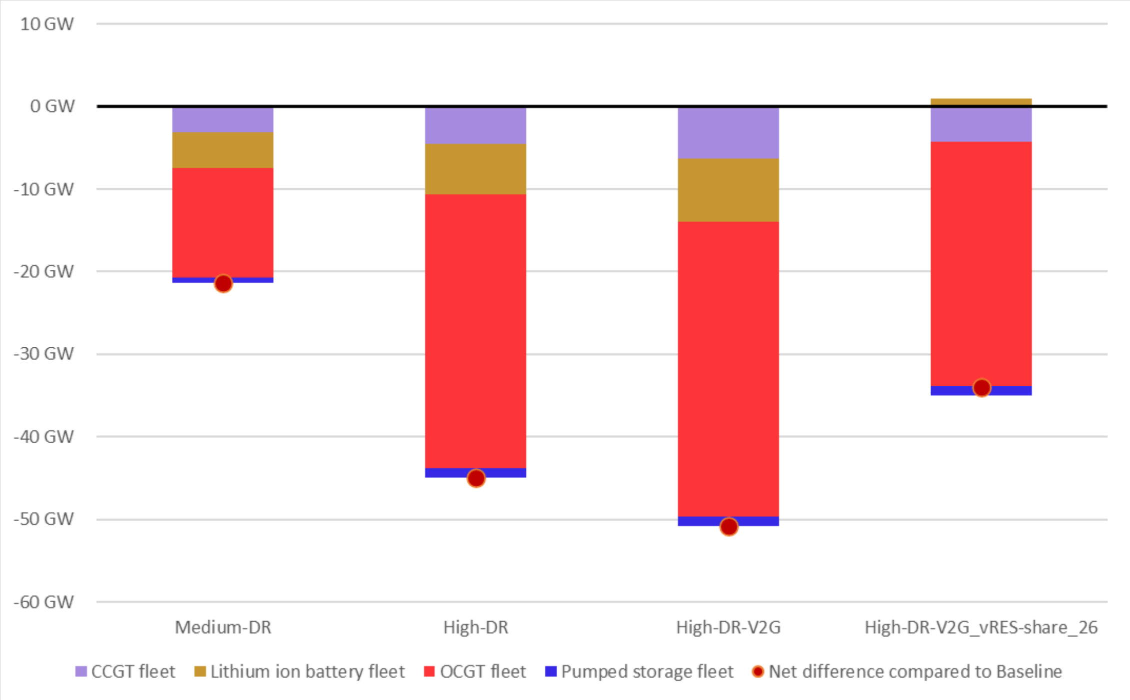


Electricity generation capacity mix

The increase in the demand side-related flexibility potential across the different scenarios (higher flexible share of demand for EVs and heat pumps, and V2G capabilities) allows a re-optimisation of the electricity generation capacity mix, as demand-response makes the system less reliant on expensive peak generation and on storage technologies. Therefore, the system reduces its investments in OCGTs (used for peak generation) by 33 GW or 30% in the high-DR model run and 36 GW or 33% in the high-DR-V2G model run. Investments in CCGTs decline by some 4 to 6 GW (-4% to -6%). Battery capacities are reduced from 8 GW in the Baseline to 2 GW in the high-DR model run (-73%). They become nearly completely dispensable in the high-DR+V2G run, dropping down to 0.8 GW (-90%).

These reduced investments in the flexible technology portfolio demonstrate the benefits of demand-response strategies with respect to integration costs in a system with significant renewable shares.
A DR strategy combining a market price and a vRES signal also allows for a reduction in flexible capacity investments, especially for peak generation with OCGTs (-27%) compared to the Baseline. Yet, compared to the case of high-DR+V2G, this effect is dampened when introducing a RES share-based signal as part of demand is shifted into hours with high RES shares but also high demand levels, thus requiring additional peak generation. Finally, this strategy requires more investments in batteries compared to the Baseline (+ 1 GW or 12%) to cope with sub-optimal consumption patterns when low-cost electricity from nuclear is available but not consumed as demand is shifted away.

Figure 0-19 Electricity generation capacities, compared to Baseline



Curtailment

The four DR strategies do not display large variations in terms of renewables curtailment. Indeed, two effects are balanced there:

- Additional flexibility potentials help to integrate further renewable generation and reduce curtailment
- Additional flexibility potentials allow for a reduction in flexible generation investments, potentially increasing curtailment if these capacities (e.g., batteries) were initially used to shift excess renewable generation.

Overall, the combination of these two effects does not affect significantly curtailment over the EU27.

Table 0-17 Renewable curtailment across the four scenarios

Baseline	Medium-DR	High-DR	High-DR-V2G	High-DR-V2G_vRES-share
11.2 TWh	10.6 TWh	10.2 TWh	10.7 TWh	10.4 TWh

Electricity production mix

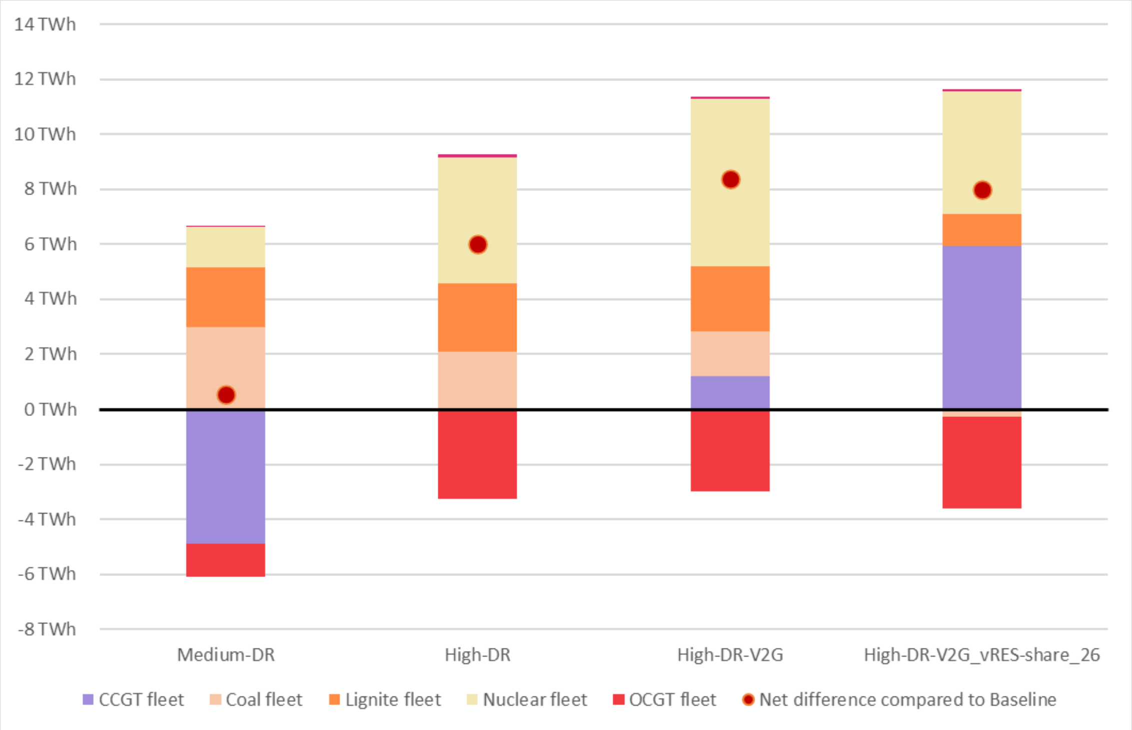
As for the electricity generation capacity mix, the increase in flexibility due to high DR (+V2G) comes with a reduced use of expensive peak capacity generation: electricity production from OCGTs decreases by 3 TWh (-1%). At the same time, the utilisation of power generation capacities featuring lower marginal generation costs (notably nuclear and lignite and to a limited extent coal[90]) is increased.

In addition, shifting electricity consumption of heat pumps requires the use of the thermal storage, which implies an increase in energy losses. Similarly, using the EV battery for V2G services implies some efficiency losses over the storage cycle. Overall, this implies a net increase of the system electricity consumption by 6 to 8 TWh in the high-DR scenario without and with V2G. This increase in electricity consumption (which is less than 1% of total annual electricity demand) is likewise met by further consumption of nuclear energy when it is possible, and increased use of CCGT otherwise.

The high-DR-V2G_vRES-share model run exhibits somehow a different behaviour. As detailed above, flexible consumers under the hourly GO price signal tend to shift their consumption from night to day-time, when RES shares are high due to important PV in-feed. This shift in the consumption pattern reduces the operation of marginal technologies at night and increases the operation of marginal technologies at day, thereby reinforcing the effects observed under the high-DR(+V2G) runs. Under the 2030 MIX55 scenario's CO_2 price, lignite generation is often marginal at night and CCGTs are marginal during the day. Consequently, the hourly GO pricing strategy implies a reduction in lignite-based power production by about 7%, a reduction in coal-based power generation by 5% (compared to the high-DR+V2G scenario) and an increase in the operation of CCGTs by 1%.

[90] Power generation from lignite and coal slightly increases in the DR price-based scenarios compared to the baseline, as it features a rather low production cost due to moderate ambition in terms of CO_2 prices (see design of the MIX55 scenario).

Figure 0-20 Electricity production mix, compared to Baseline



Economic Impacts

Overall system costs

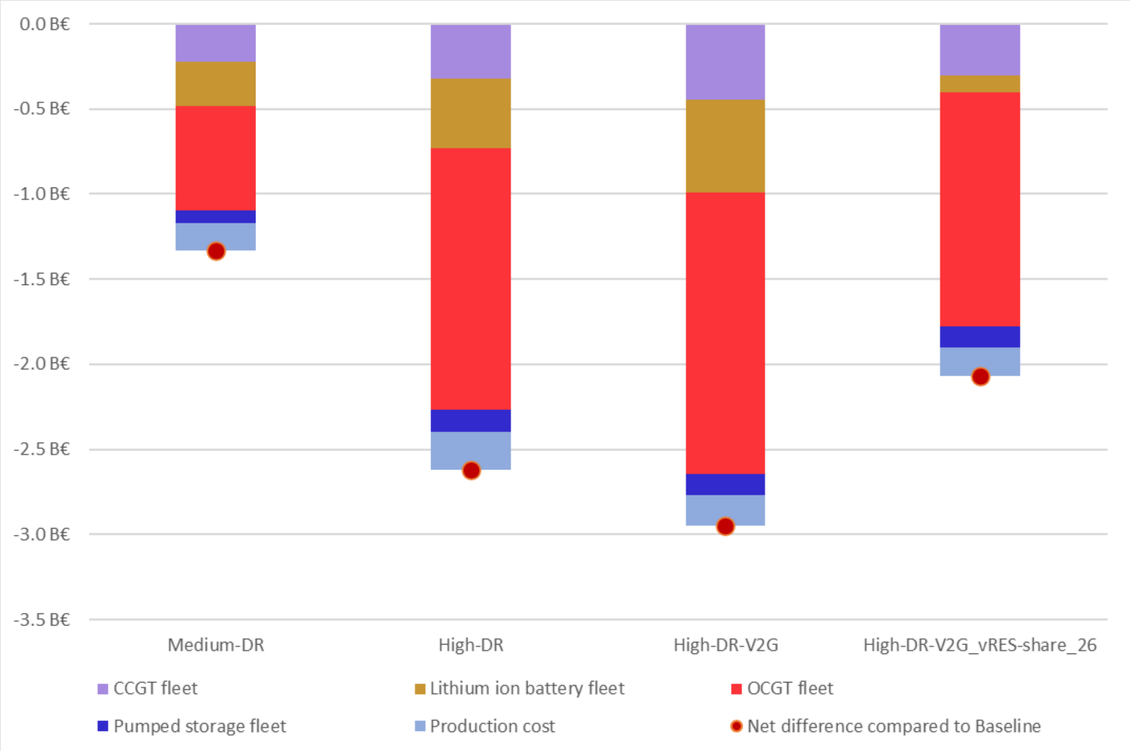
System costs are integrating both, investment costs and (variable[91]) production costs. Overall, all DR strategies decrease the annual system costs compared to the baseline, between 1.3 B€ for the medium-DR strategy to 2.9 B€ for the high-DR-V2G strategy. System costs reduction are mostly driven by reduced investments in peak generation (OCGTs) and other flexible technologies (CCGTs and batteries).

As detailed in the previous sections, production costs do not vary significantly as CO_2 emissions and fossil fuel consumption remain rather steady across the scenarios.

A mixed signal strategy combining the electricity price and hourly GOs enables shifting electricity consumption to hours featuring higher renewable generation, which slightly limits the curtailment and decreases lignite and coal consumption, along with CO_2 emissions. This is reflected in additional savings of production costs (which still remain below 1% compared to the baseline). However, it requires additional peak generation and storage capacities (compared to the high DR model run) in order to meet the increased power demand in hours with high RES-E shares and thus comes at a higher cost. In comparison to the Baseline, this means that net savings of 2.1 B€ (compared to the baseline) are lower than the savings of the High-DR-V2G run as the benefits from DR are partially offset through a less economic functioning of the power system.[92]

[91] The GO price only determines the consumption patterns of heat pumps and EVs and is not accounted for in the variable costs. Any upfront costs for the deployment of DR (such as smart metering and control infrastructure) is excluded from these cost assessments, which focus exclusively on the power-setor related costs.
[92] If the costs related to GOs would be factored in for all scenarios (i.e. incorporating explicitly the instant value of the green attribute of electricity and its restricted availability), cost savings would be highest under the scenario considering the RES share signal, i.e. High-DR-V2G_vRES-share.

Figure 0-21 Total system costs compared to Baseline



Additional vRES investments

Considering that these annual savings of 1.3 to 2.9 B€ would become available for RES investments, they could trigger additional investments between 14 and 32 GW considering the 2030 distribution across the three vRES technologies. This additional capacity would generate between 33 and 74 TWh of additional renewable electricity.

Table 0-18 Additional vRES investments triggered by the different DR strategies

		PV	Onshore wind	Offshore wind	Weighted
	Capacity 2030 (W)	384	349	77	
	Average cap. factor (%)	13%	26%	38%	21%
Medium DR	Add. investments (GW)	24	12	6	14
	Add. generation (TWh)	34	35	28	33
High-DR	Add. investments (GW)	47	24	13	28
	Add. generation (TWh)	67	70	55	66
High-DR-V2G	Add. investments (GW)	52	27	14	32
	Add. generation (TWh)	75	78	62	74
High-DR-V2G_vRES-share	Add. investments (GW)	37	19	10	22
	Add. generation (TWh)	53	55	43	52

The direct impact of the GO-based price signal on renewable investments is difficult to assess. It may be expected that GO prices would be relatively low during hours with high renewable power generation shares. Hence, they may only represent a relevant additional revenue source for renewable investors 1) if there is sufficient demand side flexibility that may shift electricity demand into hours with abundant renewable power generation or 2) if they feature an anticyclical power generation profile (e.g., PV system with east-west orientation) or are equipped with some storage system. However, deriving robust and meaningful conclusions would require a dedicated capacity optimisation with METIS which was out of scope of the present analysis.

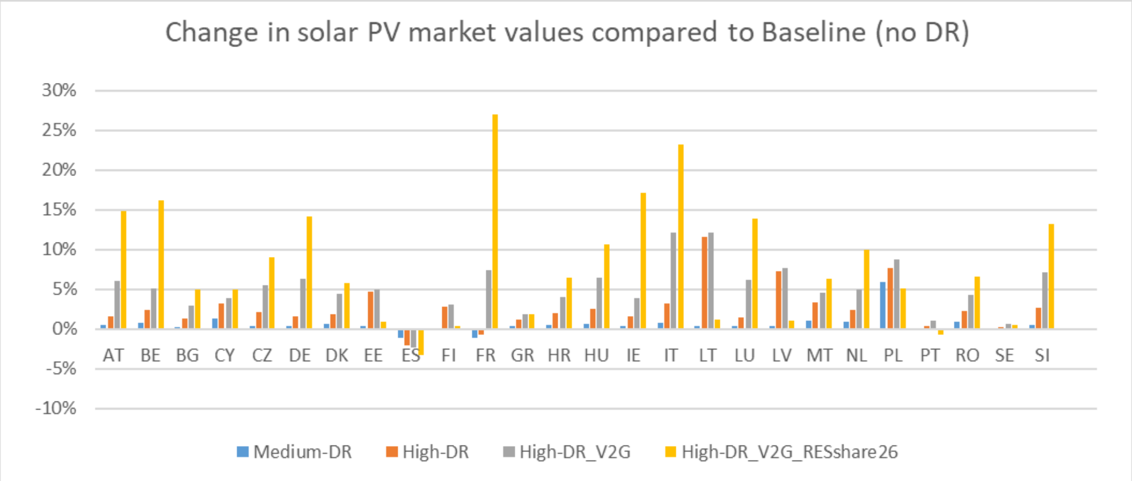
Economic impact on individual RES-E sectors

Incentivizing DR via a RES share-based price signal has not necessarily a direct impact on the integration of renewables (considering constant RES capacities). It may trigger emission reductions if power demand is shifted from hours relying notably on carbon-intensive baseload capacities towards hours with higher RES shares and a lower marginal emission factor. In addition, such a signal may reduce curtailment. However, both effects are not guaranteed and depend on the individual country's supply mix and the level of RES-E penetration.

Yet, a major benefit may be observed with respect to RES-E remuneration and investment signals for new RES-E investments: shifting demand into hours with high RES shares is likely to increase the market value of renewable generators, thereby amplifying revenue streams and reducing the need for public support. In the present analysis this can in particular be shown for solar PV, where market values increase by 8% on average and more than 20% in selected countries (e.g., Italy or France), cf. Figure 0-22.

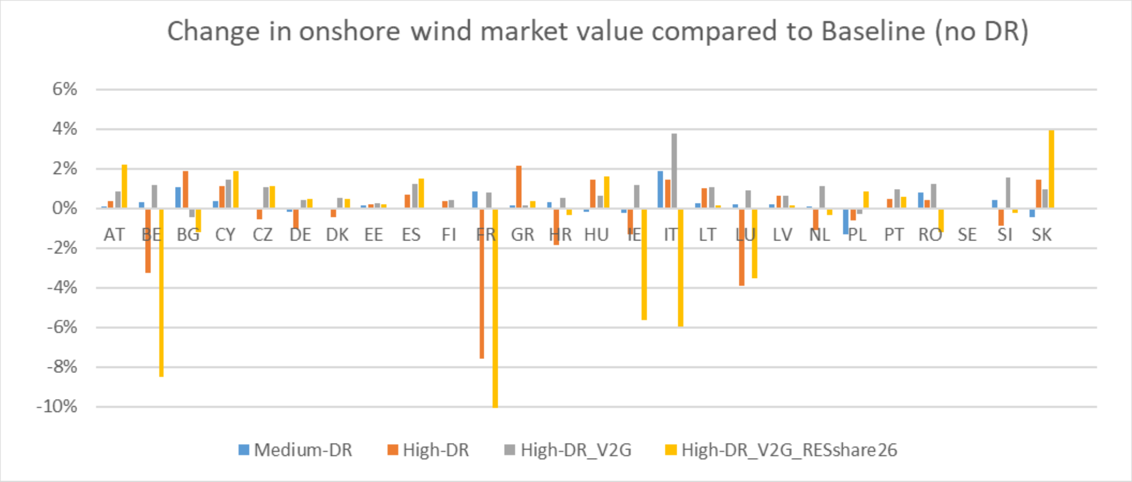
At the same time, single countries may face a decrease in PV market values. This holds for instance true for Spain and may be explained by the fact that demand is shifted into hours where the market price is low and does not increase due to the shifted demand, while market prices are reduced in those hours where demand is reduced, having a negative net effect.

Figure 0-22 Change in solar PV market values compared to Baseline



A similar phenomenon may be observed for wind onshore and offshore which in the present study exhibit in several countries a decline in market values. The major reason is that demand is only shifted within 24h time slices due to the DR constraints considered for heat pumps and electric vehicles. Hence, demand is preferably shifted into hours with high PV generation as its concentration in mid-term hours implies a high RES share, thereby lowering the market price in other hours of the day and deteriorating the market value of wind (cf. Figure 0-23).

Figure 0-23 Change in onshore wind market values compared to Baseline



More precisely, a RES share-based incentive for power consumers features a systemic preferential treatment of PV given the concentration of PV power generation on selected hours of the year. Figure 0-24 indicates the sorted total hourly generation of solar PV, wind onshore and wind offshore across the EU27. Despite the fact the solar PV generation only represents roughly half of wind onshore power generation, hourly PV power generation is quite more important, reaching up to 260 GW in selected hours (and being null during half of the year). Wind, instead, represents a more balanced hourly power generation profile (with onshore generation across the EU27 peaking at 230 GW and never dropping below 17 GW throughout the year under the given weather year). Figure 0-25 illustrates the sorted normalised hourly power generation, indicating an even more important difference when considering similar generation volumes.

To sum it up in a word: PV generation is concentrated in specific hours of the year and may thus provoke more important RES-E shares than wind even if overall wind power generation volumes are more important. This implies that shifting demand into high RES hours typically means into high PV hours, thus increasing PV market values and potentially deteriorating wind market values.

Figure 0-24 Sorted hourly vRES power generation

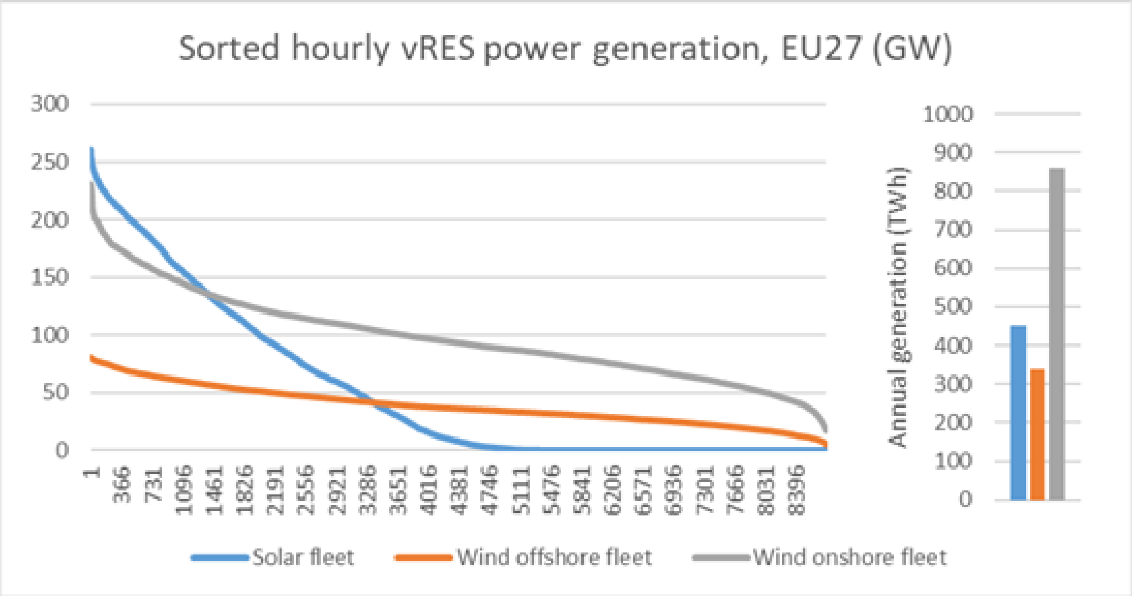
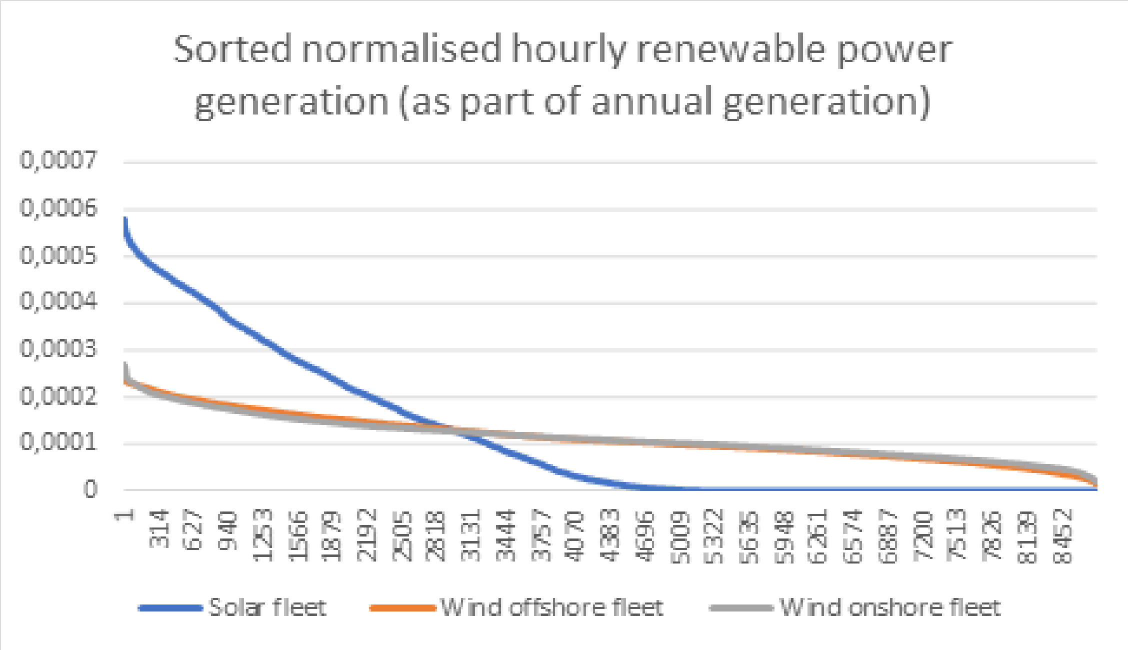


Figure 0-25 Sorted normalised hourly renewable power generation (as part of annual generation)



The deteriorating effects may be dampened if flexible consumers are able to shift their demand during longer time periods (>24h), in case of more significant DSR volumes and in case of higher RES shares.

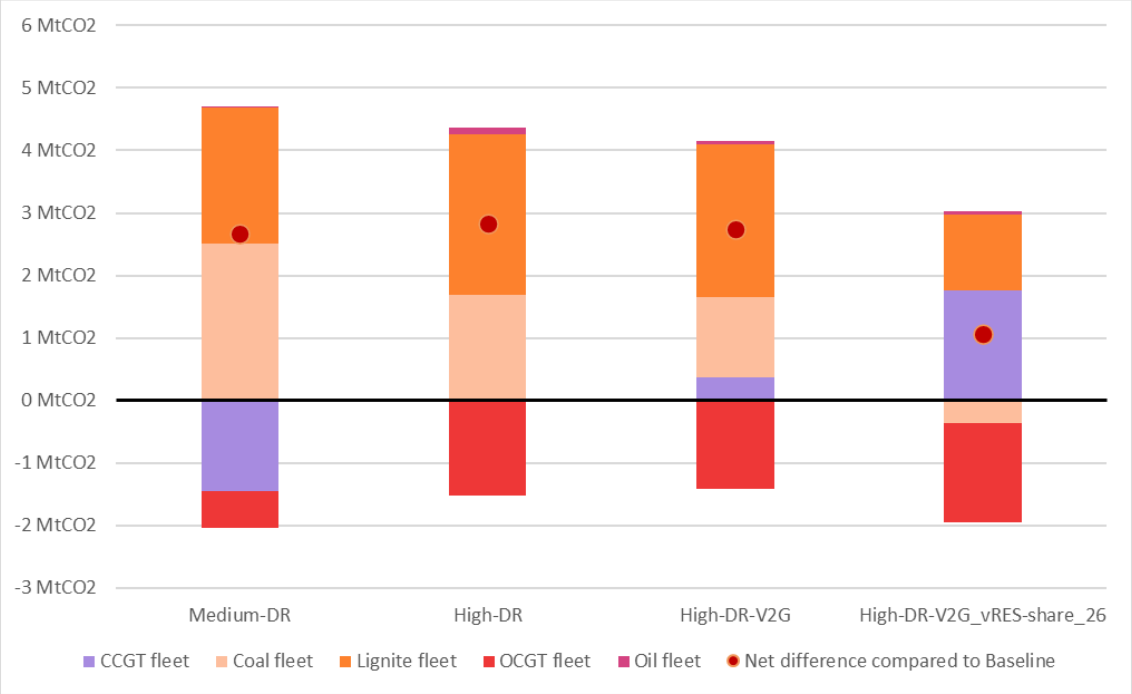
Independently from the effect on market values, valuing the green attribute of power via a dedicated (hourly) price may represent a relevant secondary revenue source for renewable power generators. This effect may become all the more important with rising RES shares and enhanced demand for GOs.

Environmental Impacts

As indicated earlier, DR entails an enhanced utilisation of baseload and mid-merit capacities. In the present case the carbon price signal is still relatively low, thus facilitating an increase in production from coal and lignite which goes along with an increase in emissions. At the same time, the reduced need for peak generation capacities implies a reduced demand for natural gas. In terms of primary energy demand, the total natural gas consumption decreases from 710 TWh in the Baseline to 708 TWh in the high-DR-V2G scenario. On the other hand, lignite consumption increases by 16%, coal consumption by 4%. In terms of CO_2 emissions, this implies an increase of about 2% in the DR scenarios compared to the Baseline.

Only in the case of the high-DR-V2G_vRES-share run, the increase in coal consumption may be effectively reduced and the increase in lignite consumption is less pronounced than in the other DR scenarios. Yet, emissions still exhibit a net increase of about 1%.

Figure 0-26 CO_2 emissions, compared to Baseline



B2 - Sub-Option 3 . 1 Accounting RES electricity to meet H&C

Economic

Accounting renewable electricity for the purpose of H&C could increase the interest in heat pumps if the H&C target (Article 23 RED) is high and difficult to reach by other means. The amount of aerothermal, geothermal or hydrothermal energy captured by a heat pump to be considered as energy from renewable sources for the purposes of the national renewable target, shall be calculated with the following formula (annex VII of RED): RES Energy (H&C) = Q_{usable} * (1 - 1/SPF[93]). Therefore, a heat pump with a SPF of 3 can account 2/3 of the amount of usable heat for the renewable target in H&C (Article 23), whatever the amount of renewable electricity consumed to produce this heat. If this electricity is 100% renewable, then 1 unit of energy is accounted as renewable electricity (art 7(2)). This option would move the consumed renewable electricity to the specific H&C target, which would then count 5/3 of the amount of usable heat for the purpose of the H&C target (Art 7(3) and Article 23). This would more than double the attractiveness of heat pumps, from a global H&C target point of view.

Several studies, such as the Heat Roadmap Europe 4 study[94], have demonstrated that an affordable decarbonisation (up to 85%) of the EU H&C sector is possible with individual heat pumps complementing energy efficiency[95] and DHC[96] as main backbone. As in most scenarios, heat pumps are an essential technology to decarbonise the heating and cooling and especially the building sector, with more and more applications in the industry (low to medium temperature levels).

[93] SPF = Seasonal Performance Factor

[94] Paardekooper, S., et al. (2018). Heat Roadmap Europe 4: Quantifying the Impact of Low-Carbon Heating and Cooling Roadmaps. Aalborg University. Available at: https://vbn.aau.dk/ws/portalfiles/portal/288075507/Heat_Roadmap_Europe_4_Quantifying_the_Impact_of_Low_Carbon_Heating_and_Cooling_Roadmaps..pdf

[95] Implementing 30% end-use savings in heating by 2050 compared to 2015.

[96] Expanding district heating in urban areas could supply up to 50% of EU heat demands in 2050.

The economics of heat pump is driven by the investment and the fuel cost. The final decision to install such system is influenced by the relative total cost of ownership differences with standard fossil-based heating technologies. Heat pump is a mature technology, well implemented, but still faces important economic barriers hampering its uptake, among which the relatively higher investment cost compared to fossil fuel-based heating technologies and the pricing structure of heating fuels and electricity that discourages the use of heat pumps. Energy and carbon pricing on fossil heating fuels is highlighted as a key driver for the deployment of heat pumps (e.g., Sweden and Denmark).[97] Hence, increasing its attractiveness may lead decision makers to tackle the different barriers, among which the relatively high price of electricity compared to fossil fuels not internalizing carbon externalities.

Building renovation or new building targeting to reach net zero emission would benefit from a higher attractiveness for heat pumps and other electric appliances.

Option 3.1 would affect positively heat pump manufacturers and installers, building professionals like architects, designers, construction companies, and final consumers.

Environmental

Half of the energy consumed in Europe is used for heating and cooling, and 75% of this energy is still coming from fossil fuels. Additionally, much of this energy is wasted due to inefficiencies in the heating and cooling systems. For option 3.1, accelerating the deployment of heat pumps would not only bring more renewable energy, but would also significantly increase the energy efficiency of the system. Heat pumps can generate heat from renewable energy sources and use only a smaller part of driving energy to do so. The difference between the driving energy (that needs to be paid for) and the energy demand of the building/process covered by the heat pump (known as useful energy) is recognised as renewable, if captured from the ambient - air, water or ground.

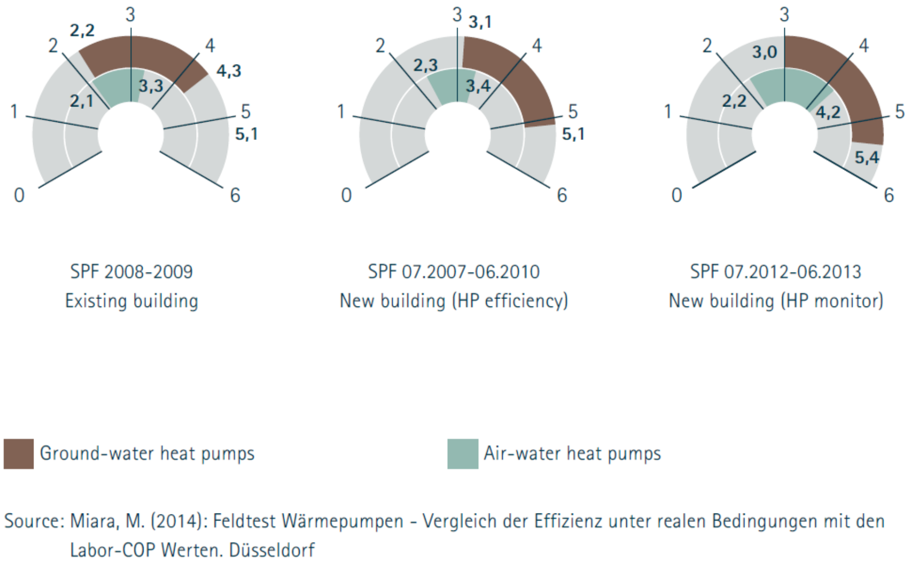
The proxy used to measure the potential environmental impact is directly linked to the amount of renewable H&C energy, which depends on the Seasonal Performance Factor (SPF), representing the most comprehensive approach to determine heat pump system efficiency by measuring the performance of a unit installed in a building or a process.

The efficiency of heat pumps has increased over time. This can be observed in the development of unit performance, as illustrated by Figure [98], and also lead to increased overall systems efficiency.

[97] Richard, H., et al. (2016). Best practice in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low-carbon heat supply. Working Paper. UK Energy Research Centre (UKERC). UKERC Technology and Policy Assessment. Available at: https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/03/heat-what-works-working-paper.pdf

[98] Fraunhofer ISE in Freiburg evaluated heat pump performance over different projects. The evaluation revealed an increase of top efficiency in new buildings from 5.1 to 5.4 for geothermal heat pumps whereas air-water heat pumps have increased their top efficiency from 3.4 to 4.2.

Figure 0-27 Efficiency increase of air-water and ground-water heat pumps over time. Source: Miara, M. (2014).



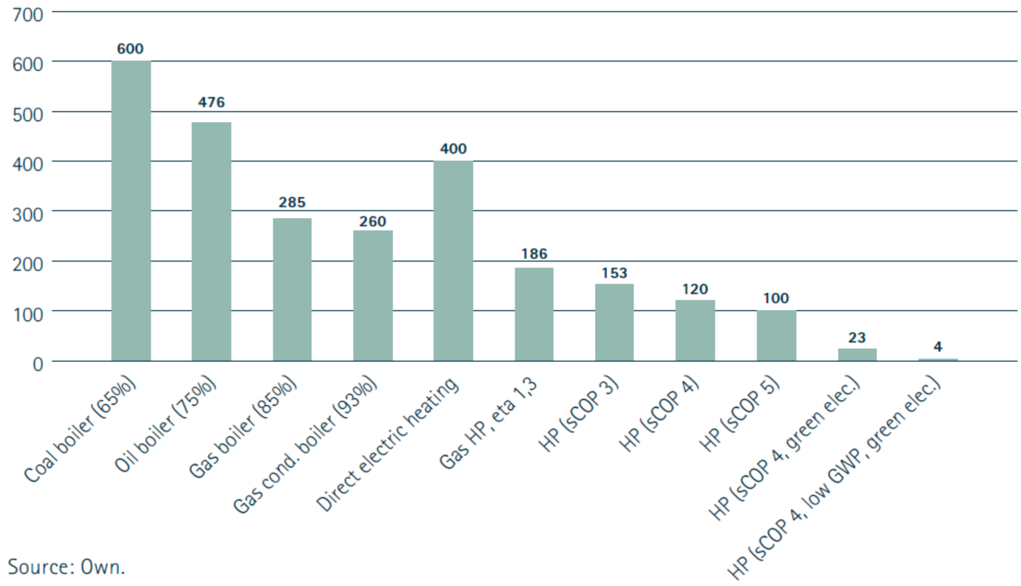
If the heat pump system is designed properly, in line with the building performance and characteristics (for existing buildings), the increased performance demonstrates a raising efficiency for the whole energy system, which is also a key argument for the large deployment of heat pumps.

An increase in energy efficiency means reaching higher energy output levels with the same energy input. This can apply via technological improvements that increase the efficiency of an existing unit or via the replacement of a fossil-based system. In this case, a large share of fossil input energy is replaced by renewable energy and thus oil and gas are no longer needed.

Heat pumps reduce greenhouse gas emissions by replacing fossil fuels with renewable energy or by making use of excess energy otherwise wasted. The consequence of replacing fossil fuels means improved efficiency, cleaner air and reducing GHG towards zero emissions. The reduction of carbon emissions from using heat pumps is calculated as a comparison of the heat pump CO_2 emissions with a given reference. Today, condensing gas boilers fuelled with fossil gas, in the case of new buildings and many existing buildings, is considered the best available technology and used as reference. With current refrigerants and renewables in the electricity mix, heat pumps can reduce carbon emissions by 35-65% compared to condensing gas boiler.

Figure 0-28 illustrates CO_2-emissions of different heating technologies per kWh of useful heat. Highly efficient heat pump technology fuelled with renewable electricity has the potential to nearly reach zero-carbon emissions.

Figure 0-28 Comparison of CO_2 equivalent emissions of different heating systems. Source : EHPA[99]



Source: Own.

Option 3.1, by accounting the renewable electricity for the purpose of heating and cooling, would allow to emphasize the GHG savings a heat pump delivers, especially when it is directly coupled to renewable electricity generation, like in the HP-PV tandem. This would support its deployment, bringing forward its abatement advantages.

However, noise pollution of air source heat pumps can be a barrier, especially in densely populated areas.[100] According to some studies, the majority of the observed air source heat pumps need to be located 10 to 20 metres away from neighbouring buildings to achieve a potential required 42 dB level.

Social

The heat pump value chain is global, but many leading companies are located in Europe, providing to the EU market locally produced systems, but also exporting opportunities. The EHPA[101] estimates that more than 80,000 full-time jobs are necessary to manufacture, install and operate the current annual sale of heat pumps in Europe (2019 figures[102]), which represents only about 1% of the total heat demand in EU.[103] In the long-run, a fast growth of heat pumps in the heating market will not increase employment significantly, but instead lead to a re-training of experts and craftsmen currently working in other product areas.[104]

[99] Nowak, T. (2018). Heat Pumps Integrating technologies to decarbonise heating and cooling. European Copper Institute. Available at: https://www.ehpa.org/fileadmin/red/03._Media/Publications/ehpa-white-paper-111018.pdf
[100] Frontier Economics Ltd. (2013): The noise generated by the external fan and compressor unit of an air source heat pump can affect the building occupants as well as their neighbours.
[101] EHPA – European Heat Pump Association
[102] Stats.ehpa. (n.d.). Available at: http://stats.ehpa.org/hp_sales/country_cards/
[103] 1% according to Fraunhofer ISE. (2017). Profile of heating and cooling demand in 2015. Available at: https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2017/3-1_Profile_of_the_heating_and_cooling_demand_in_the_base_year_in_the_14_MSs_in_the_EU28.pdf
[104] Nowak, T. (2018). Heat Pumps Integrating technologies to decarbonise heating and cooling. European Copper Institute. Available at: https://www.ehpa.org/fileadmin/red/03._Media/Publications/ehpa-white-paper-111018.pdf

B2 - Sub-Option 3.2 Credit Mechanism Electricity

All of the variants suggested under this option would diversify the options for obligated fuel suppliers to comply with their quotas, creating a more level playing field across electricity and fuels used to decarbonise the transport sector. This would result in several concrete impacts across the economic, environmental and social dimensions. Depending on the design of the credit mechanism, introducing it would potentially also significantly boost financial flows directly to parties that provide electromobility services and speed up the green transition of the European transport sector. This has direct positive economic impacts on the suppliers of green electricity as well as the sector that supplies electromobility infrastructure. At the same time, more green electricity is a concrete positive environmental impact, amplified as infrastructure is increasingly rolled further. Creating a level playing for electricity in transport would create a trade-off option to the biofuel sector, as obligated parties have more options to fulfil their obligations. However, it should be noted that major shares of green electricity would be produced within the EU, whereas feedstock for biofuels is oftentimes imported from third countries. Supporting renewable electricity production through a credit mechanism would therefore foster job creation in the EU, a positive social and economic impact. In particular, wind and PV present major opportunities for job creation in the coming years.[105]

Since RED II does not propose a harmonized way of integrating electricity in fuel markets, the variants here refer to an implementation at MS level. However, to create a bigger market, institutional convergence and greater visibility to investors, a harmonized pan-European crediting system for electricity in transport should be explored (see Annex F – Option 4 on harmonisation). This may be part of a central trading platform or EU-led auctioning. Furthermore, and this also applies to all variants, the legislation would need to decide if it adopts an approach that assigns credits based on an energy or on a GHG emission basis. To incentivise best preforming solutions, the latter would likely be more suitable. A wider discussion on how to express obligations is presented in Annex F – Options 4 and 5 on harmonisation).

Variant 1 only covers electricity supplied by public charging stations. This situation is foreseen in RED II, however without credit mechanism. For this reason, a multiplier of four has been defined for renewable electricity consumed in road transport; recital 87 states: "Multipliers for renewable electricity supplied for the transport sector should be used for the promotion of renewable electricity in the transport sector and in order to reduce the comparative disadvantage in energy statistics. Since it is not possible to account for all electricity supplied for road vehicles in statistics through dedicated metering, such as charging at home, multipliers should be used in order to ensure that the positive impacts of electrified renewable energy-based transport are properly accounted for." Variant 1 is most similar to the system in place in California, where several entities can generate credits for electricity provided to the transport sector. However, unlike California, it excludes residential charging, limiting extent to which the overall renewable electricity supplied to transport is captured [106]. In this variant, a market would be created. Since this variant envisions trade to take place between different market participants, it is unclear where any revenue from the trade would go. There would need to be a requirement in place that some of the proceeds go to specific programs aimed to promote and develop the electrification of transport or support user groups that are not at the forefront of benefitting from the electrification of transport. There are many options, including the establishment of a European electromobility fund, fed

[105] Ram, M., Aghahosseini, A., & Breyer, C. (2020). Job creation during the global energy transition towards 100% renewable power system by 2050. Technological Forecasting and Social Change, 151, 119682.
[106] In the Californian system, credits are assigned to utilities based on official estimates of the RES-share that goes to home-charging.

through some of the credit trade's proceeds, and out of which innovative green mobility projects could be financed from which a tapestry of stakeholders could benefit. At the same time, a profit component for suppliers of renewable electricity is desirable, as it ensures best efforts in maintaining and expanding their supply.

Depending on what mechanism (auctioning or not) variant 2 or 3 would adopt, this added incentive through direct trade between obligated parties and suppliers may be missing. Central allocation may create inefficiencies compared to free trade. However, central auctioning would ensure that all proceeds can be used for investments into sustainable transport systems. Variant 2 covers all electricity consumed by pure battery-electric vehicles in road transport. Caution should be exercised in order to avoid double-counting or over-estimating consumption: counting electricity supplied through public charging stations in addition to estimating electricity consumption by multiplying the number of BEV with an average consumption per vehicle, quantities supplied to BEVs through public charging stations would be double-counted. However, quantities consumed by PHEVs would not be covered fully, but only those quantities supplied by public charging stations. Also, multiplying vehicle numbers with average consumption levels could lead to an over-estimation of consumed electricity in cases where BEVs have a systematically lower annual driving range. Nonetheless, the need for a multiplier based on statistical disadvantages is greatly reduced.

Variant 3 would require substantial IT infrastructure and central oversight to be developed for collecting individual vehicle data, as well as a careful design in order to comply with data privacy requirements. As a whole, the institutional convergence necessary to develop a framework and legal footing around data privacy within and across MS, would pose a substantial administrative effort in realizing this variant. It would also require the close collaboration with OEMs, who already collect some of necessary data and could make them available. Nonetheless, such a solution is feasible and is applied in certain countries outside Europe. The benefits derived from this variant in comparison to variant 1 and 2 lie in its accuracy as all electricity consumed in transport would be fully covered. That being said, if one of the objectives is to incentivise supplying green electricity to the transport sector, credits would somehow have to be funnelled back to economic operators, I.e. suppliers, as they would either be valorised directly by EV-users (possibly through aggregators) or be centrally auctioned. This seems to be an additional administrative burden. The assignment of the consumed electricity to MS would require detailed rules but should in general be based on the location of electric charging. With this variant, all electricity consumed in road transport would be fully covered, eliminating the statistical deficiency motivation for a multiplier of four.

B2 – Option 4 Stronger, more efficient and equitable integration of system users and electric mobility services into the grid

Setting minimum requirements for the availability of intelligent infrastructure

V2G in public charging infrastructure is oftentimes less relevant as a lot of public charging points are fast-chargers, or cars park only for a short while. This is not very interesting for smart charging or V2G, which requires a longer duration to provide useful balancing services. In short, vehicles are often only parked for short times and users normally want fast and maximum charging at the time. For example, "in Norway, one of the world's most mature EV market, the share of drivers relying on public slow charging on a daily basis dropped from almost 10% in 2014 to just 2% in 2017 – only about 15% of drivers use it on a weekly basis. Fast charging along main road corridors is the only charging type that has increased in use in the country. Plausible explanations include an increase in driving range and improved charging network coverage."[107] This is not to say that in city centres, where cars are parked for pro-longed periods of time and on low power, overnight for example, smart charging is not feasible. Furthermore, flexible pricing at public charging stations to incentivize charging when renewable electricity is available is redundant insofar that it is envisioned that all the players have to make sure that they only charge renewable energy. This will be part of the contract that operators and services providers commit to with the respective authorities and most of the EV drivers will likewise recognize this and demand renewable electricity when charging publicly. This is all to say that efforts for equal treatment at public stations should be made. However, the priority of any regulation must focus on where the lion's share of charging occurs: at home or while at work. Estimates as to the share of home charging range from anywhere between 50%-95%.[ibid.] [108] Especially at home, where there will be a lot of synergies between cars and buildings, any incentives that foster self-consumption and the use of smart systems to align charging with the local energy generation will be useful. This includes removing all barriers and taxes on self-consumption to the extent possible, inter alia strongly reevaluating ideas such as having separate meters for EV-charging and the rest of the buildings' electricity consumption, which is something that could be considered by authorities: taxing EV charging separately from the rest of the electricity use. However, such measures would run entirely against the priority of optimization of the local energy grid through V2G and flexible prices that incentivize EV-charging

Looking forward, a full endorsement of V2G, flexible pricing (sub-option 4.1) with the proper incentives that ensure minimal market distortions (sub-option 4.2) and targets for renewable energy in the electricity mix at charging points (sub-option 4.3) is important. If these are fully endorsed against the background of maximizing the renewable energy share in the electricity mix, the economic, environmental and social impacts are potentially substantial.

It is important that the charging infrastructure and BEVs in different regions do not turn into a chicken and egg problem, where drivers avoid purchasing BEVs for a lack of public charging infrastructure. While this is in theory a valid concern, it is **presently a non-issue**, simply because the majority of people purchasing the oftentimes premium BEVs have access to charging spots on their own premises. Nonetheless, an intra-European "e-mobility" divide, as well as one across different strata of societies must be avoided. This will be highly relevant in the near future when the proliferation of EVs will result in them being parked in publicly accessible areas. This should work in complementarity with the provisions of the Energy Performance of Buildings Directive, currently under review. It is important to ensure that provisions are being made that ensure that all citizens have access to smart charging either in their homes, nearby, at the publicly accessible locations they park over-night (as residents) or over-day (as employees).

Such measures, could be applied via a principal provision in the regulation, requiring the MS to analyse and implement plans notified to the Commission every 3 years, for example, until EV proliferation is

[107] Muzi, N. (2018). Only 5 percent of EV charging happens at public charging points. Transport and Environment. Available at: https://www.transportenvironment.org/press/only-5-percent-ev-charging-happens-public-charging-points

[108] McKinsey. (2018). Charging ahead: Electric-vehicle infrastructure demand. Available at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand

mature. Provisions similar to the Gebäude-Elektromobilität-Infrastruktur Gesetz [109, 110] in Germany should be made, i.e., requiring investors to plan for a minimum number or share of smart charging (charging) infrastructure in new buildings. This number should aim to cover the integration needs of EVs which do not have access to private parking in residential or office buildings when parked for long hours (e.g., overnight at residential areas or over day where employees are parked). This must be mandatory as there is a reluctance amongst investors to go the extra mile and make the basic provisions for more charge points in commercial or residential buildings. It is worth noting that some of the stakeholders consulted do not see a big role for public charging, because it is not an attractive business case (at the moment). However, simply the fact that on-street residential parking is substantial across urban centres and sprawl throughout Europe, there will be a significant demand for on-street parking in the future, eventually justifying a business case. To avoid user discrimination based on their residence once that demand is significant, provisions for charging infrastructure must be made now, to ensure a minimum of public charging points in areas with high shares of residential on-street parking. This shall be done under the consideration that a reduction of the dependency on private cares may result in fewer vehicles in cities.

Box 0-2 Antwerp: price as an award criterion

The Autonomous Antwerp city Parking Agency (AAPA) assumes an operational model in which the concessionaire can deliver the full scope of services without any financial contribution of AAPA or other public authorities. In this context, the candidate should indicate in his proposal a maximum price payable by (potential) EV-drivers at its recharging points. In his bid, the candidate must specify a maximum price (per kWh) for each of the following two payment methods: (i) The maximum price per kWh [payable for contract-based recharging] (e.g., via a charging card or app) (15 points); (ii) The maximum price per kWh for ad- hoc payments by SMS (price including cost for sending SMS) (cf. 15 points); (iii) Rotation rate per 15 minutes (day) (10 points).

Ensuring a level playing field for electric mobility service providers

Lack of coordination between Smart Charging initiatives and the DSO can lead to congestion within the regional grid because the DSO is unable to plan properly. Even if data is shared with the DSO, there is a risk that data cannot be shared in a safe & secure way because there is no central certificate authority to perform authentication today in Europe. Therefore, coordination is needed to use the potential of Smart Charging to provide flexibility services.[111] Currently, there is a large variety of different protocols in place globally, which are not always interoperable. Not all protocols encompass services like roaming for payment and smart charging. ISO 11158 is expected to become the standard which will allow the market to scale up. “Public authorities should require that the CPO-concessionaire allows

[109] The GEIG was passed by the German Bundestag on 11 February 2021. The Bundesrat approved the Act in its second reading on 5 March 2021. The Act will enter into force one day after its publication in the Federal Law Gazette I. The aim of the law is to accelerate the expansion of the line and charging infrastructure for electromobility in the building sector and, on the other hand, to preserve the affordability of construction and housing. The main content of the regulation stipulates that in future every parking space in new residential buildings with more than five parking spaces and every third parking space in new non-residential buildings with more than six parking spaces must be equipped with conduits for electric cables. In addition, at least one charging point must be installed in non-residential buildings. In the case of a major renovation of existing residential buildings with more than ten parking spaces, all parking spaces must in future be equipped with protective conduits for electric cables.

[110] Bundesministerium für Wirtschaft und Energie. (2020). Gesetzentwurf der Bundesregierung, Entwurf eines Gesetzes zum Aufbau einer gebäudeintegrierten Ladeund Leitungsinfrastruktur für die Elektromobilität. Available at: https://www.bmwi.de/Redaktion/DE/Downloads/Gesetz/entwurf-gesetzes-gebaeudeintegrierte-lade-und-leitungsinfrastruktur-elektromobilitaet.pdf?__blob=publicationFile&v=4

[111] Renault Group via PricewaterhouseCoopers Advisory. (2019). Regulatory barriers for Smart Charging of EVs and second life use of EV batteries. Available at: https://www.renaultgroup.com/en/innovation-deal-the-virtuous-loop-of-electric-vehicle/

non- discriminatory third party (EMSPs) access to its recharging points, so third party- EMSPs can offer their customers services on these recharging points (start/stop a session, financial transaction, smart recharging). Moreover, this requirement should be complemented by an obligation on the CPO-concessionaire to establish a minimum number of roaming connections, without, however, mandating the way in which roaming is implemented (Peer-to- Peer or via a clearing house)."[112]

The data on the existing charging infrastructure is currently insufficient as well. There are a variety of services showing the location of charging points, but they are often faulty or incomplete. A centralized database of all existing charging points does not exist. There are national efforts to establish such a database. For example, in Germany, the Federal Grid Agency was given the mandate to establish a register. However, the availability of information depends on the voluntary notification to the Federal Grid Agency by the charging operator. Therefore, the data may remain incomplete. A comprehensive database is an important prerequisite for a coordinated approach to the rollout of charging infrastructure, interoperability and a level playing field for electric mobility service providers. "Public authorities should require that all publicly accessible recharging infrastructure is digitally connected. This implies the installation of the necessary software, standards, protocols and overall IT systems required to ensure the infrastructure is able to send and receive static and dynamic data in real time, as well as to connect the different market actors that are dependent on these data for enabling the recharging process. It is essential to ensure an adequate network connection: in this respect, best practice is to set minimum connection uptime requirements, irrespective of the chosen technology." [ibidem] Generally, open access systems are technically entirely feasible. Policy instruments should focus on standardizing ways of communication between all parties. This includes IEC 63110 and ISO 15118 (in the making) as well as balancing parameters need to be openly accessible and easy to find for balancing responsible parties (including virtual plant operators, aggregators, OEMs etc.), billing procedures. Future tenders allow the use of open data models according to the needs of CPOS and DSOs. Any aspects related to vehicle battery data may best be addressed within the larger framework of access to vehicle data. It is important to address data security appropriately and in an equitable and just manner that does not inhibit innovation and concentrate power in the hands of a few players.

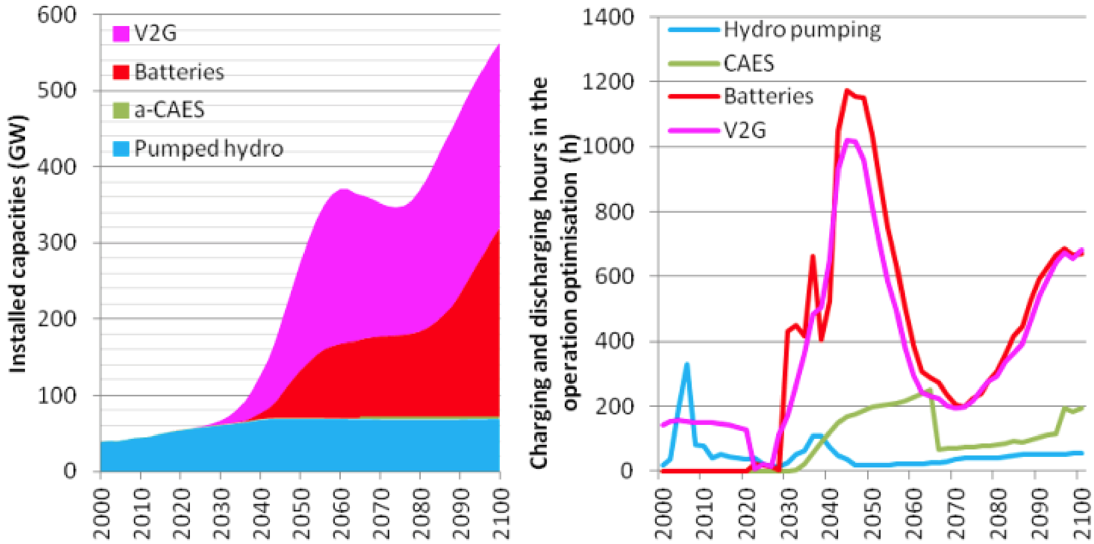
Economic

Next to facilitating unique communication protocols enabling V2G functionality and interoperability for all BEVs at all charging points an efficient and economically viable infrastructure roll-out must ensure that the installed infrastructure is future-proof. It must be avoided that "dumb-chargers" that do not communicate with the grid and do not allow bi-directional flow are installed. Charging points that are being installed today but are not smart, will be there for at least 10 years and an EV driver that charges at such a charging point in 10 years would still not be able to provide flexibility to the grid and as he would not be integrated into a smart infrastructure. Here, regulation and subsidies can play a role to push charging infrastructure that is future proof. In consultation with stakeholders, the EC should develop guidelines as to what the requirements of such a future-proof charger should be. These requirements must be reviewed on a regular basis and will ensure that the economic viability of the smart charging infrastructure is maximized.

[112] Sustainable Transport Forum. (2021). Recommendations for public authorities on: procuring, awarding concessions, licences and/ or granting support for electric recharging infrastructure for passenger cars and vans. Available at: https://ec.europa.eu/transport/sites/transport/files/sustainable_transport_forum_report_-_recommendations_for_public_authorities_on_recharging_infrastructure.pdf

A grid that relies on EV-batteries as a source of flexibility has a much cheaper cost per MWh compared to gas turbine or pumped hydropower, for example, as EV-batteries have already been paid for by driving. EV owners in Germany alone will invest about €70-100 bn in batteries until 2030[113], which is a substantial value creation, all the more so if manufacturing occurs in Europe.

Figure 0-29 Installed capacities (left) and hours of utilization (right) in the operation of different optimized energy storage technologies for Europe, 2000-2100. Note: CAES = compressed air energy storage [114]



A broad adoption of V2G and demand response measures come with an entire panoply of positive economic externalities across consumers, system operators and service providers/aggregators. While additional infrastructure can be costly, including additional equipment at private homes or offices, full-scale V2G is very likely to have an overall positive economic impact. For example, an assessment in Denmark estimated that V2G would result in yearly energy cost savings per household of 8% to 20%.[115] In the United Kingdom, a pool of 30 V2G EVs at a science park was projected to create an estimated yearly savings of around £3,500, including infrastructure costs.[116] Similarly, another study monetized the value of V2G integration in terms of day-ahead scheduling for electric power systems, noting that fleets of EVs could reduce daily operational costs for electric supply utilities by about $92,000 a day, or 3% of revenues, with most of this value coming from a reduction or shift of peak loads.[117] For example, on a small scale, the company 'The Mobility House' has realized a project in 2019 on the Portuguese island of Porto Santo, combining the charging and energy management systems, which were used for all charging points on the island, to an intelligent "marketplace". Bi-directional electric cars stabilized the grid, improving the integration of renewable energies into the power grid by 10% and lowering overall

[113] Internal communication with The Mobility House during stakeholder consultation.
[114] Després J., Mima S., et al. (2017). Storage as a flexibility option in power systems with high shares of variable renewable energy sources: a POLES-based analysis. Energy Economics, Elsevier, 2017, 64, pp.638-650. 016/j.eneco.2016.03.006.hal-01301662. Available at: https://hal.archives-ouvertes.fr/hal-01301662/document
[115] Salpakari J., Rasku T., Lindgren J. & Lund P. (2017): Flexibility of electric vehicles and space heating in net zero energy houses: an optimal control model with thermal dynamics and battery degradation. Applied Energy. Vol. 190, p. 800-812.
[116] Gough R., Dickerson C., Rowley P., & Walsh C. (2017). Vehicle-to-grid feasibility: a techno-economic analysis of EV based energy storage Appl. Energy 192 12–23.
[117] Haddadiana G., Khalilia N., Khodayarb M. & Shahidehpour M. (2015). Optimal scheduling of distributed battery storage for enhancing the security and the economics of electric power systems with emission constraints *Electr. Power Syst. Res.* 124 152–9.

cost.[118] However, certain obstacles for an efficient and quick role out of charging infrastructure and V2G adoption remain such as energy taxes and sometimes variable grid tariffs that are due every time an EV battery charges or discharges. ” This also applies when performing bidirectional Smart Charging for storage services. Double taxation applies, because the activity is classified as consumption from a tax perspective. Additionally, in some countries that have variable grid tariffs (per kWh) double grid charges can apply. Market players indicate this is a showstopper for the development of bi-directional charging. Furthermore, the Impact of the double tax issue differs per location as differences in tax rates apply based on consumption levels of a connection.”[119]

Table 0-19 Overview of potential positive impact on consumers, system operator, service providers/aggregators. Altered after [120]

	Consumer	System operator	Service provider/ aggregator
System integration with demand response and V2G	• Lower levels of demand • Reduced prices for energy, electricity, batteries, parking • Revenue streams generated from offering energy and ancillary services • More control, more choice • Can generate profits through V2G and eg. financing for installing solar energy systems	• Overall reduced system cost. • Dynamic pricing reduces peak load, • Storage decreases peak demand and system costs • Reduced need to invest in transmission lines or network improvements • Improved grid stability, leveling of load and management of intermittent supply • Could receive brokerage fees for carbon or renewable energy credits, tracking and monitoring	• Reduced costs for energy provision • Creation of revenues and profits via facilitating V2G • Revenue from offering ancillary services and lower sourcing costs for electricity retailers • Generates profits from balancing services • Combination of renewables and smart charging of electric vehicles improves financial attractiveness of those investments

Environmental

“Vehicle-to-grid technologies enable the vehicle battery to be charged when the CO_2 emission factor of the electricity currently available in the grid is at its lowest, i.e. when it is as "green" as possible. The electricity stored in the vehicle battery is fed back into the power grid during the vehicle's idle time when it can most usefully replace "brown" electricity (high CO_2 intensity) with "green" electricity (low CO_2 intensity) in the public grids. This turns the vehicle into an intelligent buffer: it draws "green" electricity when it is available as well as cheap and feeds it back into the grid when it is needed elsewhere. This stabilizes the power grid, more effectively exploits the CO_2 savings potential offered by electric vehicles, increases the degree of utilization of the battery - the most valuable part of the electric vehicle - and makes electromobility more financially attractive. It is essential that electric vehicles are connected to the charging point (i.e., the power grid) as often and as long as possible when stationary.”[121]

Until 2030 the IEA predicts, that if V2G from EVs met peak demand instead of fossil fuel-based generation, 330 million tonnes of CO_2 emissions would be avoided globally. Across China, India,

[118] The Moblity House. (2019). Referenz: Porto Santo - emissionsfreie Insel. Available at: https://www.mobilityhouse.com/de_de/unsere-referenzen/porto-santo-emissionsfreie-insel

[119] Renault Group via PricewaterhouseCoopers Advisor. (2019). Regulatory barriers for Smart Charging of EVs and second life use of EV batteries. Available at: https://www.renaultgroup.com/en/innovation-deal-the-virtuous-loop-of-electric-vehicle/

[120] Sovacool, B. K., Noel, L., Axsen, J., & Kempton, W. (2018). The neglected social dimensions to a vehicle-to-grid (V2G) transition: a critical and systematic review. Environmental Research Letters, 13(1), 013001.

[121] The Mobility House. (2021). Achieve German and European climate targets more quickly through integrated regulation of electromobility and power grids (sector coupling): Stimulus for regulatory frameworks of grid-serving charging solutions.

European Union and United States, V2G could help avoid 380 terawatt-hours (TWh) of electricity generation needs during peak demand. This is nearly equivalent to the total final electricity consumed in Italy in 2018.[122] According to a study led by Nissan, eon drive, and the Imperial College London, unmanaged regimes are shown to trigger additional power system emissions in the range of 36-52 g CO_2/km, as a result of the additional power demand created by EV fleets, whereas each V2G-enabled EV can reduce CO_2 emissions by around 60 tonnes per year while also lowering the system operation costs. In regard to the overall power system, V2G has significant impact on the dispatch of generation capacities, as it implies a further decrease of power production from flexible power plants like gas turbines. Overall, for 2050, it can be expected that V2G benefits the base load capacities and reduces costs as well as CO_2 emissions from power generation by -2.6% compared to a scenario without V2G performed by a Metis study.[123] This scenario would also be broadly in line with IRENA's forecasts on this subject, expecting a reduction in CO_2 emissions of 2%.[124]

Box 0-3 Electric Nation Project - UK

The Electric Nation Project in the United Kingdom has published findings from its three-year study into smart charging feasibility, using data collected from more than a million charging records. The project recruited approximately 700 EV drivers and installed smart charging facilities in participants homes, showing that the most popular time for EV owners to plug-in is during the evening peak time between 5pm and 7pm on weekdays, when the majority of drivers get home from work. In most cases, the vehicles were plugged in for over 12 hours, which shows that it is feasible for owners to charge away from the peak electricity demand period. Furthermore, the study revealed that an average charging event for a pure EV starts with the battery already 50 per cent full, and that most PHEV owners only charge their vehicle three times a week. [125]

The environmental impacts of switching fully to V2G can be substantial. Besides the more general contribution to climate change mitigation and also adaption in the sense that more erratic weather patterns require greater flexibility in a grid that relies fully on renewables, V2G may speed up the green electrification of transport as it can store lower-emission power in EVs that can to some extent be fed back to the grid during times when the electricity mix has a lower share of renewables. However, findings on the impact that V2G has on GHG emissions vary. For example, "one study [126] finds that more than 8% of PEVs would need to participate in V2G in order for the emissions savings from V2G to outweigh the additional electricity-based emissions as a result of charging the PEVs—though this study does not account for the avoided gasoline emissions." [127] This is a comparatively small percentage assuming that regulation for V2G readiness of EVs and charging points is set in place. Broad V2G adoption has the capacity to substantially reduce carbon emissions compared to conventional fossil-based transport [128]. However, in some electricity grids with higher CO_2-intensity electricity and no climate policy, V2G providing load shaving services might actually increase total carbon emissions.

[122] IEA. (2020). Global EV Outlook 2020. Available at: https://www.iea.org/reports/global-ev-outlook-2020

[123] European Commission. (2018). Effect of electromobility on the power system and the integration of RES. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/metis_s13_final_report_electromobility_201806.pdf

[124] IRENA. (2019). Innovation landscape brief: Electric-vehicle smart charging, International Renewable Energy Agency, Abu Dhabi. Available at: https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_EV_smart_charging_2019.pdf?la=en&hash=E77FAB7422226D29931E8469698C709EFC13EDB2

[125] Spencer Leech via CarsGuide. (2019). Electric vehicle smart charging study concludes in Europe. Available at: https://www.carsguide.com.au/car-news/electric-vehicle-smart-charging-study-concludes-in-europe-75426

[126] Zhao Y., Noori M. & Tatari O. (2017): Boosting the adoption and the reliability of renewable energy sources: mitigating the large-scale wind power intermittency through vehicle to grid technology. Energy Vol. 120, p. 608-618.

[127] Sovacool, B. K., Noel, L., Axsen, J., & Kempton, W. (2018). The neglected social dimensions to a vehicle-to-grid (V2G) transition: a critical and systematic review. Environmental Research Letters, 13(1), 013001.

[128] Hoehne C. G. & Chester M. V. (2016). Optimizing plug-in electric vehicle and vehicle-to-grid charge scheduling to minimize carbon emissions. Energy Vol. 115, p. 646–57.

Natural resource limitations should neither be overlooked in the context of V2G introduction. While the electrification of transport will likely be a driver for increased cobalt and lithium extraction in the years to come [129], this trend may to some extent be exacerbated if V2G turns out to substantially reduce battery' lifespans - or on the opposite reduced if V2G results in longer battery life, which is subject to further research as current findings are inconclusive However, broad adoption of V2G and thus the usage of EV batteries as additional storage may reduce the need for stationary storage solutions. "A key point is that stored electricity need not only be considered as storage for future use by the grid, but V2G batteries can provide a buffer between generation of intermittent RE and its end-use. Direct consumption of intermittent RE further reduces the need for storage and generation capacities."[130] Furthermore, since a lot of electric power, is currently generated from nuclear of fossil power plants, that require a lot of water, the electrification of transport could put strains on water resources in arid regions. Fully tapping into V2G and maximize the renewable energy share in the electricity mix could alleviate such concerns and even positively impact water resources.

Social Impacts

While minimizing price, service, or access discrimination of different EV-Users at different publicly accessible charging points should be dealt with, for example regulators setting minimum and maximum price ranges within certain boundaries as well as requiring operators to offer a minimum selection of the most widely used payment options, the market is at a point where it has consolidated to an extent that substantial regulation in regards to pricing or standardization of payment options comes at a late stage, according to consulted stakeholders. Over the next few years, problems that currently exist with payment at public charge points are likely to be fully resolved as the markets comes out of its growth phase. With increased competition between the different players, the systems will naturally be much more interoperable than today, as the industry has an incentive to provide the easiest access and care-free payment process to customers, who are going to automatically follow convenience and best price, similar to traditional gas stations. Additionally, with the primary objective of maximizing renewable energy in transport - in mind, business models for public smart charging can be envisioned where charging is costless in exchange to the user agreeing to its battery being used for V2G while it is plugged. Of course, for this to happen, V2G aggregators need to make sure that the battery use at the charging point is agreeable to the user and in line with the OEMs' battery requirements. Such agreements with manufacturers on what the range of use for the battery under V2G is in place and are already actively being set-up between aggregators and OEMs. However, in order for the market to stay as open to competition as possible regulation may have to be introduced that requires OEMs to provide access to their vehicle' backend to any aggregator and not only the ones affiliated to themselves.

Historically, "transportation infrastructure and technology developments often benefitted middle- and upper-class citizens because they cater to their transportation needs (the development of suburban highways, for instance)" [131]. This concerns the roll-out of EVs more broadly and not particularly the V2G thematic, but nonetheless these are important social justice consideration to keep in mind, as any introduction of regulation concerning EVs and V2G would primarily affect the households with the

[129] Pehlken, A., Albach, S. & Vogt, T. (2017). Is there a resource constraint related to lithium ion batteries in cars? Int J Life Cycle Assess 22, p. 40–53. Available at: https://doi.org/10.1007/s11367-015-0925-4

[130] Child, M., Nordling, A., & Breyer, C. (2018). The impacts of high V2G participation in a 100% renewable Åland energy system. Energies, Vol. 11(9), p. 2206.

[131] Sovacool, B. K., Noel, L., Axsen, J., & Kempton, W. (2018). The neglected social dimensions to a vehicle-to-grid (V2G) transition: a critical and systematic review. Environmental Research Letters, Vol. 13(1), 013001.

highest incomes, who would then also likely be the first ones to benefit from any potential positive externalities that come with it. Such considerations underscore the need to make electromobility as widely and equitably accessible as possible. There is relatively little information on (positive) health externalities that a wider introduction EVs (and V2G) would pose to draw on. However, the little literature that exists, potentially due to the rather self-evident nature of the questions, suggests that V2G-capable EVs will decrease air pollution[132] [133], and that by 2035 EVs could help decrease emissions by 34% [134]. Given the substantial contribution of air pollution to premature deaths every year with more than 400,000 deceased [135], this positive impact of V2G and electrification as a whole should by no means be overlooked. At the same time, "pollution and congestion often accumulate in poorer neighbourhoods; and poor residents are more likely to be displaced or have their neighbourhoods disrupted due to developments."[136] Reduced emissions from V2G introduction could however improve the lot of low-income neighbourhoods in the vicinity of extensive road infrastructure.

Figure 0-30 Income and mobility in the UK. Y-axis show the share of transport options that households with different incomes use most often. Plotted with data from [ibid.]

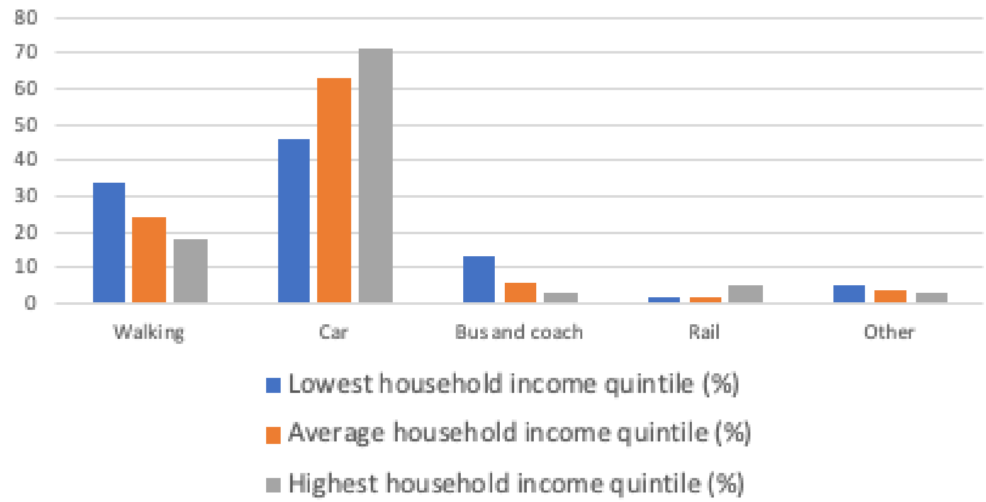


Table 0-20 Overall impacts of B2

	Overall impact		
	Economic	Social	Environmental
Promote RES-based electrification			
Option 0 -	0	0	0
Option 1 -	+	+	+
Option 2 -	++	++	++
Option 3.1	++	+	++
Option 3.2	++	+	++

[132] Noel L, Brodie J. F., Kempton W., Archer C. L. & Budischak C. (2017). Cost minimization of generation, storage, and new loads, comparing costs with and without externalities Appl. Energy, Vol. 189, p. 110–21.

[133] Noel L. (2017). The hidden economic benefits of large-scale renewable energy deployment: integrating heat, electricity and vehicle systems. Energy Res. Soc. Sci. 26, p. 54–59.

[134] Hoehne C. G. & Chester M. V. (2016). Optimizing plug-in electric vehicle and vehicle-to-grid charge scheduling to minimize carbon emissions. Energy, Vol. 115, p. 646-657.

[135] EEA. (2020). Premature deaths attributable to air pollution. Available at: https://www.eea.europa.eu/media/newsreleases/many-europeans-still-exposed-to-air-pollution-2015/premature-deaths-attributable-to-air-pollution (accessed on 31.05.2021).

[136] Roth M. W. (2004). Whittier Boulevard, Sixth Street Bridge, and the origins of transportation exploitation in East Los Angeles J. Urban Hist. Vol. 30, p. 729–748

Option 4	++	+	++

- *Options for B3: Certification of renewable and low carbon fuels*

Economic

Developing comprehensive framework for hydrogen use in all sectors

All options (except the baseline) develop a comprehensive methodology for carbon footprint calculation for hydrogen and enable tracking hydrogen through the value chain steps. This would enable counting hydrogen consumption in other sectors than transport, such as heating & cooling. In Options 2 and 6 the BC schemes for hydrogen would be allowed to operate on the same basis as today, which would offer only limited information on hydrogen carbon footprint. For the purpose of tracking the hydrogen value chain, Options 4 and 5 offer the most suitable framework as all hydrogen energy carriers would be tracked in the Union database under the MB system.

Development of green certificate markets

Inclusion of new types of fuels in certification system and enabling counting them towards sectoral obligations would facilitate the demand for these type of fuels, increasing the revenues of fuel producers. This would also level the market conditions for all types of fuels and increase the number of participants in the markets, contributing to a greater market liquidity and competitivity.

Introducing the Union database that would consider the interconnected European (gas and potentially electricity) grid as a single logistical facility would significantly improve the condition for cross-border trade of MB certificates. This would be especially an improvement for gas certificate markets, which are currently developed very unevenly. However, enabling more cross-border trade might have negative impact on economic operators in countries with lower purchasing power. Since they would have to compete for the same goods with economic operators from higher-income countries, the costs of fulfilling the sectoral obligations would increase for them. This would in turn lead to higher prices for final consumers in lower income countries.

Since electricity GOs are already traded on fairly developed market that encompass almost the whole EU, the most beneficial options for further development would be those that present only minimal intrusion in the market functioning. This would be especially options 2 and 4 that leave the scope of electricity GO markets unchanged. Option 3 would result in additional compliance costs for economic operators and producers, which could limit the willingness (and profitability) of participation in GO markets.

Real-time GOs

Requiring electricity GOs to be issued with an hourly or quarter-hourly timestamp would require substantial changes in registry IT systems with competent authorities/issuing bodies. Furthermore, electricity suppliers would need to adapt their internal processes and IT systems, and GO markets would have to adapt.

Real-time GOs are currently conceptualized and developed by various stakeholder groups, and are in early stages, but not yet mature. However, there do not seem to be fundamental technology showstoppers preventing solutions from being developed. Nonetheless, more development is needed before such solutions can be implemented, according to experts.

GOs are not commodities as electricity, which is traded to a significant extent on electricity exchanges without further qualities ("grey" electricity) but have a number of different characteristics that GO buyers are more or less strongly interested – GOs are products. The main characteristics relevant to buyers are the production technology of the renewable electricity (solar, wind, etc.), and the geography (country, region, etc.). As a consequence, the GO market is not a commodity market, but a product market. Trade is mainly bilateral, there is very little transparency with respect to prices and quantities.[137] As a consequence, purchasing the commodity "electricity" on an hourly or quarter-hourly basis would need to be combined with purchasing the product "GO" at the same granularity. Combining two commodities is understood to be less complex than combining commodity with product. As the number of GOs to be traded will increase substantially and GOs will have to be purchased for specific hours or quarter-hours, market design would have to be adjusted most probably.

The time matching of GOs with electricity supply requires data to be available at the same granularity. Therefore, the current hourly or quarter-hourly availability of data should be the basis for a decision between hourly and quarter-hourly. National differences on the other hand would limit the tradability of GOs across borders. As such, a unified decision at EU level seems advisable.

The sub-option 7-1 proposes to issue real-time GOs without the compulsory matching of GO cancellation. This would allow for the development of specialized voluntary markets for sectors where this additional information on time would bring an added value to the consumers. At a same time, it would avoid posing additional burden on consumers that have no interest in such detailed information. The two main cases where this detailed time granularity could have an added value are:

- Hydrogen production – to prove that the electricity (for electrolysis) from networks was renewable and produced and consumed simultaneously;
- Consumer information – potential for the development of a premium product that would ensure that the consumed electricity actually matches in time with the produced renewable electricity. This could reduce some barriers in consumer trust in the product. It would also increase the demand for GOs issued in times of electricity demand peaks, or low renewable electricity production.

Compliance costs

On EU level, the biggest resources required would be setting up the Union database. However, its functionality is very similar across the option and does not deviate from baseline scenario. The only

[137] Oslo Economics. (2018). Analysis of the trade in Guarantees of Origin.

exception is Option 5, which would see inclusion of electricity sector in the database. Developing the database to be able to track energy flows via electric grid in a near-to real time horizon would require additional capabilities from the database.

On national level, the compliance costs are related to setting up new certification schemes and from changing or dismantling the existing ones. These cost would in the end translate into increased prices for final consumers, as discussed later in the Social Impacts section. All options extend the scope of certification schemes to additional energy carriers (RFNBOs, RCF, waste heat and cold) in comparison to the baseline. For these fuels, the certification schemes would have to be set up. In Option 5, MB certification schemes would have to be set up for electricity, while existing GO schemes would have to be abolished or transformed into MB schemes, adding the sunk cost of investment into the GO schemes to the overall costs. In Options 3 and 6, the GO schemes have to be significantly amended to be able to carry the information necessary for MB certification purposes. This would translate into significant compliance costs for the GO schemes operators.

For economic operators, the main compliance cost would occur where the energy carrier they produce or handle would be added to the MB certification system and they would have to pay for the certification (Option 5). Added compliance cost for economic operators would also occur in options where the information content of GOs would be extended (Options 4 and 6).

For option 7 compliance costs would stem from expanding the functionality of registry IT systems with competent authorities/issuing bodies, from electricity suppliers adapting their internal processes and IT systems, and from adaptations of the GO markets including the expansion of internal procedures and IT systems of traders. Furthermore, regulatory oversight would require new functionalities and additional IT solutions. The adjustments require substantial time, at least several years, according to expert estimates. Costs could be limited to the minimum required if a typical frequency of IT revision of GO registries of typically three years would be observed.

The sub-option 7-1 would limit the compliance costs on the demand side only to those consumers that are willing to purchase the real-time GOs. The compliance cost for GO issuers would remain the same, as well the cost of developing real-time GO trading system (although its volume would be lower).

Administrative costs

From a systemic perspective, the overall administrative costs of running the certification schemes would be lower where a more unified system is applied. Therefore, Options 2, 4, and 5 should be less costly than Options 3 and 5.

The administrative costs for economic operators would be higher when more information about the energy carrier is being tracked, as in Options 3, 5 and 6. For option 7 where the number of GOs would increase substantially (see text box below) and a matching between renewable electricity production for GO issuing and electricity supply would be required on an hourly or quarter-hourly basis, the administrative costs would increase significantly. Also, there would be a very significant increase in the complexity of the matching with the number of required matching processes to increase substantially. Instead of matching an energy volume over a year or a month (as is done today) matching will have to occur in hourly or quarter-hourly intervals. Another aspect to be taken into account is the complexity of corrections in hourly or quarter-hourly data, notably related to electricity production; such corrections are made by system operators making such data available. Such corrections would have to be taken up by GO systems, which would require new procedures and systems as GOs by nature are immutable. In such a case, the number of GOs needs to be corrected in hindsight for specific hours or quarter-hours, and electricity suppliers would have to purchase such GOs in hindsight, for which case procedures need to be developed and agreed.

Box 0-4 Energy size of GOs with quarter-hourly time stamp

RED II defines in Article 19 the GO size to be 1 MWh. What would that mean for quarter-hourly GOs, or better: which size would be appropriate for quarter-hourly GOs? Paragraph 7 lit. f specifies: “Simplified information may be specified on guarantees of origin from installations of less than 50 kW.” In other words, RED II considers 50 kW to be a relevant plant size for GOs, but obviously does not exclude larger or even very much larger plants.
A typical solar PV plant of 50 kW installed capacity, e.g., a rooftop system in Germany, would produce some 50 MWh of electricity per year, and could thus generate 50 GOs. Introducing quarter-hourly GOs, this would imply that on average, 0.0014 GOs would be issued per quarter hour on an annual average. This increases to 0.0029 GOs per quarter-hour counting only daylight hours, and to 0.0072 GOs per quarter-hour assuming average sunshine hours only. For such a plant size, 1 MWh would obviously not be an appropriate GO size.

Even for a large utility-scale solar PV plant in Germany of 10 MW_P, the number of GOs issued per average sunshine quarter-hour would be 1.5 in Germany, which would require many GOs to be cut in pieces. Even for large utility-scale solar PV plants in southern Europe of 50-200 MW_P, the number of GOs issued per average sunshine quarter-hour would be 8-32, which may start to be appropriate.

As a consequence, the GO size would have to be reduced significantly for quarter-hourly GOs.
As a simple rule of thumb, reducing the time span from one year to a quarter of an hour, which is a reduction of around 1/40 000 (or more precisely 1/35 040), the size of the GO should be reduced accordingly, i.e. from 1 MWh to 0.025 kWh. However, the GO size could be kept somewhat higher, and specific solutions could be found for smaller plants, e.g., allowing such plants to be bundled over a larger geographical areas, or allowing a lower granularity.

Oversight by regulators will also become more complex. The Internal Energy Market Directive[138] in Annex 1 (5) defines: “The regulatory authority or another competent national authority shall take the necessary steps to ensure that the information provided by suppliers to final customers pursuant to this point is reliable and is provided at a national level in a clearly comparable manner.” This leaves room for national interpretation and design, so that costs of implementation of regulatory oversight of hourly GO compliance will depend on national specifications. In any case, the complexity of the task increases and will thus increase costs.

Real-time GOs will be scarce at certain times, but abundant at other times. At present, GO prices are very low for most GOs at around 0.2 €/MWh currently. In times of abundance, GO prices can only go down to zero (not below as for electricity prices), while in times of scarcity, prices can go much higher. Typical prices of “premium” GOs[139] are in the range of 1-2 €/MWh, and thus provide for a more relevant contribution to the electricity producer. Over a period of one year, real-time GOs may thus provide for higher incomes to renewable electricity producers than the current system. However, this would have to be confirmed by simulations. Higher revenues for renewable electricity producers may provide incentives for a stronger, i.e., quicker, expansion of renewable capacities. This will benefit primarily those renewable electricity producers that have dispatchable or partly dispatchable plants such as hydro power, biomass-based CHP, biogas-based plants, etc. However, it will also provide an additional incentive for operators of fluctuating plants, notably wind and solar PV, to have storage

[138] European Commission. (2019). DIRECTIVE (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast); OJ L 158/125; 14.6.2019
[139] “Premium” GOs typically relate to solar or wind power and may have a local or regional component.

capacities installed with the plants to benefit from higher electricity prices and higher GO prices in low production times (low wind, clouds/darkness).

Where voluntary schemes for the certification of RFNBOs require a temporal correlation between electricity production and hydrogen (RFNBO) production, real-time GOs would be a very suitable tool to provide the necessary data.
Limiting the real-time trading of GOs only to specialized applications like this one, as suggested in sub-option 7-1, would avoid the additional administrative cost for most consumers who are not interested in the benefits of real-time trading.

It is expected that in the coming years, GOs will be to a large extent used for other purposes than in relation to RFNBO production. Therefore, the real-time GO market size would be at least initially very limited, raising the (relative) administrative cost of system maintenance for participants. Moreover, if there is no obligation on matching electricity production and consumption for hydrogen production in real-time, there would be limited willingness to participate in such market that is connected with higher costs, and market liquidity would also be a relevant concern. Therefore, voluntary schemes would benefit from real-time GOs (either in option 7 or sub-option 7-1), but the limited market size in the short-to mid-term future may not justify the implementation of real-time GOs as such.

Environmental

Tracking the carbon footprint of fuels through the whole supply chain

The introduction of the Union database will improve the available information about the real emissions of fuel supply chain. However, this information will be limited to the energy carriers that enter the Union database. In that sense, all options offer a partial improvement in comparison to the baseline as the scope of covered fuels will be broadened. Option 6 would result in the most comprehensive tracking of energy carrier carbon footprint, since it would be mandatory to issue GOs for all gases entering networks and the scope of GO information content would include carbon content information. This information would be beneficial especially for gas consumers, who could see the real carbon footprint of their consumption and make decisions based on that. Option 5 would also allow calculation of residual energy mix for all gas consumers. Option 3 would offer similar benefits of increased information on gas carbon footprint, but this would apply only to consumers that choose to buy gas with GOs. From a systemic perspective, the most beneficial option for tracking the real emissions of energy sector would be the Option 5, since all information would be centralised in the Union database. Option 2 does not offer such substantial increase of information about supply chains, as the changes would be limited to the MB certification for the purpose of demonstrating compliance with transport sector obligations.

Establishing real-time GOs may provide benefits in terms of consumer acceptance; in fact, this would be a main motivation for their introduction. Expert opinions on this are divided. On the one hand, there have been calls for a temporal correlation of renewable electricity production and consumption since many years. On the other hand, knowledge on GOs is limited to experts. Also, a certain consumer scepticism is related to the book & claim system of GOs as such, which would only partly be resolved by real-time GOs. Another aspect to be taken into account is the very limited effect of renewable electricity consumption on the expansion of renewable capacities. The increase in renewable electricity production in the European Union may be attributed to public funding schemes for production rather than market pull. However, interest in real-time GOs has been expressed rather recently by a number of big international companies who want to demonstrate hourly matching of renewable production and consumption in their operations.

A main motivation for implementing real-time GOs is to incentivise load-shifting at the consumer end towards times of renewable abundance, and shifting renewable production to times of scarcity. As a consequence, renewable electricity would better and thus more strongly replace electricity related to high greenhouse gas emissions. For this purpose, real-time GOs may be a suitable solution; however, other policy options exist that should be considered and compared as well including notably dynamic pricing and demand response.

Increased production of renewable or low carbon energy

The effects of the proposed measures would have only indirect impacts on additional renewable energy consumption. The inclusion of new types of energy carriers into the MB certification system and enabling counting them towards the sectoral obligations might increase demand for those particular fuels but, assuming the overall obligatory share of supplied renewable energy does not change, the sum of supplied renewable energy would not change.

The compliance and administrative costs of fuel certification would increase the overall capital and operating costs of renewable energy production facilities, therefore reducing the attractivity of the investment for potential investors.

Increasing the information available to final consumers about the carbon footprint of fuels might lead to increased demand for sustainable fuels[140], increasing the demand for GOs. This would be especially the case in Option 6, as there would be an obligation to gas suppliers to disclose the carbon footprint to final consumers. In Option 3, there would be similar scope of information from GOs, but due to lack of awareness the impact would be more limited. However, the price of energy is still the most decisive factor of consumer choice, especially for consumers where energy costs take a substantial part of income. This would limit the potential for additional demand in options where new requirements are put on certification schemes serving for the purpose of consumer information disclosure – e.g., in Option 3, 5 and 6. Especially in the case of electricity GO schemes, this could lower the demand on the already developed markets, limiting the potential of GO price growth.

In conclusion, the greatest potential for growing demand for renewable energy certificates can be expected in option that do not lead to significant increase of certificate price, but offer additional information to the consumer.

Preventing the risk of fraud in renewable fuels production and double claiming of environmental benefits

Extending the scope of renewable fuels under the MB certification system will improve the possibilities of oversight over the value chain processes in all options in comparison to baseline. The introduction of Union database will centralise the available information and will make it easier for MSs to verify the correctness of certificates of foreign origin. For fuels imported from third countries, the certification process should be the same as for domestic fuels, thus ensuring the same level of fraud risk prevention. All options also introduce measures to address the issue of cancelation of hydrogen (and electricity)

[140] Sestino. (2018). Review About Consumers' Perception on Renewable Energy Market. Available at: http://dx.doi.org/10.2139/ssrn.3220528

GOs in case the energy related energy carrier is added to the Union database, by providing specific guidance in the text of RED and by introducing additional certification step or extending the scope of GO information on previous value chain steps.

Social

Impact on consumer prices

There are three main drivers of impacts on final consumer prices. Firstly, there would be an impact on the effect on the price of "premium" energy of renewable origin guaranteed by GOs. This price might increase as an effect of increased GO price or increased costs of compliance with the BC scheme. This effect would be most visible in Options 3, 5 and 6.

Secondly, specifically for Option 6, gas price would increase for all final consumers, as GOs would be mandatory issued for all types of gases entering gas grid.

Thirdly, the proposed measures would have an effect on transport fuel prices for all consumers. This would be a result of the enabling unrestricted cross-border trade of certificates, as described in the economic section. This effect would materialize primarily in lower income countries, and since the energy demand is relatively inelastic[141], this could potentially increase problems with energy poverty. This effect would materialize in all options starting from Option 2. It would be arguably more pronounced in Options 3 and 6, as the costs of compliance with GO schemes would also be translated into final fuel prices.

Impacts of real-time GOs on consumer prices are difficult to assess, but may lead to increasing prices based on higher GO prices an average, and based on higher compliance and administrative costs.

System transparency and public trust in the certification system

The transparency and trust in the certification system in the view of general public can be increased if the system discloses precise information on the carbon content of the fuels, and if there is a temporal correlation between renewable electricity production and consumption. In this sense, the most detailed and precise information would be disclosed to consumers in Options 6 (especially for gas, but also electricity GOs would enclose information on carbon content), 3 and 5 (since all energy carriers would be tracked within the MB system), and 7 through real-time GOs. Options 2 and 4 would provide the same amount of information as in the baseline scenario.

An important factor is also the perceived performance of the system and its capability to provide easily comprehensible outputs. Arguably, the complexity of Option 6 would be a hurdle to increasing public trust, especially for Sub-option 6.2 where the BC system can be used also for purpose of sectoral obligation reporting. Unifying all certification schemes under the Union database MB system in Option 5 could make the comprehension of the system functioning more straightforward for the final consumer, but it would mean discontinuing or transforming of already established GO schemes that have built the trust of customers. In the end, continuing the existing sectoral scope of carriers within the BC system for consumer information disclosure (as in Option 2 and 4) would be the most beneficial variant, since these options would also clarify the issue of GO cancellation in cases of interactions with MB systems.

[141] Labandeira et al. (2017). A meta-analysis on the price elasticity of energy demand. Available at: https://doi.org/10.1016/j.enpol.2017.01.002

Table 0-21 Overall impacts of B3.

	Overall impact		
	Economic	Social	Environmental
Certification of renewable fuels			
Option 0	--	-	0
Option 1 - (non-regulatory)	NA	NA	NA
Option 2	++	0	+
Option 3	-	--	0
Option 4	+	0	+
Option 5	-	-	+
Option 6-1	--	--	++
Option 6-2	--	--	++
Option 7	-	-	+
Option 7-1	-	-	+

- *Options for B4: Promotion of renewable and low carbon fuels*

Based on the first high-level assessment ("mapping"), option 0 only provides limited support for RFNBOs and low carbon fuels. The non-regulatory measures in option 1, like e.g., financial support, can in principle cover both RFNBOs and low carbon fuels. These measures alone, however, will most probably not be sufficient for those fuels to become competitive with reference fuels in the long-term. While option 2 and option 3 focus on different accountability-related measures with respect to existing sectoral targets to promote the consumption of RFNBOs (and other low carbon fuels in option 3), option 4 and option 5 create new sub-targets for RFNBOs alone or combined with other low carbon fuels. In the following, solely RFNBO-focussed options 2.1, 2.2 and 4 will be discussed first, followed by a combined discussion options covering low carbon fuels (i.e. option 3 - accountability for sectoral sub-targets and option 5 - combined targets for RFNBOs and low carbon fuels)

Modelling results in the impact assessment of the CTP do not foresee a significant role of RFNBOs and low carbon fuels until 2030. This situation might significantly change, in case the target of 40 GW electrolyser capacity of the EC's hydrogen strategy is achieved by 2030. Regulatory and non-regulatory measures have to be implemented to promote the required market ramp-up of the technology and hydrogen market in general. Also the modelling analysis using PRIMES in in this impact assessment[142] will explore the impact of such a production scale-up for hydrogen in Europe, by analysing two variants, where 40 GW hydrogen production capacity is installed by 2030[143]. While the first one assumes the implementation of a purely renewable-based hydrogen production (via electrolysers and applying the additionality principle), the second variant also considers low carbon hydrogen production (e.g., using nuclear energy, grid electricity without fulfilling criteria for RFNBOs in recital 90, RED II (e.g., additionality principle), or steam methane reforming including CCS).

In addition to these modelling attempts, the following analysis aims to provide a supporting analysis covering aspects, not directly addressed by the modelling analysis. It will rather focus on the economic, environmental and social impacts of the different options with regard to the affected sectors.

[142] PRIMES modelling results will be shared in a separate annex document.
[143] Results were not available at the time of this assessment.

Economic impacts

Option 0 (baseline)

The implementation of the current baseline scenario (option 0) will not result in a significant promotion for RFNBOs and low carbon fuels. Taking this into account, stakeholders in the maritime, aviation or industry sector will not face significant cost increases in the short term, since there are no additional investments in RFNBO or low carbon technologies. Still, with an increasing CO_2 price and an expansion of the ETS to maritime and aviation, companies will be encouraged to push the technological development towards RFNBOs and low carbon fuels. Some industries are already considering the use of RFNBOs, such as hydrogen-based steelmaking. This could be extended to other sectors like the refining and chemical industry.

Nevertheless, already today there are different attempts on national level to include additional provisions with regard to RFNBOs into the implementation process of RED II. One example is a proposed quota for RFNBOs in the aviation industry (raising to 2% in 2030) in Germany.[144]

Option 1 (non-regulatory measures)

Non-regulatory measures (option 1), like financial support (CAPEX and OPEX) for pilot projects and technology development, are key to bring technologies to the market and improve their competitiveness. Still, for a large-scale market ramp-up of up to 40 GW Electrolyser capacity, a bigger market for renewable and low carbon fuels needs to be created, so that customers are willing to pay the price premium for renewable or low carbon fuels compared to fossil-based technologies. Essential elements are the implementation of a carbon contract for difference system (CCfD) in industry, steering investments into renewable and low-carbon technologies by providing investment security. In addition, a carbon border adjustment mechanism (CBAM) minimizes the risk of carbon leakage and ensures a fair competition with non-EU companies. These non-regulatory measures might also be required to support options 2 to 5 aiming to include renewable and low carbon fuels into the sectoral targets or to create new sub-targets, requiring fuel suppliers to supply a certain volume of the specific fuels to the market.

Sub-option 2.1 (accounting RFNBO in H&C)

The accountability of RFNBOs towards the sectoral target in the heating and cooling sector (sub-option 2.1) will incentivise the use of renewable hydrogen and hydrogen-based methane for heating and cooling applications in the gas sector (households and possibly industry).

Accounting RFNBOs towards the H&C sector would also support their deployment in hard-to-decarbonise industrial sectors (sub-option 2.1) if the H&C target is set at ambitious level, contributing to the creation of an early market demand for RFNBOs. This would be useful, given the current low carbon price (ETS) as well as high production costs for RFNBOs. RFNBOs are far from being competitive compared to conventional fuels like natural gas or oil, but also compared to fossil-based on-site production of hydrogen via steam methane reforming. However, other renewable alternatives for the building and the industrial sectors remain more competitive than RFNBOs (e.g., heat pumps or district

[144] See Draft for BImSchG, §37(4a). German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety. (2021). Kabinettentwurf eines Gesetzes zur Weiterentwicklung der Treibhausgasminderungs-Quote. 29. January 2021. Available at: https://www.bmu.de/gesetz/kabinettentwurf-eines-gesetzes-zur-weiterentwicklung-der-treibhausgasminderungs-quote/

heating for low-temperature heat in households), and may be preferred solutions to reach the H&C target. Therefore, the impact would remain limited.

Sub-option 2.2 (accounting methodology for RFNBOs)

Sub-option 2.2 focuses on methodological changes to prevent double counting and create a consistent framework for the calculation methodologies laid out in Article 7(4) and Article 25(1) (for details see option description for Sub-option 2.2). In case, RFNBOs are consumed in the same country as the respective renewable electricity has been produced, no positive impacts are expected with regard to the actual fuel demand and market ramp up. However, the efficiency losses – which are especially high for the production of liquid RFNBOs(e.g., PtL diesel) – will be considered in the statistics, since only the energy content of fuels consumed will be taken into account – rather than the renewable electricity to produce them. Consequently, the contribution of renewable energy consumed in different countries will decrease and require a higher ambition to achieve the renewable energy targets. Considering the maximum projections of the CTP impact assessment and assuming that the total volumes of hydrogen, e-gas and e-liquid will be provided as RFNBO and not in form of other low carbon fuels in 2050, the following impact is expected (see Table 0-22). Due to the low overall efficiency, especially the production of liquid RFNBOs (here: PtL diesel) has a significant impact in the final energy demand: in case the electricity consumed is counted instead of the energy content of the final fuel, RFNBOs would contribute to with 32.3% to the final energy demand. The actual renewable energy consumed (and accordingly conventional energy substituted) would, however, only account for 19.4%.

This levering effect also applies for the question of target additionality. Since grid-RFNBO production requires additionality of the RES installation capacity (recital (90)), the additional installation of large amounts of RES electricity production sites for RFNBOs will considerably reduce the additional efforts for further RES production. The reason is that - when renewable electricity for RFNBO production is fully accounted to the renewable targets – the RFNBO production reduces the otherwise required renewable electricity generation to a certain extent, although the energy is not usable for final consumption due to conversion losses. Consequently, RES targets need to be adjusted accordingly, in case the current methodology in RES II is maintained. If sub-option 2.2 is applied instead, this would be beneficial for the renewable electricity industry, since target additionality can be ensured.

Table 0-22: Contribution of RFNBOs to RES shares based on sub-option 2.2 (Source: LBST based on SWD(2020) 176 final)

	Unit	Total	Hydrogen	e-gas (synth. methane)	e-fuels (PtL-diesel)
Conversion efficiency[145]	%	-	62%	50%	41%
Revised methodology sub-option 2.2					
Energy amount RFNBOs required according to CTP	TWh	1,447	671	212	564
Share RFNBOs in FED	%	19.36%	8.97%	2.83%	7.55%
Current methodology RED II					
Required RES electricity for RFNBO production	TWh	2,882	1,082	424	1,376
Share RES electricity in FED	%	32.34%	12.15%	4.76%	15.44%

Regarding import and trade of RFNBOs between two countries, a shift in the accountability from the RFNBO-producing to the consuming country creates an incentive for the national authorities in the latter to support the market penetration and consumption of RFNBOs. Such a market pull-effect might be created, connected to distributional effects discussed below as a social impact.

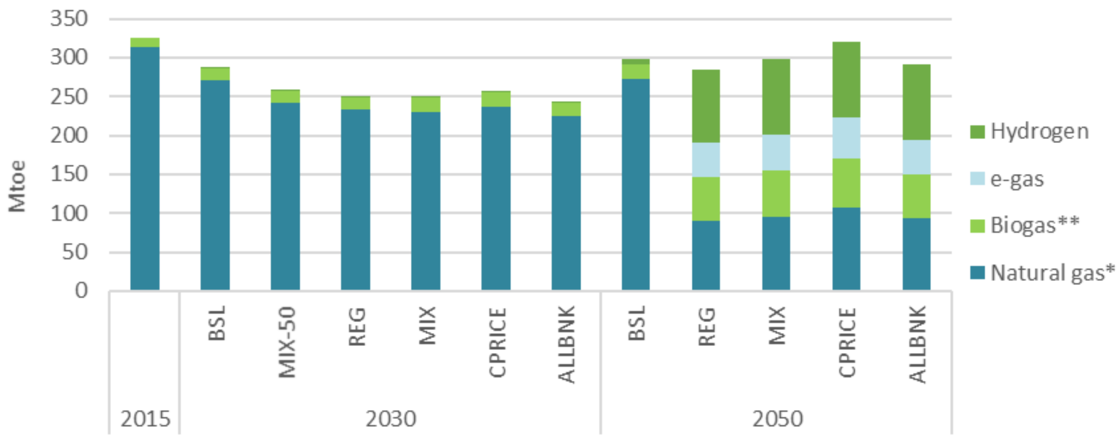
Option 4 (sub-targets for RFNBOs)

In contrast to that, sector-specific targets for RFNBOs in hard-to-decarbonise sectors will create an early market demand for RFNBOs. This is necessary, given the current low carbon price (ETS) as well as high production costs for RFNBOs. RFNBOs are far from being competitive in light of kerosine (aviation), maritime fuels, or on-site production of hydrogen via steam methane reforming for industry purposes. Such targets will create investment security for a respective market ramp-up of production facilities as well as the required renewable electricity potential.

The significant anticipated change in the importance of RNFBOs like hydrogen and e-gas (methane) is shown in Figure 0-31. In CTP scenarios achieving deep decarbonisation within all energy-consuming sectors the consumption of gaseous RFNBOs will significantly increase to about 140-151 Mtoe (1,622 to 1,752 TWh) by 2050, compared to about 7 Mtoe or 87 TWh in the baseline scenario.

[145] Values (well-to-tank) only assumptions for demonstrative reasons based on LBST & Hinicio. (2019). Future fuel for road freight. Available at: http://fondation-tuck.fr/upload/docs/application/pdf/2019-03/future-fuel-road-freight-report_lbst-hinicio_2019-02-19.pdf. Actual values of overall conversion efficiencies strongly depend on technology development, carbon source (e.g., DAC or biogenic), transport and (if required) import pathways, and application requirements.

Figure 0-31: Consumption of gaseous fuels per gas type based on the impact assessment of the CTP (Source: SWD(2020) 176 final)



In case the 40 GW target, formulated in the EC's hydrogen strategy, will be reached by 2030, theoretically 10 million tonnes of hydrogen (29 Mtoe or 333 TWh) could already be provided by 2030 (assuming high capacity factors over 8,000 hours by direct connection to renewable electricity or other mechanism like PPA ensuring criteria like additionality are fulfilled).[146]

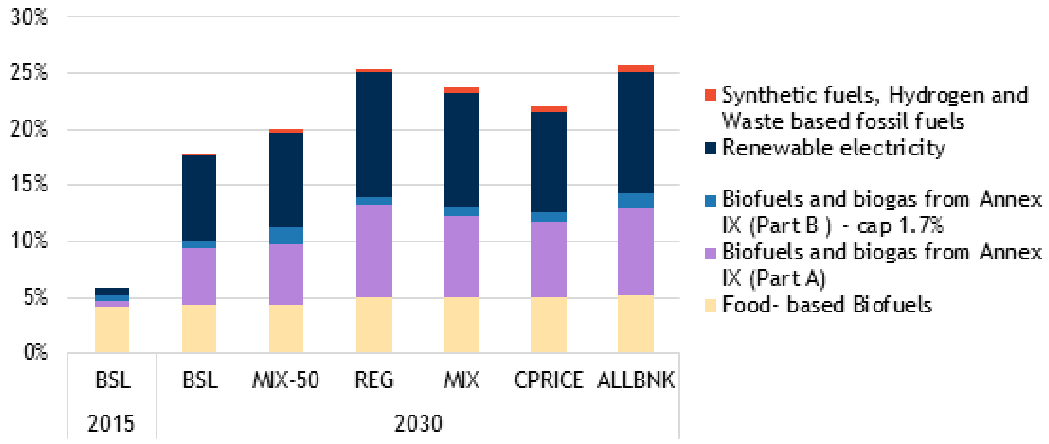
Regarding this option, the question is whether sector-specific targets will help facilitate uptake of renewable hydrogen in hard-to-decarbonise sectors, like maritime, aviation or industry. Also, the values of the actual targets are crucial for whether the sectoral demands will contribute and support the targeted installation ramp-up in electrolyser capacity.

Following the analysis in the CTP, an increase in RES-T is required to achieve the 55.0% greenhouse gas reduction target by 2030. As shown in Figure 0-32, the scenarios for RES-T (transport sector) ranges from 17.7% in the baseline scenario, to between 20.1% and 25.8% in scenarios more likely to achieve the emission reduction target set. The gap, which must be filled in case of these higher ambition, is mainly filled by additional renewable electricity or biofuels Annex IX (mainly Part A).

In addition to existing multipliers for specific fuels, overall fuel consumption in the maritime and aviation sectors are not considered in the target calculation so far. Accordingly, de facto renewable share in transport will be much lower (see also Section F - Transport sub-option 3.2 for extending the scope of RES-T and sub-option 3.3 for policy options regarding multipliers in transport).

[146] COM(2020) 301 final

Figure 0-32: Disaggregation of the renewable transport target RES-T as per RED II (Source: SWD(2020) 176 final)



Aviation

In the aviation sector, there is the immediate need for a reduction of the carbon footprint. Although hydrogen powered aircraft applying fuel cell technology or H_2 turbines are in the development, it is not expected that the technological maturity allows for a rapid market introduction before 2035. Sustainable aviation fuels (SAF) like liquid RFNBOs or biofuels will therefore be crucial for reducing emissions until 2030 in the existing airplane fleets. Based on an on-going impact assessment performed for DG MOVE, their share in overall jet fuel consumption needs to rise from 0.05% today to about 2% in 2025 and 5% in 2030. In 2050, up to 63% of the of the jet fuel consumption in the EU needs to be covered with SAF.[147]

Accordingly, the focus for short-term measures needs to lie on liquid RFNBOs, either as a drop-in fuel for conventional aircrafts (competing with advanced biofuels) or as intermediate product in the production process of aviation and maritime fuels (i.e. required for desulphurisation of heavy oils). The ReFuel EU aviation initiative addresses the problems of high costs for RFNBOs and advanced biofuels and consequently the lack of investments and limited feedstock potential.[148] To support commercial roll out of these fuels at an early stage, different measures are proposed, including a blending mandate and a revision of the multipliers.

A higher multiplier may help MS to achieve their national targets and shift the focus of fuel suppliers more on the production of RFNBOs. At the same time, this may have unintended consequences, as it could also provide the incentive to fuel producers to shift their product slate to maximize their jet fuel production while decreasing their overall production of RFNBOs. This could result in policies that spend more money on lower overall fuel production within the transport sector, thereby increasing the effective cost of carbon reductions. In case, quota for the aviation and maritime sectors are introduced, which rather focus on the demand side instead of the fuel supply side, there is no need for a specific target for RFNBOs in RED II as proposed in option 4. The ReFuel EU Initiative further discusses a funding mechanism (channelling funds through one or more EU financial instruments with the aim of encouraging the deployment of production facilities), a central auctioning mechanism (producers would be invited by a central auctioning authority to bid at the lowest price to supply a certain volume of SAF

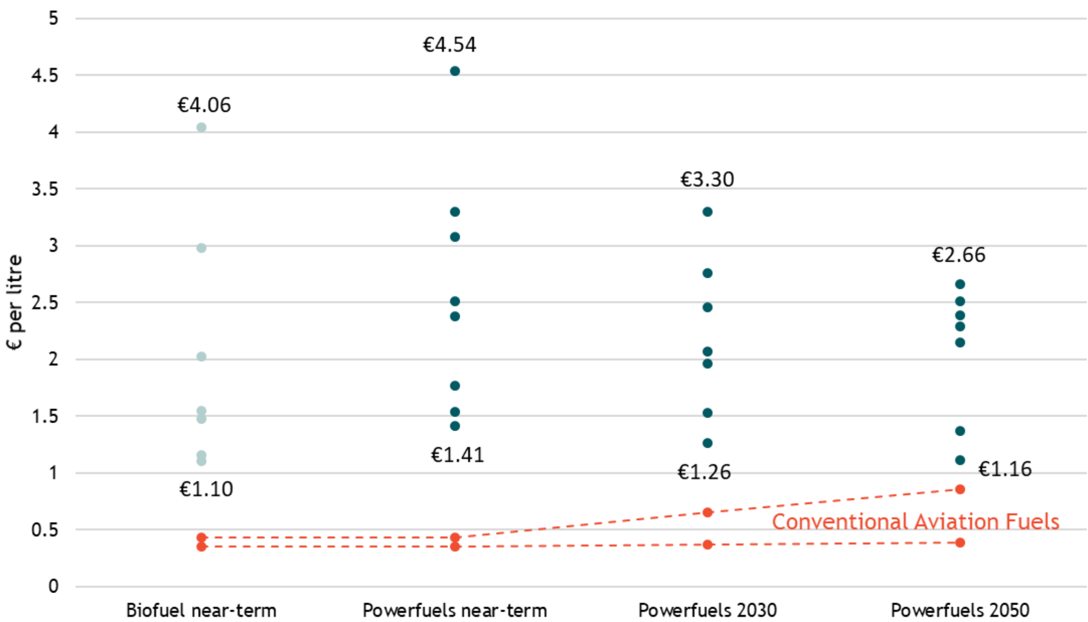
[147] DG MOVE: INCEPTION IMPACT ASSESSMENT. (2020). ReFuelEU Aviation - Sustainable Aviation Fuels. Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels

[148] For a detailed cost analysis of different transport fuels, please also see Annex F – Transport.

to the aviation market over a certain period) or better monitoring (key performance indicators could be designed to monitor the effects of policies taken). Although the aviation sector may be subject to higher operating costs in the short term, significant improvements in the sustainability of its operations will allow it to sustain its current growth trends in the longer term, including through lower carbon emission costs.

A main argument for a sectoral target regarding RFNBOs is the harmonisation within the EU and creating a level playing field among all MS. In addition, it establishes a stable policy framework over a sufficient time horizon to provide investors with the necessary confidence to invest in the production of sustainable aviation fuels and for airlines to pursue an efficient fuels policy to the target, promoting the development of SAF and reduces their costs. While for hydrogen and e-fuels the main cost driver will be the production cost for renewable electricity, limited production capacity and feedstock availability mainly cause higher cost for advanced biofuels compared to conventional biofuels. According to a calculation of the European Technology and Innovation Platform, the costs of RFNBOs are relatively high with up to 7 €/litre. However, the price is expected to fall to €1 to €3 per litre by 2050[149], if economies of scale can be achieved and the price of renewable electricity. Another literature review of several cost estimates for aviation fuels is shown in Figure 0-33, indicating the high gap between different biofuels and kerosine (short term) and e-fuels and kerosine (mid-to long-term).[150] The authors also analysed, that even a significant drop-in of SAFs will only result in moderate ticket price increases: assuming the medium of near-term cost estimation (2.4 €/litre), a 10% blending rate is expected to increase ticket prices by around 10% (15 € for a 1,700 km flight and 53 € for a 7,500 km flight).

Figure 0-33: Meta-analysis of cost estimates for biofuel and SAF ("powerfuels") in the literature (€/litre) compared with Conventional Aviation Fuel (CAF) (Source: LBST based on dena 2019)



149 European Technology and Innovation Platform. (n.d.). Overview on electrofuels. Available at: https://www.etipbioenergy.eu/value-chains/conversion-technologies/electrofuels
150 Deutsche Energie-Agentur (dena). (November, 2020). Global Alliance Powerfuels: Powerfuels in Aviation.

In the long term, however, the consumption of SAFs may focus on long-range zero-emission aircrafts, while hydrogen-based alternatives might prevail for short-range aviation. Based on an analysis by McKinsey for the FCHJU, the additional cost for hydrogen aircrafts (short-range, 2000 km in 2040) will be 25% in 2035, compared to a kerosene-based aircraft.[151] While this includes a nine percent increase in energy costs, this covers CAPEX, maintenance and other costs for the new aircraft design. This will be significantly lower than the case of e-fuel production based on renewable hydrogen and CO_2 from DAC, which shows 32% higher fuel cost compared to kerosene. Although the study projects the requirement for liquid hydrogen to be between 42 and 135 million tons per year by 2050 (equivalent to 500 or 1,500 GW electrolyser capacity), the early ramp-up is not expected to start before 2035.

Maritime

Like the ReFuel EU aviation, the Fuel EU Maritime initiative aims to accelerate the uptake of "sustainable alternative fuels", including RFNBOs and advanced biofuels for shipping. Possible measures are among others an extension of the EU Emission Trading System (ETS) to the maritime sector, as discussed for the new FuelEU Maritime Initiative. In that case, the incentive for the introduction of RFNBOs will raise with increasing carbon price. Still, the required carbon price level in 2030 for liquid e-fuels compared to oil (assumed wholesale price: 48 €/MWh in 2030) is expected to be around 579-732 €/tCO_2-eq.[152] At that level in 2030, no RFNBOs will be taken up by the maritime sector based on an inclusion into the ETS. For hydrogen used as ship fuel, carbon price levels would have to be in the range of 187-292 €/tCO_2-eq, which is still too high for any uptake based on the ETS. Ammonia produced from renewable hydrogen would be between the hydrogen and the e-fuels level, but rather closer to the lower hydrogen level than to the higher e-fuels level.

However, if maritime CO_2 emissions are included in the EU ETS, like aviation was in 2012, pressure may build on the International Maritime Organization to develop an international carbon-pricing mechanism. This, however, might be a long-lasting process. Accordingly, to promote a significant ramp-up even before 2030, a sectoral target or quota obligation might be required. Unlike the aviation initiative, the FuelEU Maritime Initiative does not foresee an obligation for fuel suppliers. Instead, another measure discussed aims at a revision of the Energy Taxation Directive: the current mandatory tax exemption could allow for the use of more targeted tax incentives to promote the use of sustainable alternative fuels while an increasing scope for the reduction of the tax rate applicable to shore-side electricity (potentially going even to zero) could further incentivise the use of shore-side electricity. Moreover, a revision of relevant environmental and energy state aid guidelines, as discussed in the Fuel EU Maritime initiative, based on the policy objectives set through the European Green Deal, would provide a level-playing field in the internal market also in this sector (including for deployment of on-shore charging infrastructures).

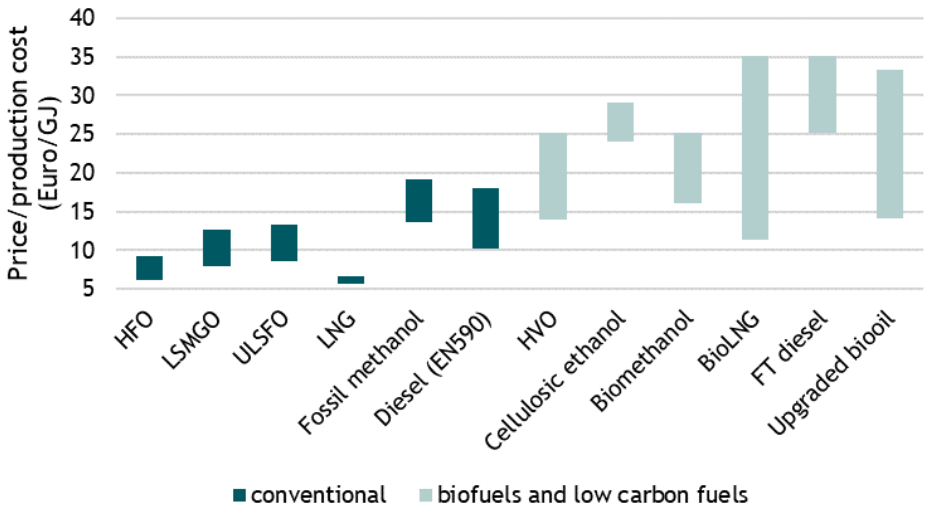
The main two types of fuels used in the shipping sector today are residual fuels such as heavy fuel oil (HFO) and distillates, produced by the distillation of crude oil (e.g., marine gas oil (MGO), marine diesel

[151] A study for Clean Sky 2 JU and the Fuel Cells and Hydrogen 2 JU (FCH2JU) by McKinsey & Company. (2020). Hydrogen-powered aviation – A fact-based study of hydrogen technology, economics, and climate impact by 2050. May 2020. Available at: https://www.cleansky.eu/sites/default/files/inline-files/20200507_Hydrogen-Powered-Aviation-report.pdf

[152] Guidehouse et al. (2020). Technical assistance to assess the potential of renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs) as well as recycled carbon fuels (RCFs), to establish a methodology to determine the share of renewable energy from RFNBOs as well as to develop a framework on additionality in the transport sector. 2nd interim report | Task 1 Assessment of the potential of RFNBOs and RCFs over the period 2020 to 2050 in the EU transport sector. 21 January 2021

oil (MDO) as well as their low-sulphur (LS) derivates). A cost comparison between conventional and advanced biofuel or low carbon alternatives (e.g., Fischer-Tropsch (FT) diesel) marine fuel prices is shown in Figure 0-34, indicating the significant price gap between conventional (dark blue) and biofuel or low carbon fuels (bright blue).[153]

Figure 0-34 Comparison of marine fuel prices with advanced biofuel costs (Source: LBST based on TNO et al., 2019)



In contrast to aviation or industry, maritime stakeholders also discuss the development of ammonia (based on renewable hydrogen) as another alternative renewable fuel for maritime applications, applying either fuel cells or internal combustion engines.[154] While it is expected that there is a cost-advantage compared to renewable hydrogen, its application will rather focus on long distance shipping due to its higher energy density and accordingly lower space requirements onboard. Despite its significant role in current chemical and fertilizer industries, there are only a small number of existing projects using hydrogen as a fuel for shipping. Accordingly, several risk- and safety-related questions remain open.

Inclusion of transport in the ETS

Aviation is included in the European ETS. However, other transport sub-sectors are not, but are currently considered for inclusion. In this case, carbon prices in the ETS would need to be in the order of several hundred Euros per ton of CO_2 equivalent for incentivising market uptake of RFNBOs if no other policy actions are complementing the ETS: ranges of 579-732 €/tCO_2-eq for e-fuels, or 187-292 €/tCO_2-eq for renewable hydrogen (up to 400 €/tCO_2-eq including distribution and refuelling station[155]) would be required (see section above). For biofuels, marginal GHG reduction costs could be lower for existing fuel production pathways[156] by improving their GHG intensity in a GHG emissions target approach compared to an energy target approach. It must be cautioned, however, that marginal improvements to existing pathways may be largely attributed to theoretical improvements (i.e. “on

[153] TNO et al. (2019). Advancefuel project: Deliverable D5.1: Market analysis RESfuels in transport sector. Available at: http://www.advancefuel.eu/contents/reports/d51-marketanalysis.pdf

[154] Lighthouse (Swedish maritime competence center): On the potential of ammonia as fuel for shipping. January 2020.

[155] See Annex F - Transport; see also: ICIS: Carbon market spotlight: Discussing sector extension options for the EU ETS; March 2021

[156] See Annex F - Transport

paper") rather than actual reductions of GHG emissions to the atmosphere as described in Annex F - Transport option 4.

As carbon pricing would not address all barriers to the deployment of renewable fuels, and as carbon price levels would not be sufficiently high in ETS, additional policy actions such as most notably provisions in RED II such as specific RFNBO targets would be necessary to ensure that all obstacles to investments in clean energy technologies and infrastructure are overcome. RED II provisions such as a target for RFNBOs (ideally differentiated between hydrogen and e-fuels, at least in road transport[157]), need to be put in place as a more specific enabling framework. Both tools are thus complementary and mutually reinforcing.

Industry

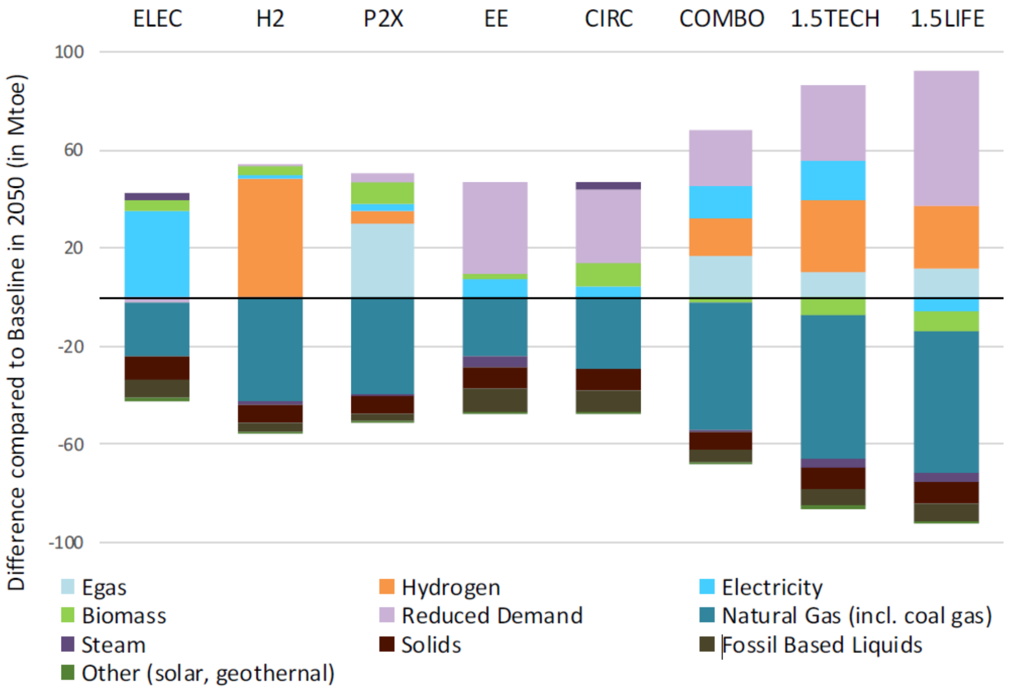
For the industry sector, impacts will be different for the different sub-sectors. The main differentiation, however, will be between ETS-sector and non-ETS sectors. As this option is dedicated to hard-to-decarbonise sectors, the focus of the analysis will be on the impacts on ETS-sectors in industry, i.e. excluding electricity generation, and it focuses on the major emitting industry sectors in order to achieve relevant emissions reductions.

Defining a target for RFNBO consumption in industry could either be accomplished through a demand-side obligation on the respective industries, or a supply-side obligation on energy suppliers to these respective industries. A supply-side obligation would follow the same logic as already established in RED II for the transport sector where an obligation is to be put on fuel suppliers to increase the share of renewable energy supplied to the transport sector. However, industry is much more diversified in terms of sectors, applications, fuels, and suppliers. Focussing on the hard-to-decarbonise sectors covered under the ETS includes consumption of coal and coke (notably in steel making), petroleum products (notably in refining and the petrochemical industry), and natural gas (notably in hydrogen production for use in refineries and chemical industries; natural gas consumption for process heat may also be relevant). As a consequence, suppliers would have to distinguish their supply between the different sectors and sub-sectors such as different industry sectors, but also buildings (for space heating) and other uses. Also, the fuel markets are different including gases (fossil or biomethane, hydrogen), liquids, solid fuels. On the other hand, the sectors covered here generally include large companies which have their own energy procurement units, which are qualified and have the resources to deal with a consumption obligation. Therefore, a supply-side obligation would require significantly less administrative resources from the economic operators affected.

For some of the major sub-sectors, renewable or low carbon hydrogen can technically replace hydrogen consumption directly, which is currently produced in general from fossil sources of energy. As illustrated by Figure 0-35 below, to reach full decarbonisation by 2050, hydrogen represents an important energy carrier for the industry.

[157] Following the efficiency first principle, the direct usage of hydrogen should be promoted over e-fuels, to take additional conversion losses and lower efficiencies of ICE engines compared to FCEVs into account (see also Annex F – Transport).

Figure 0-35: Differences in final energy consumption in industry compared to Baseline in 2050 (Source: In-Depth Analysis in support of the Commission Communication COM(2018) 773)



Major hydrogen consumers are ammonia production and methanol production as well as refineries; while ammonia production and refining are significant in the European Union, methanol production is rather limited as Europe to a large extent relies on imports. For other industry sectors, conventional processes do not allow for hydrogen consumption in existing facilities (or only to a limited extent), but new installations dedicated to production processes based on hydrogen consumption are required. Major examples are steel making, which is conventionally based on coal/coke using blast furnaces, or high-value chemicals such as olefins and aromatics produced in the chemical and petrochemical industries. High value chemicals (HVC) refer to a wide range of petrochemical products, which can be grouped into two major categories: olefins (mainly ethylene and propylene) and aromatics (benzene, toluene, and xylenes). Conventional production is mainly based on naphtha cracking. Innovative HVC production comprises the so-called Methanol-to-Olefins (MTO) and Methanol-to-Aromatics (MTA) processes based on methanol input. In this context, hydrogen is not directly a feedstock to the MTO and MTA processes, but to the preceding green methanol production (see above). For all of the above-mentioned industry sub-sectors, hydrogen costs are a major cost factor, if not the most important one. At the current level of renewable hydrogen generation costs, renewable hydrogen use in these industry sub-sectors is not cost-competitive with conventional production methods[158]. According to the EC's Hydrogen Strategy[159] for the 2025-2030 phase "*renewable hydrogen is expected to gradually become cost-competitive with other forms of hydrogen production, but dedicated demand side policies will be needed for industrial demand to gradually include new applications, including steel-making […]*".

[158] See e.g., Fraunhofer ISI: Industrial Innovation: Pathways to deep decarbonisation of Industry - Part 2: Scenario analysis and pathways to deep decarbonisation. March 2019.
Dechema: DECHEMA: Technology Study – Low carbon energy and feedstock for the European chemical industry, June 2017
[159] COM(2020) 301 final

Setting an RFNBO consumption obligation for these hard-to-decarbonise industry sectors would thus have strong negative economic impacts if no additional measures are taken to ensure international competitiveness. These could either include public funding, such as through contracts for difference, or a Carbon Border Adjustment Mechanism levelling the playing field between EU industries achieving carbon reductions, and non-EU industries not achieving these climate ambition levels. In this sense, additional measures are essential to neutralise potentially strong negative economic impacts as well as the ensuing negative social impacts, notably in terms of job losses. On the other hand, if these additional measures are established and are in force in combination with the ETS, a dedicated RFNBO target for industry in the framework of RED II may have little additional effect for GHG reduction. However, an obligation focused on renewable energy (in contrast to a GHG reduction obligation) would have positive impacts in facilitating the commercialisation and market uptake of renewable solutions rather than low carbon non-renewable solutions. As indicated above, international competitiveness would require such an obligation to be established in combination with other policy instruments. The latter would, if combined with a renewable consumption obligation, be adjusted differently taking into account higher costs of renewable solutions compared to low carbon non-renewable solutions, at least for a certain time. The motivation here would be to support market introduction of renewable solutions in a timeframe until 2030, for large-scale uptake between 2030 and 2050 for full decarbonisation. The long-term full decarbonisation perspective requires the implementation of technologies and concepts that allow for zero GHG emissions, which major fossil solutions based on CCS cannot ensure (see also option 3 and 5).

The combination of ETS with an RFNBO target for the industry could provide sufficient incentive to trigger market uptake, if the RFNBOs target is designed to fit for specific sectors where no other low carbon alternatives would be available to decarbonise. For industrial processes having various solutions for their decarbonisation, such as electrification, biomethane, or other biomass-based energies, it would be restrictive to fix a specific RFNBOs targets where these alternatives would also fit. RFNBOs target for the non-ETS would only force the use of these fuels where more efficient alternatives would be more relevant.

Sector-specific targets in hard-to-decarbonise sectors will create an early market demand for RFNBOs. However, as described in the option definition, such target for the industry would first require identifying those sectors where there is no other low carbon alternative. This would become complicated as:

- Biomethane would always remain a technically viable option, replacing natural gas with also minor changes on demand side (while some RFNBOs may require complete changes). For some industries, depending on local parameters and conditions, biomethane could be an economically more attractive solution;
- This would also strongly orient the fuel mix of MS, pushing them to deploy RFNBOs, while some may be willing to use other low carbon and renewable fuels (e.g., RCF, biomethane, etc.).

Therefore, the following variants to option 4 applied to the industry could be considered

- **Extend the RFNBOs target to other renewable gases and fuels**, but then it would be close to an overall renewable target, as these would then jeopardize the use of more directly available options such as geothermal heat, solar heat or locally available waste streams (waste heat, waste wood, etc.);

- **Oblige MS fixing clear targets of RFNBOs** in all hard-to-decarbonize sectors (especially in the industry), in line with their 55% target. This would at least ensure a commitment of MS to assess their potential for RFNBOs in those sectors, when figuring out their roadmap to reach their contribution to 55%, and update their NECP accordingly.

Another alternative to the option could cover the more precise **existing hydrogen consumption** in industry, setting a global share (% of the total national H_2 consumption) of hydrogen to be supplied with Option 4 - renewable hydrogen (replacing existing national demand of fossil-based hydrogen by renewable-based hydrogen). It could be a yearly increase of renewable hydrogen share in the total national hydrogen consumption (similar to the H&C target, Article 23 RED II), or a 2030 target. As the % would be the same for all MS, a yearly increase would probably be more adapted.

Another target may be required for the new industrial use of hydrogen/RFNBOs (mainly the industry moving from fossil fuel(s) to hydrogen/RFNBO, whatever its origin), ensuring new applications rely at least on a certain percentage share of renewable-based hydrogen.

The replacement of fossil-based hydrogen with renewable-based hydrogen may prove effective to ensure higher uptake in industries already consuming mainly fossil-based hydrogen. However, this should take care of the following: [160]

- Like in the case of a RES target for the industry, such RFNBO (or hydrogen) target for the existing use of hydrogen would certainly be lower than a global expected (from the conversion of fossil to renewable-based hydrogen) contribution to the 55% target;
- Imposing the replacement of fossil-based hydrogen by renewable-based hydrogen could be negatively perceived by some MS counting on “blue hydrogen”, as stated in their NECP (according to the Study on Opportunities arising from the inclusion of Hydrogen Energy Technologies in the National Energy and Climate Plans[161], Figure 2-2, page 16, 7 MS rely on a mix of RES-H_2 and SMR/CCUS H_2);
- It makes sense to address the existing demand as a priority (it could be a pull to deploy the production infrastructure, and already start with the production of renewable-based hydrogen, without relying on the demand side deployment which may take longer), however this would not incentivize / nor ensure the adoption of renewable-based hydrogen in sectors which do not already consume (fossil) hydrogen. In addition, specific solutions should be designed to further incentivise the deployment of renewable energy in those hard to abate sectors (e.g., steel production, chemicals / fertilisers, …). Therefore, variant 2 to option 3, obliging MS fixing clear targets of RFNBOs in hard to abate sectors should be an essential measure to couple with the target for existing hydrogen use. It should also be recommended to MS to set up targeted measures in several different sectors, such as procurement mechanisms (production tariffs or auctions) to stimulate the early phase of market deployment (see more examples of targeted measures in the Hydrogen Act, Towards the Creation of the European Hydrogen Economy, Hydrogen Europe April 2021[162]);

[160] The same aspect should be considered if a combined target for RFNBOs and low carbon fuels is implemented as described in option 5 below.
[161] Trinomics & LBST. (2020). Study on Opportunities arising from the inclusion of Hydrogen Energy Technologies in the National Energy & Climate Plans. Available at: https://www.fch.europa.eu/sites/default/files/file_attach/Final%20Report%20Hydrogen%20in%20NECPs%20%28ID%209501746%29.pdf
[162] Hydrogen Europe. (2021). Hydrogen Act - Towards the Creation of the European Hydrogen Economy. Available at: https://www.hydrogeneurope.eu/wp-content/uploads/2021/04/2021.04_HE_Hydrogen-Act_Final.pdf

- If not properly designed and implemented, this measure could create a counter-incentive to the projects/industries aiming to replace existing fossil-based fuels by hydrogen/RFNBOs, by placing additional administrative burden (to comply with the target, providing the proof that this consumption is based on renewable hydrogen). This is also counter intuitive, as the switch to hydrogen is currently driven by the need to replace fossil or at least to reduce carbon emissions (what would be the aim for a steel industry to switch to Direct Reduction Iron with hydrogen, if it's not related to decarbonise its process?). Therefore, it is expected that all switches are following a carbon logic, and in any case, this should be left to the MS to decide whether they push to RES-H_2 or low carbon H_2;
- The approach should always remain specific to each sector. For example, for refineries that are largely or fully dependent on hydrogen produced through SMR, it will be slightly more attractive to switch to renewable or low carbon hydrogen than for refineries where hydrogen is produced as a by-product of the refining process.[163] There is a large heterogeneity in the presence and size of the refinery industry across the EU and consequently in the levels of captive hydrogen demand, increasing the risk of discrepancies when fixing a conversion target (from fossil to renewable-based hydrogen);
    - In ammonia production, the CO_2 produced in SMR installations can be captured, transported, and re-used in other industries (CCU) or stored (CCS) so that hydrogen can be produced from natural gas with a low carbon intensity[164]. The latter would be an attractive option for ammonia producers at an ETS price of around 30 EUR/ton. 54% of ammonia production capacity is concentrated in four countries (DE, PO, NL & FR). In principle, the opportunity exists in all countries (12 MS in total) to switch from fossil hydrogen (SMR without CCS) to renewable or low carbon hydrogen. However, in some countries the environmental factors and policy framework might be more favourable for such a shift than in others. In the Netherlands for instance, a subsidy scheme has been introduced which also allows for financial support to CCS operations, including CCS in the ammonia industry;
    - To date, the methanol industry is the third largest hydrogen consumer in Europe. (mainly DE, NL, NO). As in ammonia industries and refineries, SMR is the dominant technology for hydrogen production in the methanol industry. However, an important difference is that methanol synthesis does not only require hydrogen as an input, but also CO_2. This means that a switch to renewable hydrogen always needs to be complemented with a 'climate-neutral' source of CO_2, such as biogenic CO_2 or CO_2 captured from the atmosphere. A switch to renewable hydrogen-based processes will hence be more costly in the methanol industry than in the ammonia industry or in refineries (that strongly depend on SMR-based hydrogen). Also, the ability to switch to such processes in the short term will depend strongly on local availability of 'climate-neutral' CO_2 sources.[165]

[163] Trinomics & LBST. (2020). Study on Opportunities arising from the inclusion of Hydrogen Energy Technologies in the National Energy & Climate Plans. Available at: https://www.fch.europa.eu/sites/default/files/file_attach/Final%20Report%20Hydrogen%20in%20NECPs%20%28ID%209501746%29.pdf

[164] For low carbon fuels, see also options 3 and 5.

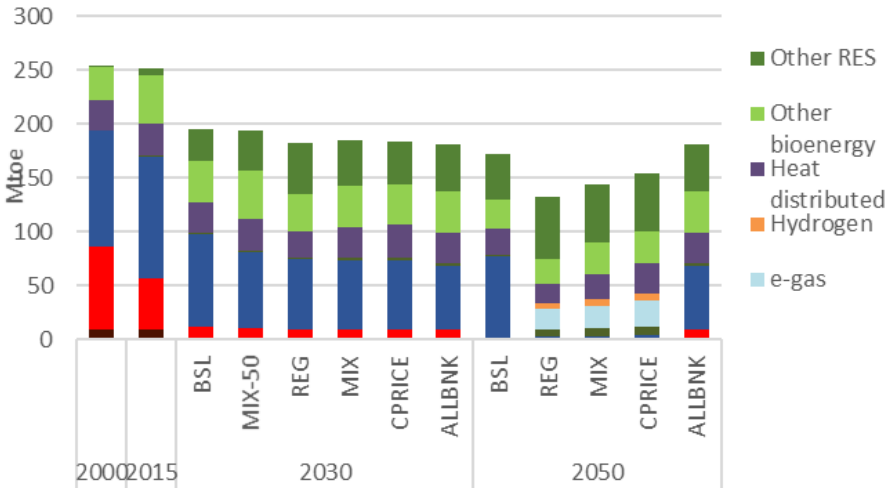
[165] The Dutch methanol producer BioMCN has done a feasibility study for installing a 20 MW electrolyser in Delfzijl, in view of expanding its methanol production capacity. The CO_2 that is needed as an input would be obtained from other industrial processes nearby, see https://www.nouryon.com/news-and-events/news-overview/2019/biomcn-to-produce-renewable-methanol-with-green-hydrogen/

In addition, from a carbon emissions perspective, the replacement of other fossil fuels and feedstocks (coal in steel, petrol, diesel, kerosene, etc.) with renewable-based hydrogen has a higher impact than the replacement of the consumption of fossil-based hydrogen. Therefore, a measure only incentivizing the replacement of fossil-based hydrogen with renewable-based hydrogen without creating the environment for the adoption of renewable hydrogen in new sectors would be a lost opportunity.

Buildings

In the building sector, hydrogen and other RFNBOs are not yet expected to play an important role, even by 2050, as illustrated by Figure 0-36.

Figure 0-36: CTP Impact Assessment Figure 57: Non-electricity energy consumption in (residential and services) buildings (Source: SWD(2020) 176 final)



Option 3 and option 5 (low carbon fuels)

Low carbon fuels in form of recycled carbon fuels (RCFs) may already be considered by MS for the calculation of the sectoral target in transport under RED II. These fuels are based on the processing of e.g., solid and liquid waste flows into different kind of gaseous and liquid hydrocarbons. However, a delegated act by the EC will define details on sustainability criteria to evaluate their impact in terms of greenhouse gas emissions by the end of 2021. In line with that, this section focuses on the advantages to also allow the accountability of other low carbon fuels (option 3).

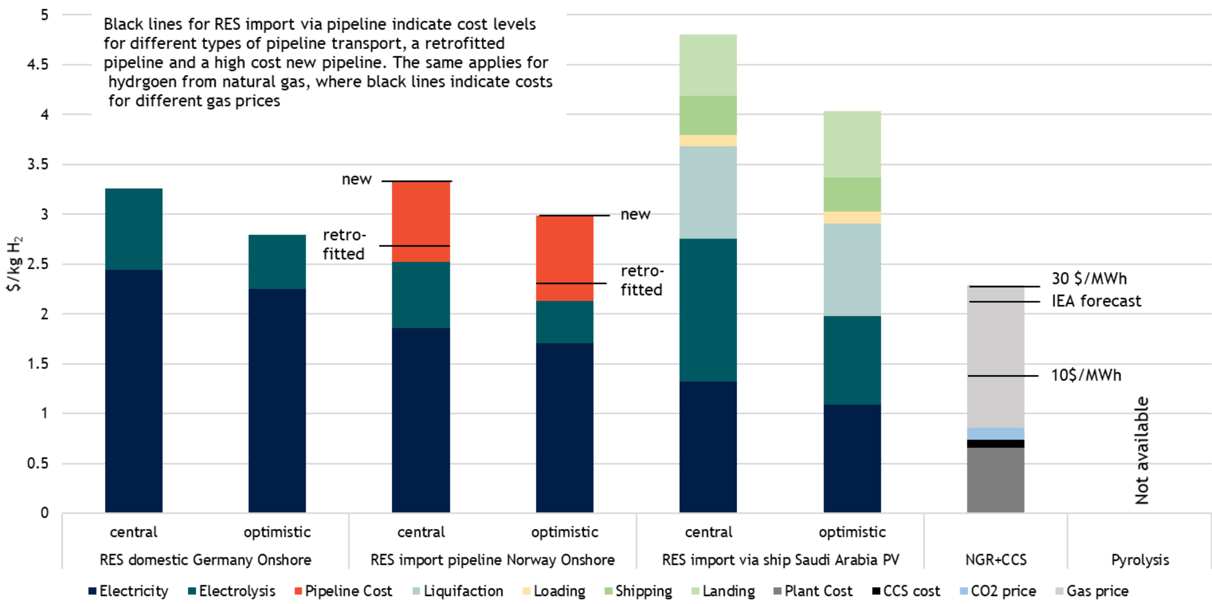
In general, to ensure a fair competition, fuel suppliers of low carbon fuels should face the same GHG emission reduction requirements for low carbon fuels as for RFNBOs (70% requirement set out for RFNBOs in Article 25(2) under RED II). Low carbon e-fuels are based on hydrogen produced mainly via steam methane reforming including CCS or CCU, pyrolysis, and electrolysis based on non-renewable electricity (e.g., grid electricity not fulfilling criteria in recital 90).

The economic impact of the accountability of low carbon fuels for the sectoral renewable targets in RED II (option 3) or even the introduction of a combined target for RFNBOs and low carbon fuels (option 5) mainly focus on the supplier of those low carbon fuels. Based on the premature character of all RFNBO and low carbon fuel production pathways, hydrogen as feedstock plays a pivotal role in cost comparison. Since low carbon fuels like hydrogen from grid electricity or nuclear power, SMR + CCS or pyrolysis are potentially low-cost alternatives compared to their renewable counterpart, these measures would create a market which would foster investments, especially in CCS and pyrolysis technologies, but also grid-based electrolyser technology, which currently all do not exist in large scale.

While in general fossil-based technologies do have a cost advantage today, depending on regional RES production potential and capacity factors and the significance of political directing instruments, i.e. carbon prices, the break-even between renewable and low carbon technologies may differ.

In the case of Germany, a comparison of different hydrogen supply costs indicates that SMR with CCS will outperform domestic hydrogen production and different import pathways in 2030 (see also Figure 0-37).[166] Only under optimistic assumptions like low costs of renewable energy, usage of existing import infrastructure (e.g., from Norway) as well as high natural gas prices of about 26 $/MWh, cost parity in 2030 could already be achieved. Carbon capture technologies might especially be a retrofit solution for current on-site production of hydrogen e.g., in refineries or chemical industry, which already today is a significant market, as Europe currently uses about 339 TWh hydrogen yearly.[167] There is an on-going political debate about long-time security and feasibility of large-scale storage of carbon dioxide in underground rock formations like saline aquifer. Consequently, potential for CCS projects will be limited to specific European countries, including mainly Norway, UK and the Netherlands with several current activities in this area. Pyrolysis is not expected to be commercially available until 2030, though technology development efforts have increased with the last years. Existing pyrolysis activities are focused on producing carbon material with predefined specifications for application mainly in the rubber industry. Accordingly, also the future competitiveness of hydrogen from pyrolysis will largely depend on possible revenues from carbon sales.

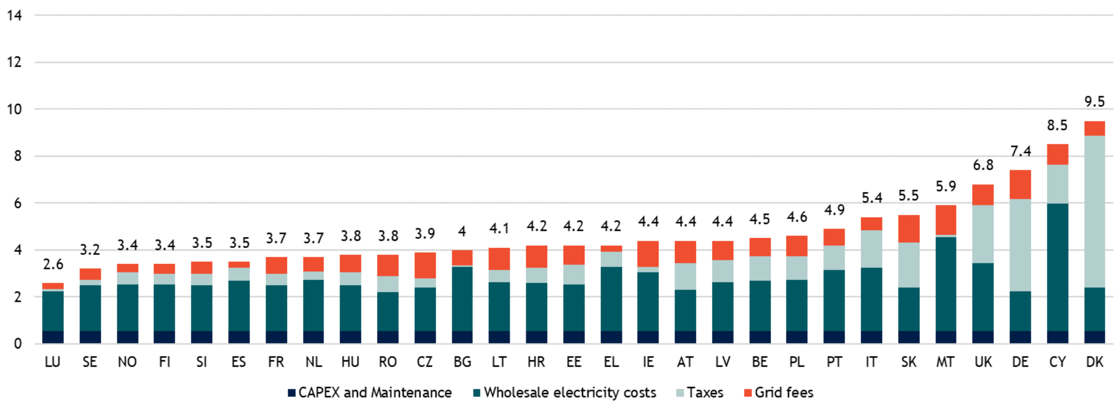
Figure 0-37: Comparison of hydrogen supply costs in Germany 2030 (Source: based on ewi (2020))



[166] Institute of Energy Economics at the University of Cologne (EWI). (2020). Estimating Long-Term Global Supply Costs for Low-Carbon Hydrogen. EWI Working Paper, No 20/04. November 2020.
[167] McKinsey. (2019). Report for the Fuel Cells and Hydrogen 2 Joint Undertaking. (FCH2JU): Hydrogen Roadmap Europe, January 2019. Available at: https://.fch.europa.eu%2Fsites%2Fdefault%2Ffiles%2FHydrogen%2520Roadmap%2520Europe_Report.pdf&usg=AOvVaw0abPrcLpsVYE1iGik5fwXm

Grid-based electrolysis would allow high utilization rates for electrolyser enabling low hydrogen production costs independent of the renewable electricity ramp-up in Europe.[168] However, due to the large cost components of taxes and grid fees in many countries, electrolysis using grid-based electricity is not a viable business case compared to renewable hydrogen production, especially at locations with preferable renewable potential. Hydrogen Europe compared todays hydrogen production cost of grid-based hydrogen production with renewable hydrogen production in different European countries. The respective costs in the EU MS (incl. Norway and the UK) in 2019 lay between 2.6 and 9.5 €/kg, with an average value of 4.7 €/kg (see Figure 0-38). In addition, only in some countries, including Norway, Sweden, Latvia, Lithuania, Luxembourg and France, the carbon intensity of grid electricity is sufficiently low to meet the 70% benchmark for RNFBO production under RED II. Due to an increased renewable electricity capacity, the national carbon footprints of the electricity mix will decrease in the next years.

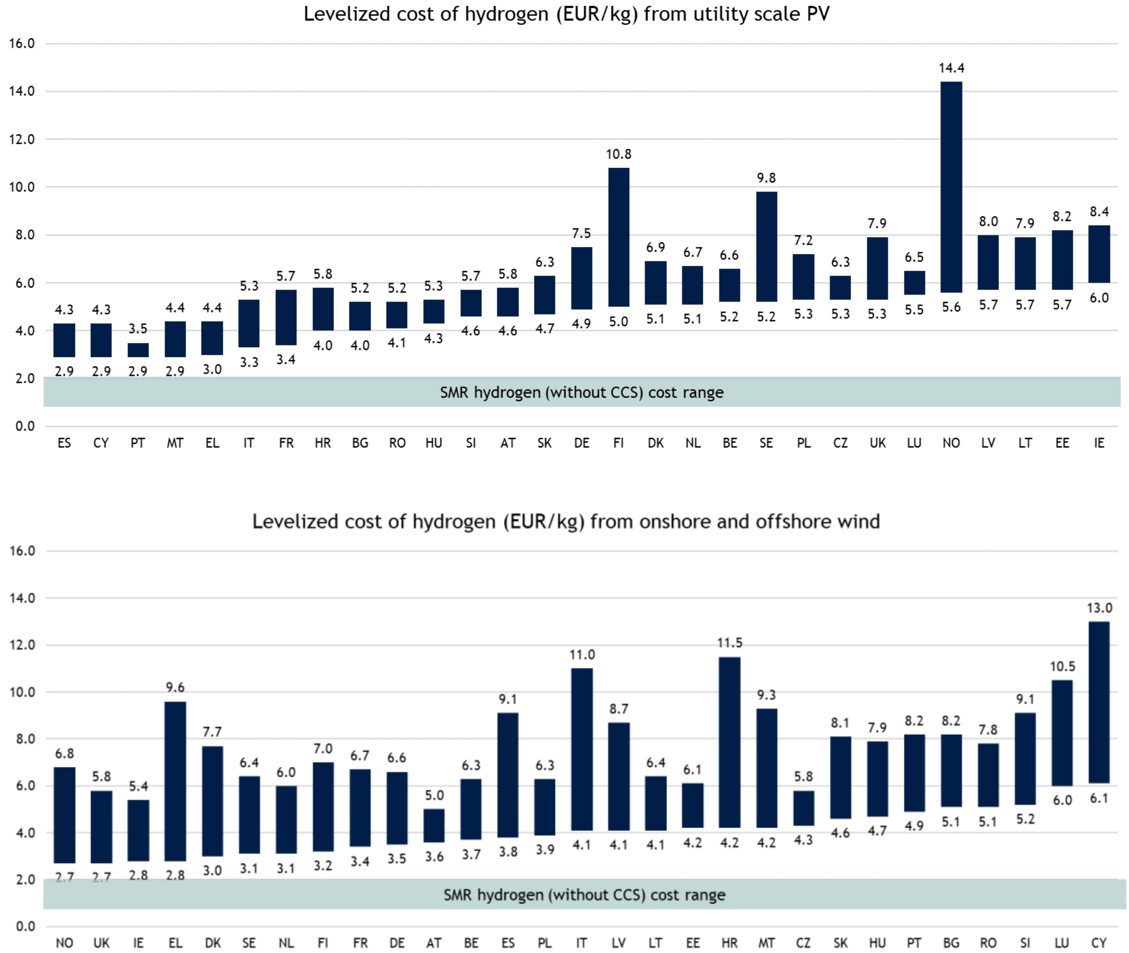
Figure 0-38: Grid connected electrolysis hydrogen production costs in EU (2019) in € per kg (Source: based on Hydrogen Europe 2020)



In contrast to that, renewable hydrogen production cost significantly differs within and between MS (including UK and Norway) (see Figure 0-39). While solar PV is the preferable pathway in southern European countries, off- and onshore wind production is cheapest in Northern Europe.

168 Hydrogen Europe. (2020). Clean Hydrogen Monitor 2020. Available at: https://reglobal.co/wp-content/uploads/2021/01/Clean-Hydrogen-Monitor-2020.pdf

Figure 0-39: Levelized costs of renewable hydrogen production in EU countries (2019) (Source: based on Hydrogen Europe (2020))[169]



The positive economic effect of the presented options for the gas industry or electrolyser industry need, however, to be compared to the risk of stranded investments, since also low carbon fuels will face a phase-out until 2050 at the latest due to their remaining carbon emissions. A recent study discussed the question of the investment window for low carbon hydrogen technologies.[170] In a combined scenario of low carbon and renewable hydrogen technologies, there is a business case at certain locations along the coast of Norway, the UK and the Netherlands for hydrogen production from natural gas and CCS in 2030, even when considering the relatively high costs for CCS infrastructure. According to the authors, this, however, is likely to change in scenarios, where policy fosters a ramp-up of renewable hydrogen production in Europe, e.g., via instruments for meeting the 40 GW target by 2030. In contrast to this, no regions could be identified in that study, where pyrolysis technology would be the most cost-efficient hydrogen production route in 2030 or 2050. To serve as a bridge technology, investments should be done at the latest before 2030, considering the long technical and economic life-time of the respective components.

[169] Note: the costs range for each technology is defined by the best wind/irradiation conditions (lower end of the cost range) in a given country and the average conditions available in this country (upper end of the range). Source: Hydrogen Europe.

[170] Agora Energiewende and AFRY Management Consulting. (2021). No-regret hydrogen: Charting early steps for H_2 infrastructure in Europe. Available at: https://static.agora-energiewende.de/fileadmin2/Projekte/2021/2021_02_EU_H2Grid/A-EW_203_No-regret-hydrogen_WEB.pdf

One short-term strategy to limit the risk of stranded investments and lock-in effects is to focus the development of hydrogen production with CCS on existing hydrogen production facilities in industry. On the one hand, retrofitting of carbon dioxide scrubbers might be cheaper compared to new installations. On the other hand, captured carbon dioxide might directly be reused for the production of low carbon fuels for other industrial processes. Still, in order to allow for a significant emission reduction, biogenic carbon sources or carbon dioxide from direct air capturing need to replace those industrial carbon dioxide streams.

Impacts of a combined target for hydrogen in form of RFNBOs and low carbon fuels for specific industry sectors, in form of substituting a certain percentage of existing hydrogen demand, are already discussed in line with option 4 above.

Environmental impacts

Environmental aspects to be discussed will focus on direct emission savings and other indirect effects. Especially the potential of RFNBOs and low carbon fuels to reduce greenhouse gas emissions in hard-to-decarbonise sectors will be analysed in the context of sector-specific or general targets. In line with this, accountability limitations of low carbon fuels for specific sectors or specific production processes, e.g., using hydrogen from specific low carbon technologies and specific CO_2 sources, need to be considered.[171]

Option 0 (baseline)

Based on the baseline scenario, it is expected that renewable electricity and advanced biofuels will mainly contribute to fill the gap between todays renewable share in the transport sector. This may also be the case for those industry sectors, where electrification is a suitable option. The role of natural gas as a gaseous energy carrier, will however still be dominant in 2030 (see also Figure 0-31).

Option 1 (non-regulatory measures)

As described above for economic effects, non-regulatory measures like financial support play a significant role in enabling technology scale up via pilot projects and to overcome the cost gap between RFNBOs and their fossil-based alternatives.

Having said this, non-regulatory measures can contribute to mid- to long-term decarbonisation in different sectors, by supporting the introduction of RFNBOs or low carbon fuels which have a significantly lower GHG footprint (see Figure 0-40 for hydrogen). However, the high efficiency losses that occur during production of liquid RFNBOs have also to be taken into account, which is why they should only be used as a decarbonisation option, when direct electrification or the consumption of RFNBOs with lower efficiency losses, e.g., direct hydrogen use in fuel cells, are not feasible.

Sub-option 2.1 (accounting RFNBO in H&C)

The accountability of RFNBOs towards the renewable target in the heating and cooling sector is expected to have a positive but limited impact in the short term. It is expected that fuel suppliers will introduce small amounts of RFNBOs either by injecting hydrogen into the natural gas grid or transforming renewable hydrogen to synthetic methane, which can be injected without limitations.

[171] Impacts related to the transport sector will be discussed in Annex F – Transport.

Due to the lower heating value of hydrogen compared to natural gas, even in case of an injection rate of 10 vol.%, the GHG emission reduction will be limited to 3.3%. Accordingly, real decarbonisation of the heating and cooling sector can only be achieved by the build-up of a pan-European dedicated hydrogen grid, connecting the main hydrogen consumers in industry in a first step, while expanding to the heating and cooling sector consequently. In any case, more efficient technologies like heat pumps or district heating networks (geothermal) may be the prevailing technologies for residential, low temperature heat.

Sub-option 2.2 (accounting methodology for RFNBOs)

Based on this option, the methodology for calculation of RES-T will be adapted in a way that in any case the energy consumption of an RFNBO is considered in the statistics of country, instead of the renewable electricity used for the production of RFNBOs. This will therefore not have a direct impact on the MS' greenhouse gas emissions.

There is, however, the indirect effect that the current provisions result in a discrepancy between additionality and target additionality which has been described under economic impacts for option 2.2 above. With increasing share of RFNBOs, this effect of RFNBO production reducing the efforts of renewable electricity installations will be more significant.

Additional, since it can be prevented that renewable electricity is counted in one MS and RFNBOs are consumed in another MS, this would massively reduce the risk of double counting or fraud, which indirectly would increase MS' support for renewable electricity production to achieve set targets.

Option 4 (sub-targets for RFNBOs)

The introduction of sector-specific targets for RFNBOs will generally support the introduction of RFNBOs with a small CO_2 footprint in sectors, where decarbonisation via direct electrification is difficult. These sectors include aviation, maritime and industry, which all face strong international competition.

Domestic flight and shipping industry will not have the possibility to bypass sectoral targets by bunkering or tankering activities. Accordingly, those sectors will directly reduce greenhouse gas emissions, although the effect will strongly depend on the value of the target. In case of maritime applications, local air pollutions in harbour could significantly be reduced by implementing zero emission technologies like fuel cells or land electricity supply.

The effect for carbon leakage to other regions will be more dominant in case of international flights and maritime shipment. Accordingly, to prevent that, a demand side obligation may be beneficial. These however, will also be targeted in the respective initiatives ReFuel aviation and FuelEU maritime.

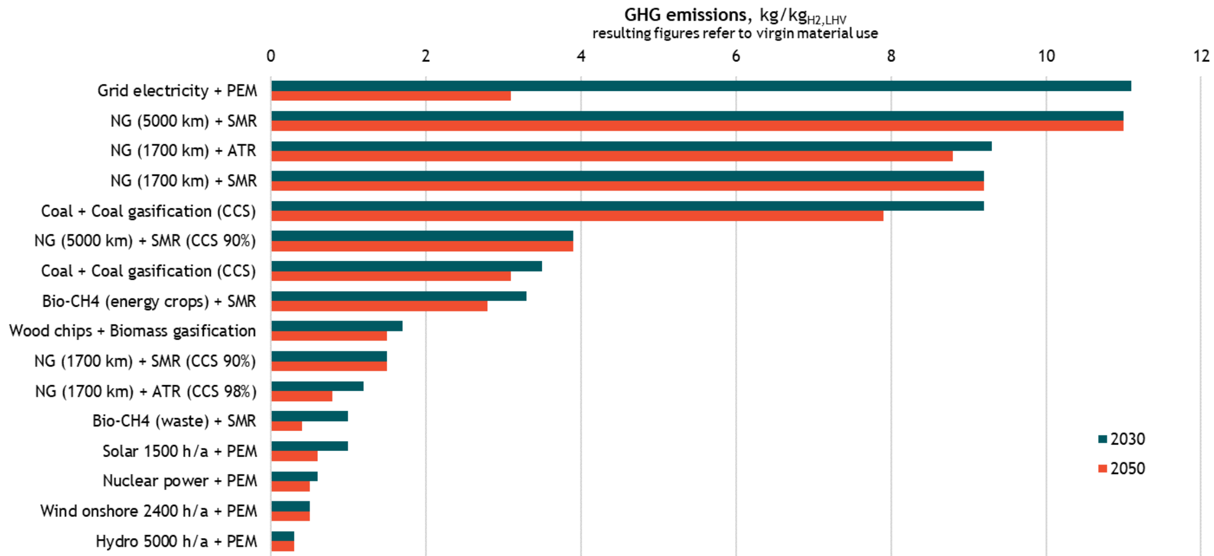
An RFNBO target for hard-to-decarbonise industry sectors would have positive direct environmental impacts as GHG reductions take place in the EU. However, carbon leakage will be important (see the discussion of economic impacts for option 4 above) leading to increased GHG emissions outside the EU, potentially even overcompensating the GHG reductions in the EU. From a global perspective, overall environmental impacts may thus even be negative.

Option 3 and option 5 (low carbon fuels)

Low carbon fuels like hydrogen and e-fuels that are produced from non-renewable sources are often considered an important pillar of the energy system on the way to carbon neutrality, especially in the short- and mid-term. The definition entails different hydrogen and e-fuel production pathways, including electrolysis using grid electricity or nuclear power as well as natural gas-based technologies like steam methane reforming or autothermal reforming with CCS or pyrolysis.

These technologies are mainly considered as low cost alternatives in the near future with the ability to provide large amounts of hydrogen, required for industrial processes. In case grid-based electricity is used for RFNBO production, following recital (90) several criteria like additionality, as well as temporal and geographical correlation between renewable electricity and RFNBO production are required (and to be set out in a reliable Union methodology by means of delegated acts to come). Also, nuclear power is used in several European countries as electricity source with low CO_2 footprint. Grid- or nuclear based electricity would allow electrolysers to achieve high utilization rates, independent of availability of renewable electricity, reducing the specific hydrogen production costs and creating early business cases for large-scale electrolysers. Regarding steam methane reforming or autothermal reforming with CCS, industry aims for high CO_2 capture rates of 90% (SMR) and up to 98% (ATR) under optimal conditions and applying best practice. Based on an industry-driven study of the Hydrogen Council[172], this would allow low carbon hydrogen production even below 3.9 $kgCO_{2\text{-eq.}}/kgH_2$ which is below 65% of current benchmark technology, e.g., defined in *CertifHy* with 10.92 $kgCO_{2\text{-eq.}}/kgH_2$. (see Figure 0-40).

Figure 0-40: Carbon-equivalent emissions by hydrogen production pathways, 2030 and 2050 (Source: LBST based on Hydrogen Council, LBST (2020))



The thermal decomposition of natural gas into solid carbon and hydrogen via pyrolysis is another pathway, currently getting attention as a possible low carbon pathway. While there are several companies working on reactor concepts on a pre-pilot stage for a co-production of carbon and hydrogen, existing pyrolysis plants focus on the production of specific carbon products for application

[172] Ludwig-Bölkow-Systemtechnik (LBST) and McKinsey. (2021). Study for the Hydrogen Council: Hydrogen Decarbonization Pathways, Part 1 – A Life-cycle Assessment, 19. January 2021. Available at: https://hydrogencouncil.com/en/hydrogen-decarbonization-pathways/

e.g., in the rubber industry. Whether a utilisation of this technology for energy-scale low carbon hydrogen production is feasible within the next decade, is unclear.

In addition, there are still several questions regarding long-term storage of CO_2 (i.e. in saline aquifer or depleted gas fields) and solid carbon. Especially, the high amount of CO_2 or carbon to be stored in case of an energy application of hydrogen is a major challenge for those technologies.

In summary, the general question whether to support low carbon fuels in addition to renewable fuels strongly depends on their role within the next decades towards a complete decarbonisation. Although they provide cost-efficient decarbonisation pathways in the short-term, they not necessarily are suited for deep decarbonisation scenarios for all sectors. Therefore, the investment decision should take these long-term aspects into account to on the one hand minimize the risk of stranded investment and steering necessary investments away from renewable technologies, while at the other hand provide a cost-efficient and pathways for specific industries to reduce their carbon footprint.

The accountability of low carbon fuels in general or only some specific towards the renewable energy targets (option 3) must prevent substitutional effects between low carbon fuels and renewable fuels. The target for renewable energies should accordingly be kept as it is and add the contribution of low carbon fuels on top or include a maximum contribution for low carbon fuels. It is also important to decide whether such an obligation should be mandatory or indicative. While the current approach for a fuel obligation in transport (Article 25(1)) allows MS to set the obligation on fuel suppliers, deciding which kind of fuels are taken into account or not, a common approach for renewable and low carbon fuels as described in option 3 would reflect the national strategies and result in a heterogenous national implementation on whether low carbon fuels are contributing towards RES-T or not. This will significantly impede the comparability of national progress towards the RES-T target, obscuring the different long-term perspectives of renewable and low carbon technologies. Accordingly, it seems reasonable to adapt the existing formulation of RES-T targets not on energy or volume basis, but rather on a GHG emission reduction basis (see also F, options 4.2).

Social impacts

In terms of social impacts, the analysis will focus on employment-related effects within the EU which comes along an increased support of RFNBOs and low carbon fuels. The increased role of hydrogen also offers potential for distributional impacts for European countries with high renewable potential, since they can export hydrogen and RFNBOs to the main industry and demand centres. This can stimulate job creation along the different supply chains, either for RFNBOs or for low carbon fuels.

Industrial potential for MS with high-RES potential

Options 2 and 4 (RFNBOs)

An analysis on the RFNBO potential in the EU transport sector reveals that there is a substantial potential to produce RFNBOs (renewable hydrogen and e-fuels) in the EU.[173] Still, the important question is less whether the potential for renewable electricity production is sufficient, but rather whether it is cost competitive compared to hydrogen imports from third countries with comparatively more economic conditions for renewable electricity production. A limiting factor is also the available

[173] Guidehouse et al. (2020). Technical assistance to assess the potential of renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs) as well as recycled carbon fuels (RCFs), to establish a methodology to determine the share of renewable energy from RFNBOs as well as to develop a framework on additionality in the transport sector. 2nd interim report | Task 1 Assessment of the potential of RFNBOs and RCFs over the period 2020 to 2050 in the EU transport sector.

electrolyser capacity and utilisation in different scenarios. Taking both aspects into account, cost-competitive hydrogen production in Europe will lie in-between 20 TWh (in case 7 GW electrolyser capacity are installed) and 140 TWh (40 GW electrolyser capacity) in 2030. The equivalent import cost account to 181 €/MWh and 123 €/MWh respectively. This overall amount of hydrogen also exceeds the maximum amount of hydrogen, e-gas and e-fuels, described in the CTP of 22 TWh for 2030. In case of higher demand in 2030, imports will play a significant role.

Still, an increase in the production of RNFBOs within Europe would also have in distributional effects among MS. Especially in northwest Europe where strong industrial clusters and accordingly a high energy demand will be located, a deep electricity sink of 325 TWh (without hydrogen production) 467 TWh (with hydrogen production) has been described for 2050.[174] As an implication, both a fundamental strengthening in the electricity and gas transport infrastructure is required between regions with electricity excess and those with substantial demand. The requirement for cheap hydrogen production combined with the additionality criteria for RFNBOs but also temporal and geographical relation between hydrogen and renewable electricity generation, however, provides industrial potential for several European regions. As production locations for electricity and hydrogen, their energy infrastructure should be strengthened. In addition, a relocation of energy-intense industries would be fostered due to lower energy prices.

Sub-option 2.2 will create a mechanism to not only transfer fuels between MS, but also consider this trade in the energy statistics of a country as part of their own target achievement. Whereas the renewable electricity of RFNBOs will no longer be accountable when calculation the overall renewable energy share of a MS, it will instead appear as renewable energy in the importing country, where it is consumed. The discrepancy between energy demand in industrial centres of North-Western Europe and more rural regions with high renewable potential in countries like North-, as well as South and Eastern Europe may create additional efforts in several MS to increase consumption of RFNBOs in order to increase their renewable shares. Accordingly, this drives the market development, followed by increasing import of RES and/or RFNBO, which ultimately creates revenues-in the electricity and RFNBO-producing countries. Fostering investments in RFNBO production in countries with high RES potential will also create local jobs and value creation.[175]

Whether RFNBOs or electricity will be traded between countries will also depend on the implementation of the additionality criteria and requirements for temporal and regional correlation laid out in recital (90) and to be developed in a delegated act by end of 2021. Also other compensation mechanisms like power purchase agreements between RFNBO producers and electricity producers should be considered.

From an infrastructure perspective, hydrogen or e-gas will mainly be traded via pipelines offering additional economic opportunities for import from European neighbouring countries like North Africa, and the Ukraine (see also 2x40 GW initiative by Hydrogen Europe). Liquid RFNBOs for an application in the aviation or maritime sector, on the contrary, will mainly be shipped, substituting existing supply chains for liquid energy carrier, e.g., from the Middle East or even South America.

Option 3 and option 5 (low carbon fuels)

[174] Wuppertal Institut. (2020). Infrastructure Needs for Climate-Neutral Industry in Europe, Policy Brief, 10.06.2020. Available at: https://wupperinst.org/fa/redaktion/downloads/projects/INFRA_NEEDS_Policy_Brief.pdf)

[175] Annex F -Transport offers further analysis with regard to job creation from RFNBOs.

Regarding low carbon fuels, these distributional effects will be more limited, since those would further support existing supply chains mainly for natural gas.

Job Creation

Options 2 and 4 (RFNBOs)

An enormous market uptake for RFNBOs and low carbon fuels would also have beneficial impacts on job employment within the European Union. Details will be covered in Section F – Transport. In general, all supporting measures that stimulate demand for RFNBOs will have a positive impact on the development of a domestic RFNBO supply chain, including producers of electrolyser and renewable electricity installations, as well as suppliers for fuel cells and other hydrogen end-use technologies. While especially hydrogen and hydrogen technologies promise the creation of an entirely new supply chain with high added value in the domestic economy, the application of liquid RFNBOs as drop-in fuel to conventional transport fuels also supports existing industries like maritime and aviation propulsion systems. Due to the long-term target for decarbonisation in all sectors, this could support these industries to proceed with their own transformation towards new, carbon-free technologies.

Whereas domestic hydrogen production competes with different import pathways (also driven by higher import costs due to liquification or compression), the import of liquid RFNBOs can be expected to play a significant role in the future. Optimal renewable electricity potential and existing shipping infrastructure for liquid energy carrier enable a low-price production in Europe's neighbouring regions, e.g., in the Middle East or North Africa. Europe, however, has a high potential to keep its leading role as technology and equipment provider for those regions, creating domestic added value in the engineering and manufacturing industry.

The maritime and aviation sectors will face higher cost based on the fuel prices in case of a sector-specific target. While domestic flights or shipping are in competition to e.g., rail or road transport, a significant price increase could result in the loss of market shares and have consequently negative impacts on employment. This is, however, not the case for international aviation or shipping. On the one hand, airlines or shipping companies could move bunkering or tankering activities to neighbouring regions of the European union to prevent cost increase due to national obligations. For domestic fuel suppliers this would reduce market potential. On the other hand, the price sensitivity of passengers for long-range flights or cruise shipping will be rather low, which is why it is not expected that the growing demand for international travel will be stopped by introducing a sector target for RFNBOs. This may especially be valid, since the impact of end-consumers prices, e.g., in aviation, are rather limited in case of quota obligations (see economic impacts above). Details on job creation and employment impacts of RFNBOs will be discussed in more detail in document F – Transport, chapter *Analysis*.

However, in hard-to-decarbonise industry sectors such as steel, ammonia and methanol production or the production of high-value chemicals, which are included in the ETS, international competition may lead to negative economic impacts of an RFNBO target for these sub-sectors (see economics impacts of sub-option 4 above). As a consequence, affected domestic industry sectors may not be competitive with non-European producers and existing jobs will be lost. Further support mechanism like CCfD and carbon border adjustment mechanism will be required to provide a level-playing-field with producers in non-EU countries.

Option 3 and option 5 (low carbon fuels)

The transition of the energy system from fossil fuels to renewable energies is accompanied by a major shift in capital and value added. Electricity production from natural gas and coal industries will, to a large extent, be phased out in most European MS until 2050. Carbon capture and storage technologies for low carbon fuel production enables natural gas producers as well as grid operators to continue their existing business models without significant changes. However, the gas industry advocates the idea of repurposing of the existing natural gas infrastructure for hydrogen as well as the creation of a dedicated European hydrogen grid, with about 6,800 km by 2030 and over 23,000 km by 2040.[176] Expected infrastructure investments are estimated to be in the range of 27-64 billion Euro (for 2040 infrastructure). The plans were updated in April 2021, extending the envisaged hydrogen grid to about 11,600 km in 2030 and up to 39,700 km in 2040 covering 21 countries.[177]

The accountability of low carbon fuels to specific sectoral renewable energy targets (option 3) must prevent substitutional effects between low carbon fuels and renewable fuels, enhancing the upcoming transition of the energy system. To prevent any possible negative impacts of low carbon fuels on the market development of renewable energies in the different sectors, a combined target (option 5) for RFNBOs and low carbon fuels (i.e. in form of a certain share of existing hydrogen production to be substituted in each MS), independent of the sectoral renewable targets for RFNBOs, seems more viable. On the one hand, this would allow to promote decarbonisation and rapid market development for renewable and low carbon fuels by allowing low-cost technologies as long as they provide the required GHG emission reduction. On the contrary, a sufficiently high target for RFNBOs (see option 4), would still allow a market development of less cost-competitive renewable options. Still, to a certain extent, investments will be steered into low carbon technologies (as a bridge technology) and away from RFNBOs.

Table 0-23 Overall impacts of B4.

	Overall impact		
	Economic	Social	Environmental
Promotion renewable and low carbon fuels			
Option 0 - baseline	0	0	0
Option 1 - financial support	+	0	+
Extension of scope of accounting			
Option 2.1 - RFNBOs in H&C	0	0	0
Option 2.2 - Accounting methodology for RFNBOs	+	+	+
Option 3 - Accountability of low carbon fuels towards sectoral RES targets	+	+	-
Creation of specific sub-targets			
Option 4- Sectoral targets for RFNBOs			
Aviation and Maritime	-	+	++
Industry	--	-	+
Building	---	+	0
Option 5 - Introduction of a combined target for RFNBOs and low carbon fuels (independent of sector-specific renewable energy targets, including a target for RFNBOs)	0	+	+

[176] Guidehouse. (2020). Study for Gas for Climate: a path to 2050: European Hydrogen Backbone, July 2020. Available at: https://gasforclimate2050.eu/sdm_downloads/european-hydrogen-backbone/

[177] Guidehouse. (2020). Study for Gas for Climate: Extending the European Hydrogen Backbone. A European Hydrogen Infrastructure Vision covering 21 Countries. April 2021. Available at: https://gasforclimate2050.eu/sdm_downloads/extending-the-european-hydrogen-backbone/

Synthesis

In this section we synthesize the findings from the analysis of the different options for Energy System Integration. These options can be grouped in four groups:

- Group B1: Options to facilitate the use of waste heat
- Group B2: Options to promote RES based electrification by better integrating RES electricity in H&C and in transport
- Group B3: Options for the certification of renewable and low carbon fuels
- Group B4: Options for the promotion of renewable and low carbon fuels

The headline findings from the analysis of each option are brought together under the three headlines of economic, social and environmental impacts.

Table 0-24 Impacts considered

Economic	Environmental	Social
Administrative costs	GHG emissions	Employment
Costs to economic operators, including effects on industry	Air quality	Education (training)
Investor certainty		Consumer energy prices
Impact on internal and external trade		
Energy security and innovation		

B1: Options to facilitate the use of waste heat

Three options were evaluated to facilitate the use of waste heat, namely:

- Option 1 concerns **non-regulatory measures** such as guidance and best-practice sharing, including on RED II Article 24(8) implementation, funding of R&D, targeted financial support, raising consumer awareness and promoting consumer engagement with labelling.
- Option 2 aims to clarify officially the definition of waste heat, therefore this option comprises an **integrated accounting framework** for waste heat/cold, a clarified definition in RED II Article 2(9) and the application to key sources from industry, data centres and the tertiary sector. A variant of this option (sub-option 2.1) includes an **obligation to count waste heat/cold in the H&C target**, covering industry and building applications, too.
- Option 3, in addition to option 2, aims to establish guidelines/templates for purchase agreements between waste heat and cold suppliers, and district heating and cooling system operators.

Economic impacts

The guidance and best-practice sharing at EU-level in Option 1 would provide technical, economic and institutional support, reducing **administrative costs** for national and local authorities responsible for the implantation of the provisions. There is no legal framework in place to manage urban waste heat sources/ make efficient contracts, therefore, guidance would also address this for national authorities. Due to an increased scope and data to monitor, Option 2 will cause a slight increase in administrative **costs** for national authorities and/or economic actors involved in the official reporting under RED II Article 7. The obligation to count waste heat/cold in the H&C target included in the Sub-option 2.1 variant would be difficult and might even not be feasible for very specific waste streams, therefore this variant would increase administrative costs significantly for national authorities. Option 3 would reduce administrative costs for waste heat owners, DHC operators and local authorities.

Compared to the baseline scenario, the three options would increase **investor confidence** and impact positively **DHC operators and waste H&C owners**. Guidelines and best practices in Option 1 would facilitate access to finance, accelerate the spread of technical and economical knowledge, and increase confidence in estimates of value heat recovered. Best practices and training materials would support bridge the gap of required employees understanding of the heat recovery process. The establishment of a clear definition and the inclusion in the H&C target in Option 2 would require precise measurement and verification capabilities, which would support setting a value on waste H&C and enable the creation of a market for it. This would increase the economic case and uptake of waste H&C recovery.

Option 1 would support DHC operators when valuing waste H&C and arranging contracts, Option 2 would also provide support for DHC operators through references and facilitation to value waste H&C. In addition to the incentives of Option 2, the purchase agreements guidelines under Option 3 would positively impact investors and DHC operators by significantly easing contractual arrangements through the identification of risks and their management. Option 3 would affect positively owners of urban waste heat who currently may have limited knowledge of the opportunities for recovering their waste H&C.

Environmental impacts

With regards to environmental impacts, the three options would lead to reduced energy needs and associated emissions of air pollutants. The reduction in need would interest both the users and the generators, the latter via a decrease in water cooling needs. The specific impacts in terms of energy needs of the options considered could not be quantified and compared.

Social impacts

The three options share positive social impacts related to an increased number of jobs in waste H&C owners, and an increased level of education and training outcomes. Options 1 and 2 would both result in positive impacts in countries with heavy industry surrounding heat consumption areas, or large urban waste potentials. In the case of Option 2 positive impacts are extended to countries with large urban unconventional waste H&C potential (e.g., data centres, tunnels and metro stations, cooling from buildings (e.g., offices, hospitals, supermarkets, shopping malls)**)**.Option 3 implies additional positive impacts for owners with limited energy expertise (urban and small industry owners) with regards to training and knowledge, as well as support addressing concerns from all players (including vulnerable households).

Concluding remarks for B1

Option 1 is seen as a necessary step to leveraging the potential waste H&C expected by RED II, even if not yet quantified, while Option 2, would support the deployment of a market with accelerated economic interest and uptake of waste H&C recovery by harmonising the scope at EU level, and make it comparable between MS. Option 3 would facilitate risk identification and management and contract setting, hence providing further support for local authorities, DHC operators and waste heat owners.

B2: Options to promote RES based electrification by better integrating RES electricity in H&C and transport

We analysed four options to promote RES based electrification by better integrating RES electricity in H&C transport. A summary of each is presented below.

- Option 1 refers to non-regulatory measures, including guidance on RED II electricity provisions related to H&C and transport (market design and market-based instruments, self-regulation and co-regulation and information and co-education). This option has significant overlaps with other sections of this impact assessment (namely Annex C – Renewable Electricity, Annex D-Heating and Cooling, and Annex F- Transport), therefore this measure was not evaluated in this Annex.
- Option 2 aims to enable system optimisation by allowing for demand response measures in H&C and electric transport, including enhanced flexibility in pricing and grid electricity renewables share (%) in real time, GHG emissions profile, as well as forecasting information where possible, in a near-real-time and interoperable manner, which can be used by all players, including EV users and those acting on their behalf, as well as devices connected to the network.
- Option 3 concerns better integration of renewable electricity into sectoral targets. For this option, two variants are considered:
    - Sub-option 3.1: better integration of renewable electricity into the H&C sector by accounting RES electricity to meet H&C targets under RED II Article 7(3).
    - Sub-option 3.2: the introduction of a credit mechanism under the fuel supply obligation rewarding supplying renewable electricity in public charging stations.
- Option 4 aims for a stronger, more efficient and equitable integration of system users and electric mobility services into the grid through setting minimum requirements for the availability of intelligent infrastructure for the integration of electric vehicles in the electricity system, and ensuring a level playing field in the market of aggregation and electric mobility services.

It should be noted that these options differ in their scope to such an extent that they were analysed separately and independently from one another throughout this document. In this section we aim to merely provide a summary of this analysis, without implying a direct comparison across options.

The analysis of demand response measures in Option 2 is based on results from a modelling exercise with the METIS model comparing projections of different scenarios against the baseline. The introduction of (market-price based) demand response under Option 2 comes with clear economic savings of 2.9 B€ annually, due to avoided investments in storage and peak generation units and an enhanced utilisation of base load capacities. However, when integrating the RES-share into the DR signal, net savings fall to 2.1 B€ compared to the baseline. These savings would trigger additional vRES investments in new generation capacity, ranging between 14 and 32 GW (depending on the level of DR deployment and the design of the DR signal). The economic impacts also include increased market value of renewable generators, and a subsequent reduced need of public support. Yet, this might not be the case for all Member States and RES-E technologies. In countries featuring a homogenous supply structure (i.e. generation units feature similar marginal generation costs), market price might stagnate in hours where demand is shifted to, while decreasing in hours where demand is shifted from, hence implying a net increase in market values. Further, given the temporal concentration of PV generation in selected hours of the day, demand is typically shifted into hours featuring high PV generation. Hence, DR is typically beneficial for PV market values, but the benefit is less certain for more equally distributed power generation, such as wind.

Demand response measures in Option 2 would result in negative environmental impacts, with an increase of CO_2 emissions of 2% compared to Baseline. There is only one model run (the high-DR-V2G_vRES-share) when coal consumption is reduced, but net increase in CO_2 emissions is still 1% compared to the Baseline. No social impacts were accounted for in Option 2.

Option 3 variants have overall positive economic impacts. Accounting for RES electricity in the H&C targets (sub-Option 3.1) would raise interest in heat pumps, affecting positively heat pumps manufacturers and installers, as well as building professionals and final consumers. In addition, the introduction of a credit mechanism under the fuel supply obligation (sub-option 3.2) would reward the supply of renewable electricity in public charging stations, which would positively impact the suppliers of green electricity and the industry sector supplying electromobility infrastructure. These sub-options would result in positive social impacts, with an increase of around 80,000 jobs related to manufacture, installation and operation of heat pumps in Europe. This would also imply an increase in education due to re-training of experts and craftsmen to instal heat pumps. Sub-option 3.2 would result in reduced imports of biofuels feedstock from third countries, which would be replaced by more green electricity produced in the EU, which would also lead to further job creation in the region.

Options 3.1 and 3.2 are expected to have positive environmental impacts. Sub-option 3.1 would imply a reduction in GHG emissions due to the replacement of fossil fuels with renewable energy and making use of excess energy. The increased use of heat pumps is expected to affect carbon emissions, by reducing CO_2 emissions compared to continued use of condensing gas boiler (the main used technology at present).

The efficient and equitable integration of system users and electric mobility services into the grid in Option 4 has overall positive economic impacts across consumers, system operators and service providers and aggregators. Compared to gas turbine or pumped hydropower, EV-batteries provide cheaper cost of grid flexibility per MWh, as EV-batteries are paid for by driving. With smart charging, electric vehicles can function as flexible storage for the grid, resulting in a stabilised grid and maximisation of renewable energy utilisation. This would turn electromobility financially affordable for all citizens, as electricity would be consumed when it is at its cheapest price. While additional infrastructure can be costly, including additional equipment at private homes or offices, full-scale vehicle-to-grid (V2G) is very likely to have an overall positive economic impact. If manufacturing of EV-batteries takes place in Europe, the economic impacts would increase even further. It should be noted though that the starting point for an efficient and economically viable infrastructure roll-out is to ensure that the installed infrastructure is future-proof (e.g., avoiding “dumb-chargers”). Otherwise, installed chargers that are not smart will not be replaced for at least 10 years, excluding EV drivers charging at such points from providing flexibility to the grid.

The environmental impacts of Option 4 are expected to be positive. V2G technologies would enable vehicle batteries to charge when the CO_2 emissions of electricity are at their lowest (i.e. with green electricity), and it can feed electricity back into the grid during the vehicle’s idle time to replace fossil-fueled electricity. Switching fully to V2G would also increase the degree of utilization of the batteries, and contribute to climate adaptation, providing grid flexibility even in more erratic weather patterns affecting renewables. Broad V2G adoption has the capacity to reduce carbon emissions compared to conventional fossil-based transport.[178] However, in some electricity grids with higher CO_2-intensity and no climate policy, V2G providing load shaving services might actually increase total carbon emissions.

Option 4 has positive social impacts due to a minimized price, service or access discrimination of different EV users at different publicly accessible charging points. With increased competition between different players the systems will become more interoperable, and will have an incentive to provide better services and price to customers. Option 4 would also reduce health risks due the expected decrease in air pollution, as the use of V2G-capable EVs would result in lower exposure to air pollution risks (including premature deaths), when compared to conventional internal combustion engine vehicles.

Concluding remarks for B2

Some of the options considered, in particular option 3, would bring additional compliance and administrative costs to stakeholders involved. However, option 2 and option 4, if implemented adequately, can allow the energy system to tap into significant economies of scale and innovation and create a kind of system integration conducive to more decentralized and therefore resilient grid. Under scenarios where most energy is generated from renewables this is important and comes with positive environmental and social impacts in the long-term. The market has a significant role to play and within option 2 and 4 regulatory efforts shall ensure to introduce limited changes to the existing dynamics on the market, while minimizing potential market distortions that existing, powerful players or new market participants may introduce as the system integration between OEMs, electric mobility service providers, storage service providers and end-users advances further.

B3: Options for the certification of renewable and low carbon fuels

We analysed 7 options to enhance the current system for tracking the flows of renewable energy. The considered options include:

- Non-regulatory option: there is no non-regulatory option for this section.
- Option 2 aims to extend the scope of the Union database for renewable fuels certification to all gaseous and liquid fuels (used in transport, H&C, and power sectors) as well as to feedstock with high fraud risk (e.g., UCO from the point of collection to the consumption of the biofuel).
- Option 3 aims to Further develop and harmonise the GO system across the EU for electricity and gas (including H2) and H&C to include sustainability information on carbon footprint (production & use);
- Option 4 would apply the Union database as main traceability tool for all energy carriers except RES electricity;
- Option 5 would apply the Union database as main traceability tool for all energy carriers including RES electricity;
- Option 6 would apply the GO system as main traceability tool for renewable and low carbon gases and waste heat/cold, and as a sub-option, the use of the book and claim system would be either limited to the transfers across grids or also used to determine the place of consumption of renewable gases;

[178] Hoehne C. G. & Chester M. V. (2016). Optimizing plug-in electric vehicle and vehicle-to-grid charge scheduling to minimize carbon emissions. Energy, Vol. 115, p. 646–657.

- In option 7 the electricity GOs would be required to be issued and cancelled simultaneously in "real-time" (hourly or quarter-hourly). As a sub-option, it could be only required to issue the close-to-real-time stamps for electricity GO issuing.

Economic impacts

Although already the baseline option would result in substantial additional compliance costs connected to the establishment of the Union database for mass balance certification system, all the considered options would require additional compliance on top of that. Significant compliance cost for certification systems would be required especially for Option 5, 4 and 6. In option 3, 6 and 7 there would be significant compliance costs connected with enhancing the functionality of GO systems.
The administrative costs, connected to operation of energy tracking schemes (under MB or BC system) and to certification activities of energy producers, would be higher in options 3, 5, 6 and 7. Administrative costs in option 2 would be lower as it proposes only limited changes to the existing system, and in options 4 and 5 that streamline the tracking of renewable energy under the MB certification system (and thus cost of operation of 2 types of tracking systems would be largely avoided).

The economic benefits of considered options are to a large extent only indirect. The most significant benefit is enabling development of markets for large spectrum of renewable energy carriers in various end-use sectors and thus enabling integration of production and consumption of renewable energy across different sectors. This is in particular important for development of renewable hydrogen economy. All of the considered options enable this to some extent, as they address the most significant shortcomings of the existing system. However, since the production and demand for renewable fuels such as hydrogen is expected to be limited in this decade, the potential benefits might be limited to justify the additional compliance and administrative costs. Therefore, **it might be more economical to introduce only a limited changes to the existing system and gradually reform it** following the growth of concerned markets (such as renewable hydrogen). However, **indicating a target model of the future certification scheme might help increasing the investor certainty** for the stakeholders and might incentivise bottom-up development of suitable technological solutions.

Environmental impacts

There are **no significant additional environmental benefits** expected from any of the considered options, in comparison to the baseline scenario. The options might bring additional information on renewable quality of consumed energy to the consumers, which might increase consumer demand for renewable energy. However, there is no evidence that green certificates would assure additional renewable production, in particular due to their low price. Governmental subsidies or consumption quotas are more effective tools for facilitating additions of new renewable energy sources. The introduction of real time GO trading in option 7 might have a limited impact on additional renewable production, as it would increase the demand for renewable energy sources that are capable of delivering energy in times of consumption peaks (on the other hand, this might be detrimental to more intermittent renewable energy sources).

Social impacts

In terms of social impacts, the most valid impacts is the difference in consumer energy prices. There are three main drivers of impacts on final consumer prices. Firstly, there would be an impact on the effect on the price of "premium" energy of renewable origin guaranteed by GOs. This price might increase as an effect of increased GO price or increased costs of compliance with the BC scheme. This effect would be most visible in Options 3, 5 and 6. Secondly, specifically for Option 6, gas price would increase for all final consumers, as GOs would be mandatory issued for all types of gases entering gas grid. Thirdly, the proposed measures would have an effect on transport fuel prices for all consumers. This would be a result of the enabling unrestricted cross-border trade of certificates, as described in the economic section. This effect would materialize in all options starting from Option 2 and primarily in lower income countries, and since the energy demand is relatively inelastic, this could potentially increase problems with energy poverty. It would be arguably more pronounced in Options 3 and 6, as the costs of compliance with GO schemes would also be translated into final fuel prices.

Concluding remarks for B3

While most of the considered options would bring substantial additional compliance and administrative costs to many involved stakeholders, their benefits in terms of environmental and social impacts remain limited. To ensure that the costs do not outweigh the potential benefits, it is preferable to select an option that introduces limited changes to the existing system, while still enabling better tracking of new renewable fuels (especially hydrogen) through the system. Based on this criteria, the **Options 2 and 3** would be the most suitable ones.

B4: Options for promotion of renewable and low carbon fuels

Finally, five options for the promotion of renewable and low carbon fuels across different sectors have been discussed. These options can be grouped in non-regulatory measures, measures that include the extension of the scope of accounting and measures creating specific sub-targets. In addition, the main options focus on RFNBOs only, while in some options, the scope is further extended to include also low carbon fuels.

Non-regulatory measures:

- Option 1 includes the promotion of renewable and low carbon fuels with non-regulatory measures such as guidance, best-practice sharing, funding of R&D, targeted financial support for renewable and low carbon fuels as well as raising consumer awareness.

Measures including an extension of scope of accounting:

- Option 2 considers accounting of RFNBOs to comply with RED II targets and sectoral sub-targets. Two variants were analysed:
  - Sub-option 2.1 focusses on starting accounting RFNBOs beyond transport also in heating and cooling and in the industry sector.
  - Sub-option 2.2 includes 2.1 and in addition a change in the current methodology to account RFNBOs for the overall target for renewable energy. According to this approach, the energy content of RFNBOs shall be accounted in the MS where they are consumed instead of the renewable energy consumed for their production in the production country.
- Option 3 extends the scope of option 2 to also cover low carbon fuels to be compliant with the sectoral targets for RFNBOs. A further extension to the overall renewable target in RES II is, however, not considered.

Measures creating sectors-specific sub-targets:

- Option 4 includes the creation of sub-targets for RFNBOs in hard to decarbonise sectors (maritime, aviation and industry).
- Option 5 assesses the possibility to extend the scope of option 4 in form of a combined target for RFNBOs and low carbon fuels (independent of targets for renewable energy in RES II).

Economic impacts

Non-regulatory measures (option 1, such as financial support for CAPEX and OPEX for pilot projects and technology development) are key to bring technologies to the market, trigger production ramp-up, and increase the number of existing projects, drastically. Since renewable and low carbon fuels lack competitiveness against fossil-based alternatives, financial support is required to achieve the envisaged targets for electrolyser capacity of 40 GW by 2030 in Europe. Possible elements besides subsidies and funding are implementation of market-based instruments like a carbon contract for difference system (CCfD) in industry, steering investments into renewable and low carbon technologies by providing investment security. In addition, a carbon border adjustment mechanism (CBAM) would lower the risk of carbon leakage and ensure fair competition with non-EU companies. Non-regulatory measures might also be required to further support implementation of options 2 to 5 aiming to include renewable and low carbon fuels into the sectoral targets or to create new sub-targets.

The accountability of RFNBOs towards the sectoral target in the heating and cooling sector (sub-option 2.1) would incentivise the use of renewable hydrogen and hydrogen-based methane for heating and cooling applications in the gas sector (households and possibly industry). However, depending on the applications, other renewable alternatives for the building and the industrial sectors remain more competitive than RFNBOs (e.g., heat pumps or district heating for low-temperature heat in households) and may be preferred solutions to reach the H&C target. Therefore, the impact of option 2.1 would remain limited.

With a revised accounting methodology for RFNBOS (sub-option 2.2), efficiency losses – especially high to produce liquid RFNBOs – would be considered in the statistics. Only the energy content of fuels consumed would be considered (rather than the renewable electricity to produce them), eliminating current inconsistencies between different fuels. Consequently, the contribution of renewable energy consumed in different countries would decrease and require a higher ambition to achieve the renewable energy targets. The production of RFNBOs will have a significant impact in the final energy demand: in case, renewable electricity is considered in statistics, they would contribute with about 32.3% to the final energy demand in transport in 2050, although the actual energy consumed (and thereby substituted in transport) would be only 19.4%. Target additionality would be ensured if renewable electricity for RFNBO production is fully accounted in the renewable targets, and RES targets are adjusted to account for conversion losses. This would impact positively the renewable electricity industry, due to the additional installation of large amounts of RES electricity production sites for RFNBOs. This sub-option would create an incentive for the national authorities in the consuming countries to support the market penetration and consumption of RFNBOs. Such a market pull-effect might be created, connected to distributional effects between RES producing and RFNBO consuming countries (discussed below as social impacts).

In contrast, sector-specific targets for RFNBOs in hard-to-decarbonise sectors (option 4) would create an early market demand for RFNBOs. Such targets would create investment security for a market ramp-up of production facilities as well as the required renewable electricity potential. The sector-specific impacts and implications of sector-specific targets for RFNBOs are discussed below.

- **Transport:** the main argument for a sectoral target regarding RFNBOs is the harmonisation within the EU and creating a level playing field among all MS. In addition, it establishes a stable policy framework over a sufficient time horizon to provide investors with the necessary confidence to invest in the production of sustainable aviation fuels and for airlines to pursue an efficient fuels policy to the target, promoting the development of SAF and reduces their costs. Carbon pricing would not address all barriers to the deployment of renewable fuels, and carbon price levels would not be sufficiently high in ETS. Therefore, additional policy actions including provisions in RED II such as specific RFNBOs targets or quotas, as discussed in ReFuel EU aviation and the Fuel EU Maritime initiatives, would be necessary to ensure that all obstacles to investments in clean energy technologies and infrastructure are overcome. RED II provisions such as a target for RFNBOs (ideally differentiated between hydrogen and e-fuels, at least in road transport[179]), need to be put in place as a more specific enabling framework. Both tools are thus complementary and mutually reinforcing.
- Impacts for **ETS-sectors in industry:** a supply-side obligation would require significantly less administrative resources from the economic operators affected. It would follow the same logic as already established in RED II for the transport sector where an obligation is to be put on fuel suppliers to increase the share of renewable energy supplied to the transport sector. Setting an RFNBO consumption obligation for these hard-to-decarbonise industry sectors would have strong negative economic impacts if no additional measures are taken to ensure international competitiveness. These additional measures would include those mentioned in option 1 (public funding, CBAM, CCfD, etc.). In this sense, additional support is essential to neutralise potentially strong negative economic impacts as well as the ensuing negative social impacts, notably in terms of job losses. On the other hand, if these additional measures are established and are in force in combination with the ETS, a dedicated RFNBO target for industry in the framework of RED II may have little additional effect for GHG reduction. However, an obligation focused on renewable energy (in contrast to a GHG reduction obligation) would have positive impacts in facilitating the commercialisation and market uptake of renewable solutions rather than low carbon non-renewable solutions. Different variants have been discussed, including also the option to oblige MS fixing clear targets of RFNBOs in all hard-to-decarbonise sectors or focus on the substitution of a certain percentage share of the existing hydrogen consumption in European industry with renewable hydrogen.
- **Buildings**: hydrogen and other RFNBOs are not yet expected to play an important role in low temperature heating, especially since other renewable technologies seem preferable from an efficiency perspective.

The economic impact of the accountability of low carbon fuels for the sectoral renewable targets in RED II (option 3) or even the introduction of a combined target for RFNBOs and low carbon fuels (option 5) mainly focus on the suppliers of those low carbon fuels. To ensure a fair competition, fuel suppliers of low carbon fuels should face the same GHG emission reduction requirements as for RFNBOs (70% requirement set out for RFNBOs in Article 25(2) under RED II). Low carbon fuels such as hydrogen from grid electricity (i.e., not fulfilling requirements of recital 90) or nuclear power, SMR + CCS or pyrolysis

[179] Following the efficiency first principle, the direct usage of hydrogen should be promoted over e-fuels, to take additional conversion losses and lower efficiencies of ICE engines compared to FCEVs into account (see also report F – Transport).

are potentially low-cost alternatives compared to their renewable counterpart. Option 3 and option 5 measures would create a market, which would foster investments in CCS and pyrolysis technologies, all of which currently do not exist in large scale. The positive economic effect of the presented options for the gas industry or electrolyser industry need, however, to be compared to the risk of stranded investments, since also low carbon fuels will face a phase-out until 2050 at the latest due to their remaining carbon emissions. To serve as a bridge technology, investments should be done at the latest before 2030, considering the long technical and economic life-time of the respective components.

Environmental impacts

Environmental impacts of the five options were found to be mainly on direct emission savings and other indirect effects, however environmental impacts related to the transport sector will be discussed in Annex F - Transport.

In the baseline scenario the role of natural gas as a gaseous energy carrier will still be dominant in 2030. Non-regulatory measures in option 1 can contribute to mid- to long-term decarbonisation in different sectors, by supporting the introduction of RFNBOs or low carbon fuels which have a significantly lower GHG footprint. However, the efficiency losses that occur especially during production of liquid RFNBOs ('e-fuels') need to be taken into account, which is why they should only be used as a decarbonisation option, when direct electrification or the consumption of RFNBOs with lower efficiency losses are not feasible.

The accountability of RFNBOs towards the renewable target in the heating and cooling sector (sub-option 2.1) is expected to have a positive but limited impact in the short term. Due to the lower heating value of hydrogen compared to natural gas, even in case of an injection rate of 10 vol.%, the GHG emission reduction will be limited to 3.3%. Real decarbonisation of the heating and cooling sector can only be achieved by the build-up of a pan-European dedicated hydrogen grid, connecting the main hydrogen consumers in industry in a first step, while expanding to the heating and cooling sector consequently. More efficient technologies like heat pumps or district heating networks (geothermal) may be the prevailing technologies for residential, low temperature heat.

In the case of an adaptation of the methodology for calculation of RES-T (sub-option 2.2) in a way that the energy consumption of an RFNBO is considered in the statistics of a country, instead of the renewable electricity used to produce RFNBOs, there are no direct impacts expected on the Member State's GHG emissions. Taking efficiency losses into account will however decrease the calculated share of renewable energy and consequently force MSs to increase their efforts to further expand RES deployment.

The introduction of sector-specific targets for RFNBOs (option 4) will generally support the uptake of RFNBOs with a small CO_2 footprint in sectors, where decarbonisation via direct electrification is difficult. These sectors include aviation, maritime, and industry, which all face strong international competition. Domestic flight and shipping industry will not have the possibility to bypass sectoral targets by bunkering or tankering activities. Accordingly, those sectors will directly reduce greenhouse gas emissions, although the effect will strongly depend on the value of the target. An RFNBO target for hard-to-decarbonise industry sectors would have positive direct environmental impacts as GHG reductions take place in the EU. However, carbon leakage will be important (see the discussion of economic impacts for option 4 above) leading to increased GHG emissions outside the EU, potentially even overcompensating the GHG reductions in the EU. From a global perspective, overall environmental impacts may thus even be negative.

In case of option 3 and option 5, low carbon fuels like hydrogen and e-fuels are covered that are produced from non-renewable sources are often considered an important pillar of the energy system on the way to carbon neutrality, especially in the short- and mid-term. The environmental impacts depend on the different hydrogen and e-fuel production pathways:

- Electrolysis using grid- or nuclear based electricity would allow electrolysers to achieve high utilization rates, independent of availability of renewable electricity. GHG emissions will strongly depend on the national electricity mix. It could especially in the short-term support market ramp-up for electrolyser technology and renewable hydrogen, despite the fact that additionality as well as temporal and geographical correlation criteria in recital 90 are not fulfilled. While this would decrease GHG emissions only marginally in the short-term, increasing RES shares in national electricity mix would continuously improve the GHG footprint.
- Regarding steam methane reforming or autothermal reforming with CCS, industry aims for high CO_2 capture rates of 90% (SMR) and up to 98% (ATR) under optimal conditions and applying best practices. Based on an industry-driven study of the Hydrogen Council[180], this would allow low carbon hydrogen production even below 3.9 $kg_{CO2\text{-}eq.}/kg_{H2}$ which is below 65% of current benchmark technology, e.g., defined in *CertifHy* with 10.92 $kg_{CO2\text{-}eq.}/kg_{H2}$.
- Thermal decomposition of natural gas into solid carbon and hydrogen via pyrolysis is currently getting attention as a possible low carbon pathway, however the feasibility of using this technology for energy-scale low carbon hydrogen production within the next decade is still unclear.

The accountability of low carbon fuels in general or only some specific towards the renewable energy targets (option 3) must prevent substitutional effects between low carbon fuels and renewable fuels. The target for renewable energies should accordingly be kept as it is and the contribution of low carbon fuels should be independent of existing RES targets: it could either be added on top or included as a maximum contribution for low carbon fuels. It is also important to decide whether such an obligation should be mandatory or indicative. While the current approach for a fuel obligation in transport (Article 25(1)) allows MS to set the obligation on fuel suppliers, deciding which kind of fuels are considered or not, a common approach for renewable and low carbon fuels as described in option 3 would reflect the national strategies and result in a heterogenous national implementation on whether low carbon fuels are contributing towards RES-T or not. This will significantly impede the comparability of national progress towards the RES-T target, obscuring the different long-term perspectives of renewable and low carbon technologies. Accordingly, it seems reasonable to adapt – in this case - the existing formulation of RES targets not on energy or volume basis, but rather on a GHG emission reduction basis (see also report F- Transport, options 4.2). In case of a combined target in industry (i.e. substituting a certain share of hydrogen production with renewable hydrogen), emissions of existing hydrogen productions will be reduced, although fostering investments into new applications for hydrogen will be limited.

Social impacts

In general, the social impacts of the options assessed suggest that an increased support of RFNBOs and low carbon fuels will have a positive impact on the development of a domestic RFNBO supply chain,

[180] Ludwig-Bölkow-Systemtechnik (LBST) and McKinsey. (2021). Study for the Hydrogen Council: Hydrogen Decarbonization Pathways, Part 1 – A Life-cycle Assessment, 19. January 2021. Available at: https://hydrogencouncil.com/en/hydrogen-decarbonization-pathways/

including producers of electrolyser and renewable electricity installations, as well as suppliers for fuel cells and other hydrogen end-use technologies. This would result in positive employment-related effects within the EU. The increased role of hydrogen also offers potential for positive distributional impacts for European countries with high renewable potential since they can export hydrogen and RFNBOs to the main industry and demand centres. This can stimulate job creation along the different supply chains (either for RFNBOs or for low carbon fuels).

In the case of options 2 and 4 (RFNBOs), would positively affect MS in northwest Europe, where strong industrial clusters and accordingly a high energy demand will be located. Nevertheless, a relocation of energy-intensive industries could be fostered due to lower energy prices, providing industrial potential for several European regions. In sub-option 2.2, the effect of trade in energy statistics between countries might create additional efforts in several MS to increase consumption of RFNBOs to increase their renewable shares. This would foster investments in RFNBO production and create local jobs and value creation in rural regions with high renewable potential, such as in countries located in North- as well as South and Eastern Europe.

Domestic hydrogen production competes with different import pathways (also driven by higher import costs due to liquification or compression), while the import of liquid RFNBOs can be expected to play a significant role in the future. Optimal renewable electricity potential and existing shipping infrastructure for liquid energy carrier enable a low-price e-fuel production in Europe's neighbouring regions, e.g., in the Middle East or North Africa. Europe, however, has a high potential to keep its leading role as technology and equipment provider for those regions, creating domestic added value in the engineering and manufacturing industry.

While especially hydrogen and hydrogen technologies promise the creation of an entirely new supply chain with high added value in the domestic economy, the application of liquid RFNBOs as drop-in fuel to conventional transport fuels also supports existing industries like maritime and aviation propulsion systems (i.e. ICE fleets). Nevertheless, in the case of a sector-specific target, the maritime and aviation sectors will face higher costs based on the fuel prices. While domestic flights or shipping are in competition to e.g., rail or road transport, a significant price increase could result in the loss of market shares and have consequently negative impacts on employment. This is, however, not the case for international aviation or shipping, since airlines or shipping companies could move bunkering or tankering activities to neighbouring regions of the European union to prevent cost increase due to national obligations. In overall, higher fuel prices could this affect international competition with non-EU countries in close neighbourhood to Europe, resulting in a risk of reallocation of jobs.

In hard-to-decarbonise industry sectors included in the ETS (e.g., steel, ammonia and methanol production, or the production of high-value chemicals), international competition may lead to negative economic impacts of an RFNBO target for these sectors. The size of related potential job losses in Europe will, however, strongly depend on additional measures taken, as for example CBAM or CCfD (see economic impacts).

Distributional effects related to option 3 and option 5 (low carbon fuels) will be more limited, since these would further support existing supply chains mainly for natural gas.

Concluding remarks for B4

The general question whether to support low carbon fuels in addition to renewable fuels strongly depends on their role within the next decades towards a complete decarbonisation. Although they provide cost-efficient decarbonisation pathways in the short-term, they are not necessarily suited for deep decarbonisation scenarios for all sectors. Therefore, the investment decision should take these long-term aspects into account to, on the one hand, minimize the risk of stranded investment and steering necessary investments away from renewable technologies, and, on the other hand, provide a cost-efficient pathway for specific industries to reduce their carbon footprint.

The accountability of low carbon fuels to specific sectoral renewable energy targets (option 3) must prevent substitutional effects between low carbon fuels and renewable fuels, enhancing the upcoming transition of the energy system. To prevent any possible negative impacts of low carbon fuels on the market development of renewable energies in the different sectors, a combined target (option 5) for RFNBOs and low carbon fuels (i.e. in the form of a certain share of existing hydrogen production to be substituted in each MS), independent of the sectoral renewable targets for RFNBOs, seems more viable. On the one hand, this would allow to promote decarbonisation and rapid market development for renewable and low carbon fuels by allowing low-cost technologies as long as they provide the required GHG emission reduction. On the contrary, a sufficiently high target for RFNBOs (see option 4), would still allow a market development of less cost-competitive renewable options. Still, to a certain extent, investments will be steered into low carbon technologies (as a bridge technology) and away from RFNBOs.

Appendix I

Short description of the METIS model

The analysis of the impacts of RES-optimised consumer behaviour in the transport and H&C sector was realised by making use of the EU energy system model METIS[181]. The METIS model was developed by Artelys on behalf of the European Commission. METIS is a multi-energy model covering in high granularity (in time and technological detail) the entire European energy system, representing each MS of the EU and relevant neighbouring countries as a single node.

METIS includes its own modelling assumptions, datasets and comes with a set of pre-configured scenarios. These scenarios usually rely on the inputs and results from the European Commission's projections of the energy system, for instance with respect to the capacity mix or annual demand. Based on this information, METIS allows to perform the hourly dispatch simulation (over the duration of an entire year, i.e. 8760 consecutive time-steps per year). The result consists of the hourly utilisation of all national generation, storage, conversion and cross-border capacities as well as demand side response assets. In addition, METIS can jointly optimise the investments in a large number of technologies together with the dispatch optimisation of the hourly demand-supply equilibrium.
With respect to flexible consumers, METIS represents explicitly electric vehicles (EVs and PHEVs, being charged at home or at work) and heat pumps (HPs, taking into account the deterioration of the COP in function of the outdoor temperature; potentially configured as hybrid power-gas assets) as national fleets. Based on arrival/departure timeseries for EVs and heat demand timeseries (derived from hourly national temperature timeseries) for heat pumps, it allows to optimise the behaviour of these consumers with respect to total system costs (i.e. considering some kind of real-time pricing (RTP) mechanism).[182]

Integration of the MIX55 scenario in the modelling exercise
In order to assess demand-side response strategies with respect to renewables integration, the MIX55 PRIMES scenario has been integrated into METIS. Some of the main characteristics of these scenarios have been taken into account in the modelling exercise. We present below the list of assumptions that have been directly taken from the MIX55 scenario:

- Installed capacities
  - Solar fleet
  - Onshore wind fleet
  - Offshore wind fleet
  - Hydro fleet
  - Geothermal fleet
  - Other renewables fleet
  - Nuclear fleet
  - Lignite and Coal fleet
  - Oil fleet
  - OCGT, CCGT and CCGT with CCS fleets (optimised)
  - Derived gasses fleet
  - Biomass and waste fleet

[181] European Commission. (n.d.). METIS. Available at: https://ec.europa.eu/energy/data-analysis/energy-modelling/metis_en?redir=1
[182] See METIS Technical Note 8 for further details at: https://ec.europa.eu/energy/sites/default/files/documents/t8_-_metis_demand_and_heat_modules.pdf

- Power demand
  - Direct power demand, with a specific distinction of electric vehicles and heat pumps consumption
  - Indirect power demand (i.e. electricity dedicated to P2X, in order to produce synthetic hydrogen, e-gas and e-fuels; electricity dedicated to batteries and pumped storage)
- Commodity prices
  - Fuel prices (gas, coal, oil)
  - EU-ETS carbon price

Currently, no publicly available datasets characterise the MIX55 scenario. In order to have an appropriate level of details for the modelling, we have been granted access to confidential datasets at MS level. However, following the terms of our confidentiality agreement, we only provide EU-wide assumptions and results in the following sections as well as illustrative examples for representative countries.

Box 0-5 Disclaimer about the scenarios used in the modelling

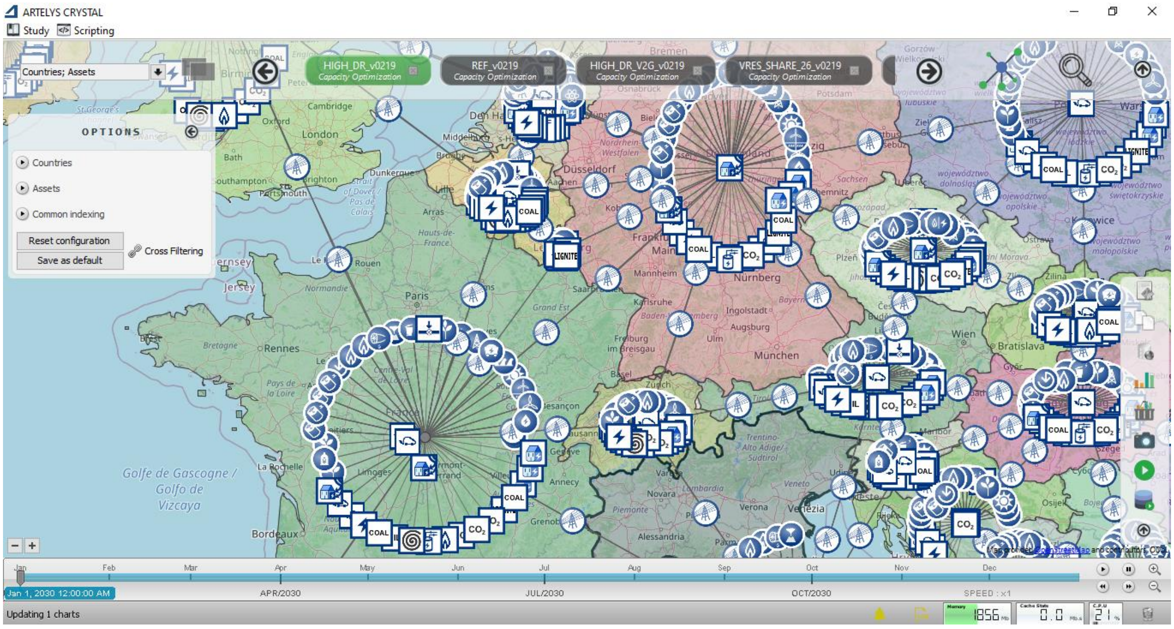
> The scenario that was built to assess the role of DR in renewables integration is partly based on the MIX55 scenario, and some structural datasets are directly taken from the MIX55 assumptions (see list above). However, the modelling of the power system behaviour and the identification of the optimal flexibility portfolio relies on additional assumptions (e.g., potential, capital costs, etc.) and applies an hourly granularity while modelling an entire year. Therefore, results can differ from those of the MIX55 scenario, especially in terms of installed capacities of the flexibility solutions that are optimised in our work (gas-fired power plants, pumped hydro storage, batteries).

In addition to the European Union, 7 neighbouring countries have also been modelled to capture their interactions with the EU MSs. These 7 countries are the following:

- Bosnia-Herzegovina
- Montenegro
- Norway
- North Macedonia
- Serbia
- Switzerland
- United-Kingdom

For all these countries except the UK (which was included in the MIX55 scenario), their associated power production capacities and demand is extracted from the TYNDP 2018 work of ENTSO-E. The Sustainable Transition" (ST) 2030 scenario has been selected, as it is the closest to the 2030 objectives of the European Union.

Figure I-41: Pan-European energy model in METIS,



Optimised investments

Regarding the optimisation scope, it is important to keep in mind that the model performs a joint optimisation of the operation of the whole power system, and the investments in different flexibility solutions. Investments in the following technologies are optimised:

- Back-up power plants: gas capacities (OCGT, CCGT, CCGT+CCS)
- Storage capacities (Pumped hydro and stationary batteries)
- Power-to-X technologies (electrolysers and methanation)

Table I-25: Technoeconomic assumptions for investments in flexible technologies

	Potential	Optimised capacity	Investment cost (€/kW)	Fixed O&M costs (% CAPEX)	Efficiency	Lifetime
OCGT	-	□	386[183]	3%	39%	25
CCGT	-	□	579	3,6%	62%	30
CCGT with CCS	-	□	1625	2,4%	48%	30
Pumped Hydro	+ 15 GW	□	1212[184]	1,20%	81%	60
Batteries	-	□	120€/kW + 120€/kWh[185]	4,30%	90%	10

The flexibility of the power system can be provided by these additional capacities, but also by the other flexible technologies whose capacities are directly coming from the MIX55 scenario (nuclear, hydro, coal/lignite, biomass) or demand-side response (smart charging of electric vehicles and heat pumps with thermal storage).

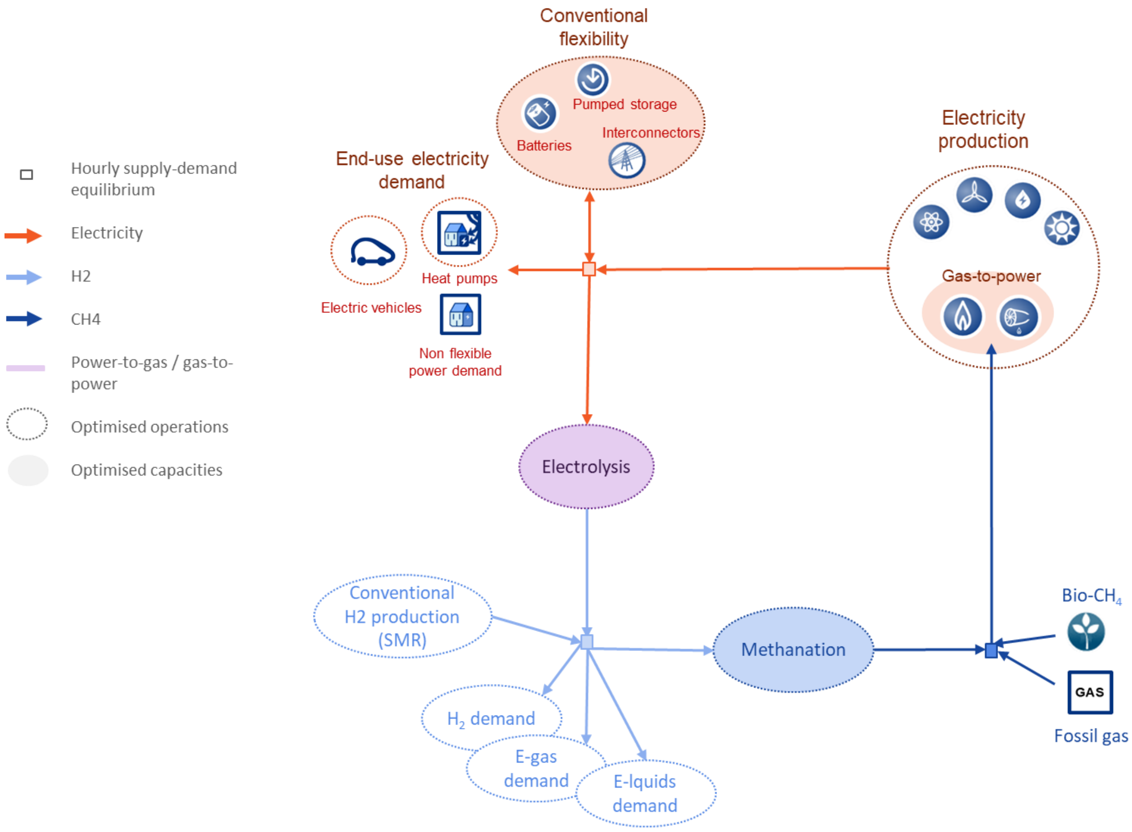
[183] CAPEX source: "Technology pathways in decarbonisation scenarios", 2018
[184] CAPEX source: ETRI and METIS S8
[185] Sources: ETRI and METIS S8

Figure I-42 summarizes for which technologies the capacity investments are optimised and which elements of the power system are only optimised operationally. Since it is central to the analysis at hand, we emphasise the power-to-gas-to-power loop.

It should be noted that, in our scenario, the whole P2X demand (hydrogen, e-gas and e-liquids) is represented by an aggregated hydrogen demand. Since the possible flexibility on the end-user side is difficult to predict (possible storage of hydrogen, refurbishment of existing network and storage for e-gas, flexibility of the fuel supply for vehicles, etc.), a common hypothesis on the flexibility of the hydrogen demand has been made. In our model, we assume a large flexibility on the demand-side of hydrogen, e-gas and e-fuels with only a limitation on the annual volume that should be provided, in line with the values of the long-term strategy pathways.

In the different scenarios, hydrogen production from electrolysis can be complemented by hydrogen produced by SMR (steam methane reforming) combined with CCS (carbon capture storage) plants when RES generation is not high enough to produce all the required hydrogen. The associated production cost is 90€/MWh.

Figure I-42: Description of the METIS model used in the study[186]



[186] Adapted from METIS study S1. Available at: https://ec.europa.eu/energy/studies/optimal-flexibility-portfolios-high-res-2050-scenario_en

Annex C - Renewable electricity

Annex C to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

Acronym	Full name
BEVs	Battery Electric Vehicles
CAPEX	Capital Expenditures
CCGT	Combined-cycle gas turbine
CCS / CCU	Carbon Capture and Storage / Carbon Capture and Usage
CSR	Corporate social responsibility
CTP	Climate Target Plan
DSR/DR	Demand Side Response
EC	European Commission
ETS	Emission Trading System
EVs	Electric vehicles
GO	Guarantee of origin
GW	Giga Watt
LCOE	Levelized cost of energy
LTS	Long-term Strategy
MS	Member State
MW	Mega Watt
NECP	National Energy and Climate Plan
NPBI	National Promotional Bank or Institution
OCGT	Open-cycle gas turbine
OPEX	Operating Expenditures
PPA	Power purchase agreement
PV	Photovoltaics
RED	Renewable Energy Directive
REFM	Renewable Energy Financing Mechanism
RES	Renewable Energy Sources
RES-E	Renewable electricity
SME	Small and medium-sized enterprise
SMR	Steam Methane Reforming
TWh	Tera Watt hour
V2G	Vehicle to Grid
vRES	Variable renewable electricity
WACC	Weighted average cost of capital

Background

Historically, the power sector has made the most significant progress towards decarbonisation in comparison to other sectors, thanks to a significant shift towards renewable power generation. The current share equals 34% (2019), and it is projected to meet around 65% in 2030[187].

A large-scale deployment of renewable electricity generation technologies is thus a key lever for all credible pathways to decarbonise the entire European economy. Generating large volumes of renewable electricity enables to reduce GHG emissions via:

- the decarbonisation of the current end-uses consuming electricity;
- enabling a number of end-uses to switch to decarbonised electricity instead of consuming fossil fuels (e.g. electric mobility, heat pumps, etc.), also referred to as *direct electrification*;
- the production of hydrogen through electrolysis (potentially coupled with additional processes to produce synthetic methane or liquid fuels) to decarbonise otherwise hard-to-abate sectors, also referred to as *indirect electrification*.

In its recently released Strategy for Energy System Integration[188], the European Commission underlines the importance of accelerating the electrification of energy demand, building on a largely renewables-based power system. In most cases, direct electrification is the most efficient way of using electricity when compared with the indirect electrification route (e.g., electric vehicle vs gas-based mobility; heat pumps vs gas boilers), and therefore results in a lower need for investment in electricity generation and conversion capacities.

When taken together, the direct and indirect electrification of end-uses in the industry, heating and mobility sectors will imply a significant increase in power demand. By 2050, power demand is expected to more than double[189], with half of future demand being exclusively related to indirect electrification. Substantial investments in electricity generation capacity are required to keep up with this rise in demand. The need for increased electricity supply can be a huge opportunity for Europe:

- to develop new, innovative energy technologies and entire supply chains, which represent a significant value for foreign trade;
- to upgrade market design towards the objective of a fully-integrated EU internal energy market, without any technical or regulatory barriers;
- to foster cooperation between Member States, especially in offshore technologies (it is estimated that 240-440 GW of offshore wind capacity will be required in 2050, compared to 12 GW currently on the EU-27 perimeter).

In this regard, regional cooperation may represent a key enabler. Regional cooperation between MSs (as well as between MSs and third countries) represents a major opportunity for MSs to make RES deployment materialise in a cost-efficient manner, in particular in situations of limited domestic RES-E

[187] European Commission. (2018). EU Long Term Strategy, COM(2018) 773 final.
[188] European Commission. (2020). Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM(2020) 299 final.
[189] European Commission. (2020). Investing in a climate-neutral future for the benefit of our people. EU2030 Climate Target Plan, COM(2020) 562 final.

potentials or unfavourable domestic conditions in terms of site-specific climatic conditions (i.e., low load factors) or a disadvantageous economic environment (reflected by a high WACC).

In the past, high heterogeneity in capital costs across EU MSs made regional cooperation a means to reduce overall investment costs and support costs[190]. Today's national WACCs are more aligned, but significant gaps remain and WACC within individual countries tend to further diverge[191,192], making regional cooperation still an effective option to exploit the most cost-efficient RES potentials first, thereby decreasing overall costs. Regional cooperation may further enhance the internal market, harmonise policies and facilitate the development of capital-intensive projects (e.g., cross-border offshore or hybrid projects).

Another relevant key enabler for the materialisation of an enhanced large-scale deployment of renewable power generation consists of power purchase agreements (PPAs). A pipeline of around 21 GW of subsidy-free renewable energy projects have been announced at this time. Wind PPAs concentrate in the Nordics and North Western Europe. Spain leads the field in PV[193]. Nearly 9 GW of PPA deals were signed in 2020, despite an increase in price volatility due to lockdowns in the pandemic.

PPAs become more important as 1) an increasing number of RES installations come to the end of their funding period (after 15/20 years) and require alternative revenue schemes and to cover operational costs, 2) some RES investors look for alternative investment options than public support and 3) there is an interest for power consumers to hedge against market risks or 4) offtakers intend to move to renewable supply for strategic/CSR reasons (cf. e.g. the RE100 initiative[194]).

This document provides inputs to the impact assessment for the revision of the Renewable Energy Directive recast (RED II). Part of the revisions considered are a range of policy options to better align the existing and proposed regulatory framework with the objective of increasing the cost-effective deployment of renewable electricity in the system, in line with the Climate Target Plan.

In the next section we first introduce the problem definition for increased deployment of renewable electricity. Subsequently, we define and develop the policy options that are considered for addressing the problems and map their potential impacts. In the third section we assess the merits of each policy option per the most relevant assessment criteria.

[190] European Commission. (2016). Impact Assessment on RED II - Accompanying document (SWD(2016) 418 final).
[191] Eclareon. (2020). Trends and evolution of the Costs of Capital in RE Financing (AURESII project).
[192] Fraunhofer ISI et al. (2016). The impact of risks in renewable energy investments and the role of smart policies. DiaCore project.
[193] Enervis. (2020). Status quo: Market parity of renewables in Europe.
[194] RE100. (2021). About us. Available at: https://www.there100.org/about-us

Design

Problem definition

RED II introduces a number of measures to facilitate the deployment of renewables, including renewable electricity production. For example, it introduces the possibility for Member States to introduce support schemes (Art. 4) that can be opened to participation by bidders in other Member States (Art. 5). Joint projects between Member States or with a third country may be implemented and can count towards reaching Member States' targets, under some conditions for the latter type of projects (see RED II Article 11(2) in particular). Joint support schemes (Art. 13) can allow Member States to coordinate their efforts and pool their resources to enable a set of more cost-efficient projects to materialise than under different uncoordinated support schemes. Procedures to be followed by potential investors are also simplified with single-contact point for permit granting (Art. 16), simple notification for grid procedures (Art. 17), etc. Finally, measures are introduced to facilitate renewables self-consumption and the emergence of renewable energy communities (Art. 21-22).

Yet the measures introduced by the RED II may provide an insufficient legislative environment to reach the newly agreed climate ambitions (either introduced by the Climate Target Plan (CTP) for 2030 or the Paris Agreement and the respective carbon neutrality pledge for 2050) in a cost-effective way. According to the CTP Impact Assessment, specific measures need to be built upon RED II in order to be able to deliver 2030 objectives, in particular in terms of shares of renewables in electricity generation, which is estimated to reach at least 60% in order to achieve the 55% GHG emission reduction target.

The Long Term Strategy 1.5TECH scenario assumes 760 GW of onshore wind, 450 GW of offshore wind and 1030 GW of PV to deliver climate neutrality through large direct and indirect electrification of the EU economy. To make such capacities materialise, yearly installation rates need to range between 30 and 40 GW for each technology, which is much more significant compared to current rates, which are no larger than 15 GW (for PV) or 2 GW (for offshore wind).

Within the current legislative framework, the achievement of 2030 and 2050 targets will benefit from the significant reduction of capital costs of RES technologies. Yet, strong barriers remain for RES-E deployment, namely risk management, undersized upstream value chain, low consideration of offshore technology specificities, public acceptance, or lack of RES-E specific targets.

With recent renewable investments being exposed to **market risks**, revenue uncertainty with respect to market price volatility and long-term price evolution has increased. Such risk increase may refrain investors and is not yet commonly addressed with facilitated revenue stabilisation tools, such as power purchase agreements (PPAs).

PPAs are explicitly addressed in Art. 15.8 of RED II: "*Member States shall assess the regulatory and administrative barriers to long-term renewables power purchase agreements, and shall remove unjustified barriers to, and facilitate the uptake of, such agreements. Member States shall ensure that those agreements are not subject to disproportionate or discriminatory procedures or charges*." However, RED II does not provide explicit additional guidance on PPAs.

The PPA market is continuously growing, PPA offtakers are typically large-scale commercial consumers, heavy industries or aggregators, while SMEs remain underrepresented.[195,196]

With respect to PPAs' contribution to enhanced renewable deployment, this is notably guaranteed in case of on-site power generation, or if the offtaker purchases the related amount of GOs.[10] Without GOs (i.e. in the unbundled case), the offtaker may receive economic benefits but cannot make evidenced carbon reduction claims.
In addition, investments suffer from long, complex and uncertain **permitting processes**, which are expected to be tackled with the actual implementation of Articles 16 and 17 of the RED II. In particular, offshore projects face significant investment and related risks, as reported in the RES progress report 2019: "*The barriers mainly arise from high cost of grid connection as well as from the lack of predictability and transparency of the grid connection procedures*". Risks supported by investors imply a higher risk premium and thus increase the cost of renewable projects. Eventually, complying with the 2050 targets will depend on all kinds of RES-E technologies, including those that are still immature today. They should be supported in order to de-risk investment, increase their deployment and to accelerate technological learning.

Going to 2,200 GW of vRES capacity by 2050 means a massive change of scale for wind and solar sectors in less than 30 years. Notably for the offshore sector, which has the lowest installation rate, such a pace change requires additional considerations to reinforce the upstream value chain and ensure that all players can scale up capacities and cope with the expected increase in rates of deployment.

RED II encourages **regional cooperation** by means of statistical transfers, joint projects, joint support schemes or the opening of support schemes (cf. Art. 3.5(d) as well as Articles 5, 8-13). However, in the past only little use was made of such schemes and the European Commission's analysis of NECPs states that "*few Member States describe specific measures to optimise access to and use of regional facilities or how to plan better renewable energy deployment and energy efficiency measures in cooperation with other Member States*"[197].

The 5th report on progress of renewable energy in the EU[198] notes that currently, Sweden, Germany, Denmark, Luxembourg, Estonia, Lithuania, Netherlands and Malta are already making use of cooperation mechanisms:

- Sweden and Norway have agreed upon a joint support scheme for renewable electricity production by means of a common market for electricity certificates (introduced in 2012);
- In late 2016, Germany and Denmark held pilot calls for a tender for ground-mounted PV installations that were open to participation by both MS. PV installations in both Germany and Denmark were able to participate in these first cross-border tenders in Europe. In Germany, an open tender with a volume of 50 MW was conducted (five projects situated in Denmark submitted successful bids), Denmark tendered 2.4 MW that were open for competition from bidders in Germany (yet only Danish projects were awarded);

[195] PV-Magazine. (2020, Nov). More solar PPAs from Spain, Germany. Available at: https://www.pv-magazine.com/2020/11/20/more-solar-ppas-from-spain-germany/
[196] CapGemini. (2019). World Energy Markets Observatory 2019.
[197] European Commission. (2019). An EU-wide assessment of National Energy and Climate Plans (COM/2019/564 final).
[198] Navigant et al. (2020). Technical assistance in realisation of the 5th report on progress of renewable energy in the EU.

- Four contracts on cooperation agreements on the statistical transfer of renewable energy amounts were signed;
    - Luxembourg (buyer) – Lithuania (seller): transfer of 700 GWh or more between 2018 and 2020;
    - Luxembourg (buyer) – Estonia (seller): sales to be carried out between 2018 and 2020, with 400 GWh for 2020;
    - Netherlands (buyer) – Denmark (seller): statistical transfers of 8 TWh RES volumes for 2020; an additional volume of up to 8 TWh could be traded if required for RES target achievement;
    - Malta (buyer) – Estonia (seller): statistical transfer of 100 GWh (for a total amount of two million euros), with the possibility for Malta to increase or reduce the amount to be purchased by 20%.

The reasons for the limited uptake of regional cooperation are diverse[199]. The technical complexity of designing the most appropriate cooperation model as well as the reluctance to take the associated "first mover risk" represent major barriers. This goes along with a perceived uncertainty and complexity about the distribution of costs and benefits between the cooperating countries, as distribution risks to be unbalanced (even though RES targets might still be met in a cost-efficient manner). The barrier is amplified by the perception of significant transaction costs due to substantial political, technical and legal coordination efforts and uncertainties including for the first projects. MSs consider that such efforts can only be made by allocating sufficient resources and time, which are also required to integrate all relevant stakeholders and consider the specific legal, administrative, economic and political circumstances in both countries (e.g., alignment of timing of cross-border auctions). If one of the cooperating countries has already implemented detailed provisions into national law, this reduces the flexibility in negotiating the agreement, as the partner country has to agree with most/all of these national provisions, too, so that they can be incorporated in the agreement. This is linked to concerns that cooperation might affect the effectiveness or efficiency of domestic policy measures and in consequence national energy policy (e.g., security of supply or other policy goals). On top of that, the national electorate needs to be convinced of the benefits of cooperation over reliance on domestic resources. Policy makers might fear the public opinion preferring spending taxpayers/consumers' money for reaping the RES benefits nationally (e.g., in terms of associated creation of jobs). A final barrier consists of a potential lack in the integration of the internal electricity market (e.g., in terms of insufficient cross-border interconnector capacities).

As part of the Green Deal, the Commission has published in November 2020 a European **offshore renewable energy strategy** that will be rolled out in the context of the post COVID-19 crisis recovery. Given the scale of the required deployment of RES and the speed of this deployment, the regulatory framework does not yet enable efficient and effective investment processes to materialise. The offshore sector gathers a large set of technologies, including non-mature technologies such as floating offshore wind, tidal and wave energy, as well as floating PV, and these technologies lack specific support that would help to foster offshore development, including but not limited to offshore wind. Eventually, offshore technologies are not enough considered in the legislation as combined with hydrogen generation, storage or grids, even if the latter can bring strong benefits to the system. A

[199] VITO, PBL & EEA. (2020). Cross-border regional cooperation for deployment of renewable energy sources.

better representation of these specificities in the legislative environment as well as an increased focus on energy sector integration would facilitate the roll-out of offshore energy.

In particular offshore projects can benefit from international cooperation, in the form of hybrid assets, joint projects, or projects supported by joint support schemes. This international cooperation framework has been introduced in the RED II and applies to all kind of RES-E technologies, with modest success as only few countries have sought to develop joint projects, and only Sweden and Norway have tried to align their support schemes. Yet a cost-efficient development of renewables needs to build on regional cooperation, in order to make the most of each country's specificities and resources and ensure an efficient delivery of 2030 and 2050 targets.

Deployment of renewable electricity generation implies large infrastructure needs – either RES-E or grid connection lines –, both on land and on sea, and this deployment may be hindered by limited public acceptance. Beyond the increased cost borne by final consumers on their electricity bills for RES-E support, locally, citizens can be concerned by the visual and noise impacts of renewable and grid installations, which may directly depreciate property value in their neighbourhood. The emergence of renewable energy communities directly addresses the issue of public acceptance, providing a larger role for consumers in the development of their renewable infrastructure. Yet only 4,000 of them were established by 2019, whereas it is estimated that 50% of households could belong to an energy community by 2050[200]. Their development should be facilitated by Articles 21 and 22 of the RED II, yet additional measures lack to encourage consumers to group in communities and get involved in RES-E development.

Building on the measures introduced by the RED II (some of which being described above), and in light of the scale of the required deployment, additional options have to be considered to increase the cost-effective deployment of renewable electricity in the European energy system.

Objective Setting

The comparison of (draft) PRIMES data reveals that current policies and ambitions indicated in MSs' NECPs (reflected under the Reference scenario) will facilitate a RES share of 60% in net power generation, up from 34% in 2019 (cf. Table 1-1). However, compliance with the 55% GHG emission reduction target by 2050 requires a RES share of 63% to 64% (in generation) according to the latest PRIMES projections for the three different policy scenarios.

Three scenarios were calculated:

REG55 considers a high intensity of policies energy efficiency, renewables and transport, plus the extension of "current" ETS to also cover intra-EU maritime navigation. The carbon price equals 42 €/tCO_2;

- MIX55 and MIX55-CP consider both one "current" ETS (current extended to intra-EU maritime) plus a "new" ETS applied to buildings and road transport; yet they differ with respect to the policy intensity on energy efficiency, renewables and transport: while MIX55 considers a medium intensity and a carbon price of 46€/tCO_2, MIX55-CP reflects low policy intensity on energy efficiency and renewable which requires a carbon price of 50€/tCO_2 to meet the 2030 target.

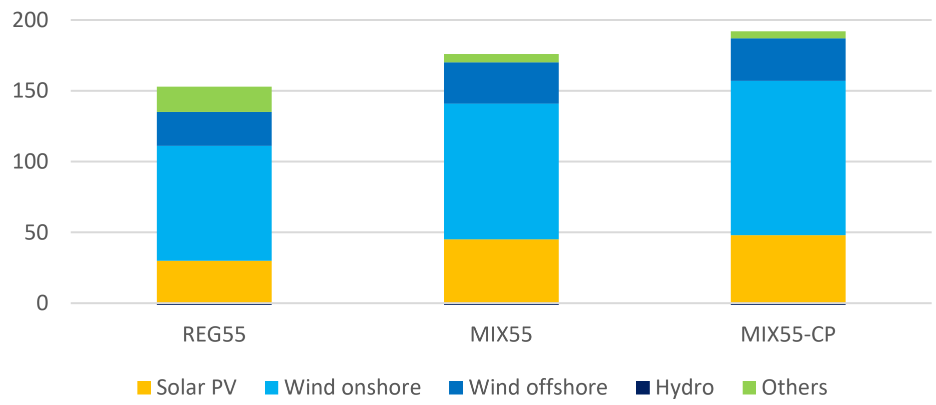
[200] JRC. (2020). Energy communities: an overview of energy and social innovation. EUR 30083 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-10713-2, doi:10.2760/180576, JRC119433.

Table 0-1 Overview of key scenario characteristics

		2019	REF	REG55	MIX55	MIX55-CP
Net RES generation (TWh)	Solar PV	125	385	415	430	433
	Wind onshore	348	668	749	764	777
	Wind offshore		200	224	229	230
	Hydro	342	363	361	361	361
	Others	168	181	199	187	186
	TOTAL	**984**	**1,797**	**1,948**	**1,970**	**1,988**
RES-E share in total generation		**34%**	**60%**	**63%**	**63%**	**64%**
Final electricity demand (TWh)		**2,512**[201]	**2,689**	**2,771**	**2,781**	**2,800**
Carbon price (€/tCO_2)		**ca. 25**	**30**	**42**	**46**	**50**

The gap between the Reference scenario and the three policy scenarios translates into a need for 150 to 190 TWh of additional power generation from renewables (cf. Figure 1-1), i.e., the installation of 78 to 108 GW of additional capacities in wind and solar PV power generation. This translates into an increase in ambition of 11% to 16% compared to the currently projected ambition level under the Reference Scenario. The range relates to the actual power demand level, which varies in function of the energy efficiency policies put in place and the trends in electrification of final end uses.

Figure 0-1 Delivery gap in 2030 between the policy scenarios and the Reference scenario; Source: based on PRIMES modelling results

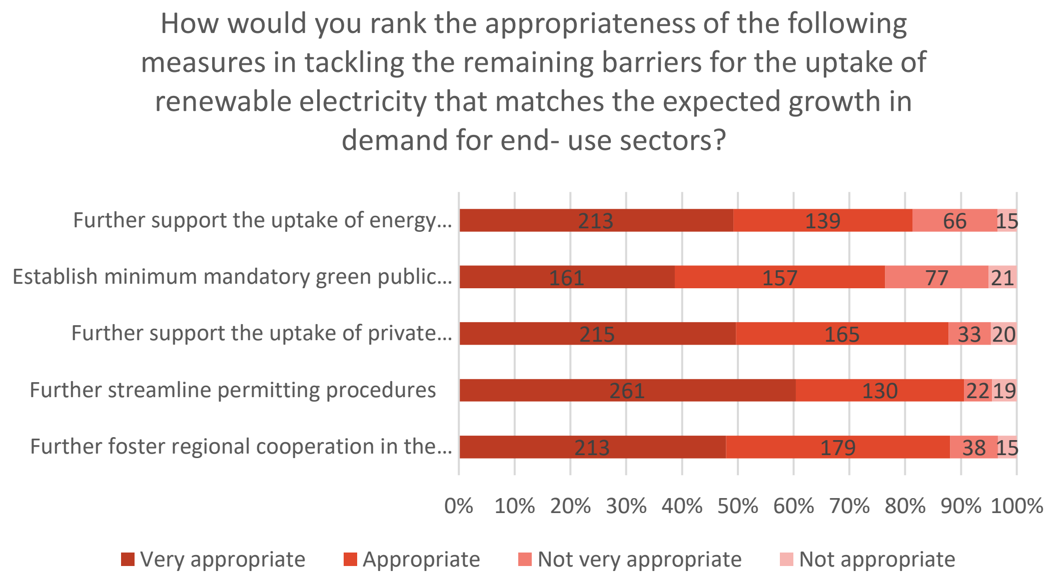


The policy options analysed in the following should facilitate the deployment of renewable power generation in order to close the gap previously identified to attain the required RES-E share in the projected power demand that allows to meet the 55% emission reduction target.

The relevance of the topics of PPAs and regional cooperation is also mirrored in the results of the Open Public Consultation. Both topics ranked among the top 3 measures considered to be very appropriate or appropriate when tackling barriers for the uptake of renewable electricity (cf. Figure 1-2).

Figure 0-2 Results from the open public consultation on the appropriateness of different measures in tackling the remaining barriers for RES-E uptake.

[201] 2018 value



Development of policy options

This section presents a description of the sets of two policy options considered for facilitating the deployment of renewable electricity in the revision of the Renewable Energy Directive recast.

For each policy option, a table is presented with an overview of the options and sub-options to be analysed, sorted by increasing level of ambition, starting from the current situation (e.g., Option 0 is the baseline, Option 1 are non-regulatory measures, etc.). Subsequently, a full description of the option is presented.

- ***C1: Promote power purchase agreements***

The purpose of the measures under C1 is to promote renewable power purchase agreements (PPAs) to increase the cost-efficient deployment of renewable electricity.

Table 0-2 Options for C1: Promote power purchase agreements

Options	Description
Option 0 (baseline)	Maintain current policies under RED II (Member States to facilitate the uptake of PPAs).
Option 1 (non-regulatory)	Guidance on PPAs, including for example draft template contracts for both virtual and physical PPAs, which includes cross-border PPAs spanning across bidding zones. Investigate the use of blockchain technology and distributed ledger platforms, as an instrument of automatic tracing and contracting electricity.
Option 2	Introduce support at EU level through for example financial instruments supporting in particular offtaker risk, including for multi-buyer / aggregated PPAs.
Option 3	Introduce more specific provisions in RED II on the administrative and regulatory barriers to PPAs that Member States need to tackle.

C.1 - Option 0: No updates - Baseline scenario

Under Option 0, current policies under RED II are maintained. This implies in particular that Member States are primarily bound to facilitate the uptake of PPAs, in compliance with Article 15 of RED II. Article 15.8 indicates: “*Member States shall assess the regulatory and administrative barriers to long-*

term renewables power purchase agreements, and shall remove unjustified barriers to, and facilitate the uptake of, such agreements. Member States shall ensure that those agreements are not subject to disproportionate or discriminatory procedures or charges. Member States shall describe policies and measures facilitating the uptake of renewables power purchase agreements in their integrated national energy and climate plans and progress reports pursuant to Regulation (EU) 2018/1999."

C.1 – Option 1: Guidance on PPAs

Non-regulatory options: guidance on PPAs, including for example draft template contracts for both virtual and physical PPAs, which includes cross-border PPAs spanning across bidding zones.

Currently, some barriers hinder the uptake of PPAs, and Member States did not sufficiently address the identification and removal of administrative barriers (Art 15.8 in RED II), as only 8 MSs considered the issue in their NECP[202]. 19 MSs do not include any evaluation of the current barriers to PPAs nor propose dedicated measures to facilitate their uptake. Such barriers consist for instance of the fact that the contract complexity and length introduce inertia into market activity and thus prevents corporates with strong green mandates but limited understanding of energy markets, particularly in markets where utility sleeving is limited and expensive.

The problem is particularly true among SMEs. Numerous platforms and some utilities are already attempting to simplify the process[203]. Administrative barriers around the non-issuance of GOs if the producer benefits of a public support scheme and the various conditions for expiry and cancellation of GOs, which may differ significantly across EU MSs, create unnecessary burdens to renewable energy purchasing for private companies. Regulatory barriers may prevent public support schemes from coexisting with the corporate PPA market and therefore act as a barrier to corporate PPAs[16].

Cross-border PPAs are even more complex to be set up, given the involvement in two different markets with potentially differing regulatory frameworks[204]. However, they represent a meaningful option to exploit least-cost RES potentials for offtakers in other markets, in particular in the case of so-called virtual cross-border PPAs. In this regard, Spain experiences a boom in cross-border PPAs, which is not only driven by favourable climatic conditions (implying a particularly low LCOE) but also due to the fact the bureaucratic hurdles are low (in contrast to France for instance)[205].

In a **virtual cross-border PPA**, "the producer sells the generated electricity into the wholesale power market. The payments received by the power producer from the wholesale power price are settled against the PPA price agreed with the corporate buyer. The corporate buyer continues to purchase electricity under its local contracts. As the virtual PPA contract is a financial settlement, a physical network connection between the generation asset(s) and the load is not necessary"[206].

Physical or direct cross-border PPAs, instead, require a physical network connection between the generation asset and the consumption centre of the corporate buyer. The generated electricity is nominated with the system and/or market operator to be delivered to the corporate buyer's

[202] RE-Source. (2021). Response to the Public Consultation on the Revision of the Renewable Energy Directive (RED II).
[203] Such as the European Investment Bank.
[204] WBCSD, (2020), Cross-border renewable PPAs in Europe: An overview for corporate buyers.
[205] BNEF. (2021). EU Power Weekly: EU's Renewable Power Hubs - 8 Feb 2021.
[206] WBCSD. (2020). Cross-border renewable PPAs in Europe: An overview for corporate buyers.

consumption centre via the public network. This allows for direct delivery of power from the power producer to the corporate buyer. Direct/physical PPAs guarantee full transparency and traceability. However, currently no examples are known in Europe.[19]

Eventually, GOs are treated differently in the various GO markets of the EU; this hinders the treatment of GOs linked to (cross-border) PPAs.[19] The 2019 study by COWI[207] finds that in some countries such as France and Germany, if a renewable energy project benefits from a government support scheme, the government will either not issue GOs for the electricity or not allow the GOs to be transferred to another entity, even if the power is purchased through a corporate PPA. GOs are central to the business cases for renewable energy purchasing as they allow corporate buyers to trace the renewable electricity they purchase and validate the claim that it is renewable. This is a key barrier and one reason why there are few corporate PPAs in these markets. The fragmented registration of GOs and lack of harmonisation across countries also creates an administrative burden, particularly when retiring a large number of GOs as countries have different systems for tracking and retiring GOs.

The COWI report[20] indicates that "*in some MSs, energy consumers are not entitled to buy and cancel unbundled GOs. In countries like Ireland only electricity producers or suppliers can cancel GOs, so there is no option for unbundled GOs. In other countries (e.g., Belgium), electricity consumers cannot directly buy and cancel GOs, but they can potentially rely on traders to deal with unbundled GOs. Unbundled GOs are not necessarily easy to source, especially for SMEs, as they need to be purchased via a broker. In fact, the market is still not liquid enough, they are traded over-the-counter (no active trading platform is available, despite attempts from exchanges to set such platforms up) and prices can be very different depending on the type of certificate (primarily based on country and technology*)".

This option aims at incentivising MSs to fully implement Art.15.8; reducing the implementation complexity of PPA contracts in order to overcome the lack of energy markets understanding by corporates; facilitating the uptake of renewable energy PPAs by simplifying transactions, helping to reduce costs and procedure time; and ensuring the GO system is implemented in a harmonised way.

For such a purpose, the EC could:

- Provide guidance on how to implement Art. 15.8 (sharing best practice examples from frontrunners);
- Create some kind of implementation body or forum to facilitate the exchange between MSs themselves and between MSs and industry;
- on best practices of implementation of Art 15.8;
- on PPA legislation between MSs (e.g., definition of non-binding targets for PPAs, as realised in IE);
- on GOs issuance in each MS, resulting in some kind of centralised database or transparency register where MSs could/should indicate the number of GOs issued for which type of energy carrier (electricity, gas, H2 etc.), distinguished by technology, month, region, support, age class of installation etc;
- on any kind of barriers to PPAs perceived by industries (sellers and potential off-takers);

[207] COWI & CEPS. (2019). Competitiveness of corporate sourcing of renewable energy.

- Develop templates for physical/virtual PPAs, including cross-border PPAs (e.g., for different PPA models with varying structures, business models and allocation of key risks associated, based on the EFET example;
- Provide guidance on best practice treatment of GOs and encourage harmonised treatment across EU GO markets;
- Publish a Green Paper on the use of blockchain and distributed ledger platforms;
- Provide information on best practice for platforms facilitating the use/cancelation of GOs with hourly granularity and validity[208].

Ad-hoc assessment: The potential role of blockchain as an instrument of automatic tracing and contracting electricity

Blockchain

Blockchain is a distributed, real-time mechanism that has already passed the-proof-of-concept stage, being currently widely used e.g. in Bitcoin trading. As a decentralized and secured technology, it can be investigated as a tool for automatic contracting and tracing for electricity (notably peer-to-peer).

Smart contracts

Blockchain enables the definition of smart contracts, which consists in a code linked to a blockchain which establishes a set of rules agreed by the parties. The code integrates the negotiation of the contract, that is smart contracts can be designed or programmed to realise money transfers in the case of specific events and to self-execute when these specific conditions are met.

On wholesale markets, such contracts remove the need of third-party intermediaries (e.g. trading agents, exchanges, banks and regulators), whereas current procedures involve manual processing and relevant communication efforts to consolidate information related to each part of the transaction.

It comes along with a reduced transaction cost and possibly a reduction in unitary trading volumes too, enabling small-scale consumers to participate in energy markets. Thus, blockchain empowers consumers to manage their own electricity supply contracts and consumption data, allowing faster supplier switching and increasing competition.

In addition, it comes with the ability to set up automated billing for consumers and distributed generators or even micro-payments and pay-as-you-go energy consumption.

Traceability and green certificates

The very principle of blockchain being that data is shared between the users within an inviolable "chain", such a tool ensures traceability of the energy, from the generator to the consumer. Thus, consumers can be informed about the origin and cost of their energy supply, at the hourly basis, as blockchain is inherently a real-time mechanism.

Currently, audit processes are often performed manually by a central authority, and are thus prone to errors or even fraud. Blockchain systems can automate green certificates issuance, reduce transaction costs, increase transparency and prevent double spending.[209] Yet, it does not apply to the certification and verification of the provided services (e.g., the meter that certifies the amount of renewable electricity generated).[210]

[208] Cf. for instance Energinet.dk, (2021), Project Origin - background. https://github.com/project-origin/documentation/blob/master/background.md

[209] The specification of the blockchain system would have to be mandated by an authority, so it need to be centralised somehow.

[210] The necessary certification goes beyond the meter, but implies also auditing of the facility generating the electricity. In particular in case of complex facilities like co-fired biomass/biogas plants and combined hydropower/storage.

Overall, it could be extended to emission allowances and energy-efficiency improvements.

Major barriers to the use of blockchain in energy trading

First, blockchain needs to scale up, both in terms of number of operations and speed. Currently, the number of transactions that can be cleared using blockchain is substantially smaller than what is possible through conventional electronic payments.

There is no existing interface with the electricity markets, making it rather difficult to integrate the technology in energy market structures within a moderate period of time. Yet, the use of blockchain could be limited to some segments of the energy market. In addition, ultimately, the TSO/DSO control the grid infrastructure and have responsibility of power delivery. Even in a decentralised market, network operators are expected to play a pivotal role.

As blockchain relies on data sharing across the users, it should be made sure that using such technology for electricity trading is GDPR-compliant, and that commercial sensitive data is not open-access to all counterparts. Eventually, the infrastructure implies high development costs, and validation and verification of data comes with high hardware and energy costs. There is a lack of standardisation of communication protocols, which refrains investors from engaging while no specific blockchain technology is identified. Along with the blockchain technology itself, smart meters would be required for all stakeholder involved in electricity trading.

Overall assessment of the technology

Blockchain is in itself a promising technology, yet facing strong potential barriers to an actual and short-term integration in energy markets. It is further expected that blockchain-based solutions (as an enabling technology) will appear automatically (similar to trading platforms for other commodities that offer their services when market size and liquidity gain momentum) once barriers for the bilateral trading of electricity and (sub-) hourly GOs are removed.

In order to investigate its concrete implementation for electricity trading, the Commission should:
Publish a Green Paper on the use of blockchain and distributed ledger platforms;
Provide information on ongoing polit projects for blockchain and distributed ledger platforms facilitating the use/cancelation of GOs with hourly granularity and validity[211,212].

Sources: Andoni et al. (2019)[213], RECS International (2019)[214], Florence School of Regulation, (2019)[215], Flexidao (2020)[28], PwC[216], IRENA (2019)[217]

C.1 – Option 2: Introduce financial support schemes at EU level

Introduce support at EU level through for example financial instruments supporting in particular off-taker risk, including for multi-buyer / aggregated PPAs

Some financial barriers hinder the development of PPAs. For instance, SMEs have not sufficient credit rating (not attractive for the project developer) and low visibility on future electricity demand. In

[211] Energinet.dk. (2021). Project Origin - background. Available at: https://github.com/project-origin/documentation/blob/master/background.md
[212] Flexidao. (2020). How digitalisation can help on energy and emissions reporting.
[213] Andoni, M. et al. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities.
[214] RECS International. (2019). The blockchain and energy attribute tracking.
[215] Florence School of Regulation. (2019). Blockchain meets Energy.
[216] PwC. (n.d.). Blockchain – an opportunity for energy producers and consumers?
[217] IRENA. (2019). Blockchain - Innovation landscape brief.

addition, it has become increasingly difficult for Independent renewable generators (IRG) to secure PPAs on bankable terms – there are few off-takers considered sufficiently credit-worthy to offer long-term contracts. The lack of competition puts at risk the availability of efficiently priced long-term PPAs. In addition, SMEs (which represent an estimated 40% to 50% of power demand in the tertiary sector) might continuously refrain from signing PPAs due to the before-mentioned barriers, replying to their willingness to purchase green electricity only via unbundled GOs which does not necessarily result in additional investments in renewable power generation capacities.

A credit guarantee offered by a financial institution, and in collaboration with an aggregator of corporate demand (e.g., utility, large corporate, or PPA platform), could in principle unlock more PPAs in Europe's more mature markets (Spain, Netherlands, Germany, Sweden) where larger, credit worthy entities have led the way[218].

In a credit guarantee scheme, a National Promotional Bank or Institution (NPBI) or an international financial institution such as the EIB provides a guarantee to a project lender or project owner in relation to the liability of an offtaker in the event of default. The project or the intermediary would specify the quantum of the guarantee and pay a fee linked to the guaranteed quantum and credit strength of the end user. The range of the acceptable credit profile would need to be defined but a lower-risk target group would be users without a credit rating but with a long business cycle or with short business cycles and little visibility regarding the evolution of their electricity demand. Eligibility for the guarantee could be linked to projects that are additional and trigger investment in new capacity.

A study prepared by Baringa on behalf of European Investment Bank[219] considers it worth to explore the role of the EIB as guarantee provider as such a service is currently not available in the market. Yet, this requires significant scale beyond EIB's existing project financing activity in order to pool enough parties together to reduce the effective risk. Further, assessing the credit worthiness of offtakers is not a capability typically held within the renewables market. Hence, suitable partners are needed for assessing credit risk and aggregating demand.

Under a PPA scheme (more specifically a virtual PPA), the corporate buyer benefits from a guaranteed fixed price for the electricity he is purchasing only during the hours when the renewable power plant generates electricity and only for the amount of electricity that he is physically consuming. Hourly over- or underproduction entails that the renewable energy producer (and potentially the corporate buyer) is exposed to power market risks.

PPA contracts generally extend over long time periods, on which some stakeholders may be refrained to engage as they bet on lower prices for renewables in the medium term due to the maturation of technologies and economies of scale[220].Specifically, offshore wind assets in parity markets: contracting sufficient volumes of PPAs ahead of financial close is difficult given size of assets and length of construction.

[218] European Investment Bank. (2020). Financial Instruments for Commercial PPAs in Europe.
[219] Ibid.
[220] Rödl & Partner. (2021). Power Purchase Agreement (PPA). Available at: https://www.roedl.de/erneuerbare-energien/maerkte/modelle/ppa

This option aims at facilitating access to PPAs for SMEs (i.e., small scale consumers and producers) and other off-takers with limited visibility on their future energy consumption and lower credit rating. It should also transfer the remaining risk from market exposure for residual electricity needs to an insurer, both for the off-taker and the renewable energy producer.

In this regard, the EC could:

- Provide a credit guarantee (or requiring MSs to do so), which would widen access to PPAs to smaller off-takers by guaranteeing their long-term credit worthiness:
    - According to the European Investment Bank, none of the rated SMEs among RE100 are credit worthy;
    - The Norwegian model (GIEK) guarantees either energy sellers against buyer's non-fulfilment of power contract (guarantees the income of the power seller, ensuring that the seller is paid for the power it provides even if the industrial company fails to pay) or banks to ensure repayment of loan the buyer has taken out to pay in advance for portions of the power delivery[221]. Under conditions:
        - The business must have annual energy consumption of at least 10 GWh, and the power contract must have a volume of at least 35 GWh during the contract period. GIEK can guarantee for both physical and financial power contracts with durations between 7 and 25 years;
        - GIEK charges a premium upon issuing a guarantee, which is determined on the basis of: power buyer's creditworthiness (credit rating), power contract's duration, volume and price of electricity, power buyer's loan for advance payment: size and repayment period.
- Follow the suggestions from the European Investment Bank[222]:
    - Support mezzanine financing for construction, which is a high yield debt product that widens window for PPAs by delinking PPAs signing and financial close – especially relevant for offshore wind farms, where signing a large number of PPAs ahead of construction is difficult;
    - Support project loans with merchant tail, which splits the project life in a first part relying on PPAs and a second one with exposure to markets. Debt (or guarantee on debt) to projects with shorter PPA tenors with a merchant tail could reduce the tenor required of PPAs;
    - Support Volume Firming Agreements, which transfer the financial risks of a renewable power plant's over or underproduction from the corporate buyer to an insurer, the latter being able to diversify that risk.

[221] GIEK. (2021). Power purchase guarantee. Available at: https://www.giek.no/power-purchase-guarantee/
[222] European Investment Bank. (2020). Financial Instruments for Commercial PPAs in Europe.

C.1 – Option 3: Introduce more specific provisions in RED II

Two different dimensions should be considered under this option: PPAs and GOs.

PPAs

First, most MS do not address PPA barriers, yet they are required by RED II article 15.8. Second, the majority of PPAs is signed by larger companies as SMEs have not sufficient credit rating (not attractive for the project developer, cf. Option 2) and low visibility on the long-term evolution of their long-term electricity demand. SMEs frequently lack the (sufficiently trained) staff to elaborate a PPA with a RES producer as they fear the complexity of PPA set up.[35]

However, many PPAs structures potentially suitable for SMEs (and other actors at the edge of entering the market) are implemented in only some EU countries: self-owned off-site, multi-buyer PPA, multi-seller PPA, cross-border PPA, multi-technology PPA, proxy Generation PPA (anticipation of operational risk and prices). These are tried and tested architectures that allow greater flexibility for the various players to meet their needs but their lack either the awareness about their existence among offtakers or the enabling legal ground in selected MSs[223].

Third, PPA off-takers are inclined to sign a PPA in order to underpin their CSR strategy in terms of sustainable electricity supply[224]. In certain MSs (e.g., DE, FR), RES projects under public support schemes are not allowed to sell the GO from their generation facilities. In Germany, GOs are not issued to the generation owners, while in France the GOs are issued, but sold in a centralized auction which does not enable an appropriate link with the generation facility. This lack of GO associated with specific projects may eliminate the reputational benefit of entering into a corporate PPA and thus potentially hinders the renewable generator to sign a PPA[225].

GOs

Guarantees of Origin are explicitly addressed under B3 of Annex B3, dealing with certification. The present assessment focusses in particular on the interest of hourly GOs for green electricity.

GOs reflect the green attribute of power generation. GOs can be traded, and have certain value. They serve as a means to enable consumers/electricity suppliers to green their power consumption (in 2018, 702 TWh worth of renewable energy documented by GOs were consumed [overall RES production in the same year: 1244 TWh], compared to 244 TWh in 2009[226]) and serve as an additional revenue source for renewable power generators.

The current GO system is characterised by a high **supply** of certificates and relatively little demand, implying that prices per certificate are inferior to 0.5 €/MWh. The bulk of those GO originate from depreciated generation assets such as hydro power facilities and therefore it does not represent an additional revenue stream/incentive for new RES projects, despite the fact that there is an increasing demand for GOs. However, for specific types of generation assets, such as non-supported photovoltaic

[223] RE-Source. (2020). Introduction to corporate sourcing of renewable electricity in Europe.
[224] RE100. (2020). Growing renewable power: companies seizing leadership opportunities.
[225] Bird&Bird. (2018). Corporate PPAs - An international perspective.
[226] RECS. (2021). Response to the 2021 review of the RED-2.

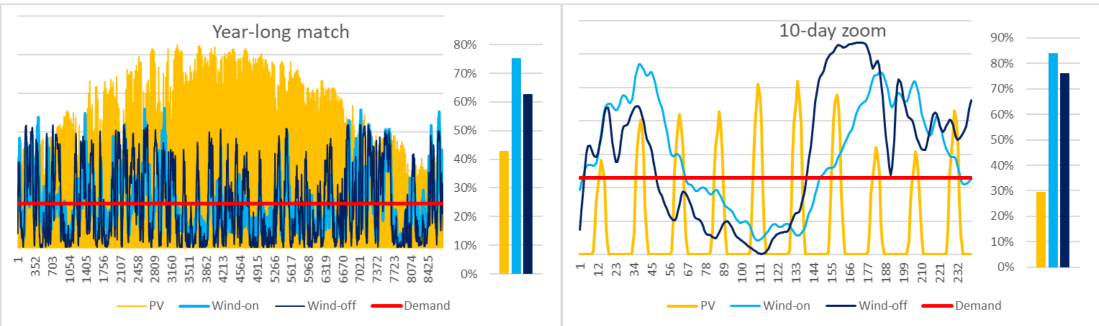
facilities, prices may reach 2 to 3 €/MWh (e.g., for recent PV and wind projects in the Netherlands[227]) or even beyond (up to 10 €/MWh[228]).

The current GO system is often considered by the public as a means to **greenwash** suppliers' power offer as 1) there is a perception of double-claiming under the book-and-claim approach, due to the impression that green electricity is "physically" consumed in one country (e.g. in Norway), while the GOs are sold to other countries (such as Germany[229]) and 2) GOs feature a validity period of 12 months[230] implying that the production of green electricity is decoupled from its consumption.

In their current form, GOs do not facilitate power consumers' willingness to ensure a 100% **green power supply at every hour** of the year, as the certificate only states the start and end date of production (see also the discussion of quarter-hourly GOs in the context of certification Annex B, B3).

In reality, while purchasing GOs with a yearlong validity, to meet 100% of a consumer's power demand (as it is for instance stated as the objective of the 280+ signatory companies of the RE100 initiative[231]), the actual share of RES-E coverage ranges actually between 40% and 80% when considering the simultaneity of power demand and RES generation - depending on the renewable source and considering a flat consumption profile (cf. Figure 1-3 and Chalendar & Benson (2019)[232]).

Figure 0-3 Simultaneity in renewable power generation compared to a constant demand throughout an entire year (left) and during a 10-day period (right). Source: METIS database.



The objective of this option is to:

- Ensure the **effective implementation of Article 15.8**, in particular with respect to MSs' own announcements in their NECPs;
- Facilitate the access to PPAs for SMEs;
- **Make GOs a more efficient mechanism**, providing additional incentives for RES investments;
- GO buyers (including generators of green synthetic fuels) shall be enabled to purchase GOs coherent with their hourly demand, ensuring a real-time supply with green electricity; this further supports storage and flexibility by providing another price signal in addition to the wholesale market.

[227] Trinomics, Öko-Institut & LBST. (2021). Technical assistance for assessing options to establish an EU-wide green label with a view to promote the use of renewable energy coming from new installations.
[228] RE-Source. (2020). Introduction to corporate sourcing of renewable electricity in Europe.
[229] European Commission. (2016). Impact Assessment on RED II - Accompanying document (SWD(2016) 418 final).
[230] Art. 19.3 of RED II states "For the purposes of paragraph 1, guarantees of origin shall be valid for 12 months after the production of the relevant energy unit. Member States shall ensure that all guarantees of origin that have not been cancelled expire at the latest 18 months after the production of the energy unit. Member States shall include expired guarantees of origin in the calculation of their residual energy mix."
[231] RE100. (2021). About us. Available at: https://www.there100.org/about-us
[232] Chalendar, J. A., & Benson, S. M. (2019). Why 100% Renewable is not enough. Joule 3, 1389-1393.

Mid-term vision on GO markets

In the medium-term, a **liquid secondary market for GOs** featuring the time granularity of the electricity wholesale market (i.e. hourly or even below) would represent an effective mechanism to reflect the market value of the individual production attribute of a unit of generated electricity. A dedicated market would allow GO offtakers to purchase the kind of electricity they would prefer (e.g. being renewable or low-carbon, being generated in the same or another MS, being generated by a recently installed plant and notably being generated at a specific point in time). It would represent an additional revenue source for renewable/low-carbon power generators, as well as storage and flexibility providers. It would further facilitate the tracking of renewable electricity used to generate renewable heat or synthetic fuels (such as hydrogen) based on renewable electricity. Finally, if the hourly GO price is integrated in the electricity supply price and reflected via some real-time pricing scheme to the final consumer, the latter may decide to shift its load into hours with low prices (hours with high RES share) thus facilitating RES integration.

The efficiency and liquidity of a (not necessarily hourly) GO market and even of the current GO system could be further raised by:

- Harmonised GO issuance procedure across all MSs, applying similar rules[233] in order to overcome the market fragmentation which results from the requirement introduced by RED (in 2009) to establish national GO systems;
- Mandatory issuing of GOs for all types of power generation (full production disclosure[234]):
  - Ensures a level playing field between renewable and non-renewable sources since currently only renewable energy consumers have to meet the requirements of a GO scheme to prove their use of renewables;
  - Allows to evaluate the emission factor for consumers (in real time), if emission factors would be included in GOs;
  - This would include the issuance for renewable power generators under a public support scheme, which is also considered as a major barrier for the uptake of PPAs (notably in DE, FR[235]).
- Full consumption/supplier disclosure, meaning that a certificate must be cancelled for every MWh consumed, either directly by the consumer or via the supplier;
- Requirement of MS to introduce “Renewable Portfolio Standards” (evolving over time, potentially in line with NECP projections), i.e., obligations on supply companies (and potentially large scale consumers) to ensure a minimum amount of their electricity being supplied by renewable power generation, to be proved via GOs. This enhances the demand for GOs of renewable power generation (raising prices), counteracts suspicions on greenwashing48,[236]) and ensures an effective increase in renewable power generation;
- Providing flexibility providers (e.g., storage operators, power-to-X assets) access to the market, ensuring the traceability of power when being stored (e.g., in batteries, pump storage or via hydrogen) or converted into other energy carriers.

[233] Cf. for instance CA-RES. (2019). Questions and answers on Directive (EU) 2018/2001 on the promotion of the use of energy renewable sources (“RED II”) or Trinomics, Öko-Institut & LBST. (2021). Technical assistance for assessing options to establish an EU-wide green label with a view to promote the use of renewable energy coming from new installations.
[234] Cf. for instance RECS. (2020). What full disclosure means and why it is important.; Florence School of Regulation. (2021). Upgrading Guarantees of Origin to Promote the Achievement of the EU Renewable Energy Target at Least Cost.; RECS. (2021). Response to the 2021 review of the RED-2.
[235] COWI & CEPS. (2019). Competitiveness of corporate sourcing of renewable energy.
[236] European Commission. (2016). Impact Assessment on RED II - Accompanying document (SWD(2016) 418 final).

Blockchain or distributed-ledger technologies may facilitate the trading of hourly GOs, but they are not a prerequisite. It can be expected that appropriate technology solutions will emerge automatically with the evolution of markets (cf. Option 1).

Existing examples of companies pledging for full hourly renewable consumption includes **Microsoft** and **Google** that aim to reach 100% RES consumption 24/7 by 2025 and 2030[237], respectively. Companies of this kind were also the first to announce meeting 100% of their power demand with renewable power in the past. Acting as front-runners they made the system of PPAs and GOs becoming a credible and effective option for companies interested to comply with their internal CSR strategies by means of renewable power supply.
The **EnergyTag** Initiative is "an independent, non-profit, industry-led initiative to define and build a market for hourly electricity certificates that enables energy users to verify the source of their electricity and carbon emissions in real-time"[238].

PPA-related policy options

The Commission could:

- Strengthen the provisions of Article 15.8 on the removal of administrative barriers. The EC requires MSs:
    - To provide in the bi-annual Progress Reports on NECPs (cf. Art. 17 of the Governance Regulation, first Progress Report to be submitted by 15/03/2023) an update on the identified barriers, policies/measures undertaken to remove barriers and facilitate the uptake of PPAs and report the utilisation of PPAs (MRV), by indicating:
        - evolution of signed PPAs (in number/capacity/ energy) over time;
        - distinguishing generator type (wind/solar PV/other);
        - distinguishing the consumer type (mean size of the off-taker).
    - The objective of the MRV on PPAs consists of having some quantitative indicator that can be used for comparison and to verify the effectiveness of policies over time. The respective information would be scrutinised in the framework of the assessment carried out by the European Commission in order to evaluate whether sufficient action is taken and whether the uptake of PPAs follows the trends in other MSs.
- Amend Article 15.8 by requiring MSs to facilitate notably the access to PPAs for small scale consumers/generators (with the actual implementation being left to the MS), e.g., by amending national legislation to integrate multi-seller/buyer PPAs. Multi-buyer PPAs represent one of the few possibilities for SMEs to purchase green electricity, in particular if they want to opt for bundled GOs and ensure additionality of the renewable power generation capacity.

[237] Microsoft and Vattenfall have announced in 2019 the creation of a platform facilitating the hourly matching of renewable energy, cf. Vattenfall. (2020). Vattenfall to deliver renewable energy 24/7 to Microsoft´s Swedish datacenters. Available at: https://group.vattenfall.com/press-and-media/pressreleases/2020/vattenfall-to-deliver-renewable-energy-247-to-microsofts-swedish-datacenters

[238] EnergyTag. (2021). The EnergyTag Initiative. Available at: https://www.energytag.org/

GO-related policy options

The Commission could oblige MSs to adapt their GO systems ensuring that GOs may contain information about the precise time of production;

- MSs will need to adapt GOs that allow to state the start and end time of the production of a MWh with an hourly granularity (in contrast to the monthly granularity which is currently applied)[239];
- The completion of the hourly information remains voluntary[240];
- This amendment could be directly integrated in Art. 19.7 of RED II

C2: Foster regional cooperation

Table 0-3 Options for C2: Foster regional cooperation

Options	Description
Option 0 (baseline)	Maintain current policies under RED II (Art. 5, 8-13, opening of support schemes and use of the Cooperation Mechanisms on voluntary basis).
Option 1 (non-regulatory)	Issue guidance the opening of support schemes and use of Cooperation Mechanism, including cooperation model agreement template (similar to 2013 COM Communication). **Sub-option 1.1:** COM guidance for offshore wind: Option 1 + issue specific COM guidance for offshore wind relating to tender design, IGA templates hybrid / joint projects / opening of support schemes, CBA and CBCAs for the development of hybrid / joint projects / opening of support schemes.
Option 2	Obligations to implement a pilot cross-border project (cooperation mechanism): Obligation for MS to “test” an opening of support schemes/ cooperation mechanisms via an obligation to implement a cross-border projects [until end of 2025], (unless MS can demonstrate why this was not possible). For such projects, MS could choose from a partial opening of support schemes (Art. 5), statistical transfers (Art. 8), joint projects and support schemes (Art.9-13), the EU financing mechanism (Art. 33 Governance Regulation).
Option 3	Mandatory partial opening of support schemes: Include a mandatory partial opening of support schemes (similar to the RED II proposal) of least 5 % from 2023 to 2026 and at least 10 % from 2027 to 2030.
Option 4	Enhancing the Renewable Energy Financing Mechanism: Implementing additional tender rounds of the financing mechanism, financed through: a. EU budget (enabling framework) ¤ rev. MFF (donor clause in different funding programmes); b. Member States (A certain mandatory use of the REFM for MS). **Sub-option 4.1:** Enhancing the Renewable Energy Financing Mechanism specifically for offshore wind projects where host countries are Member States with offshore potential and contributing countries are Member States who have a limited offshore potential or who want to benefit from lower support costs. Such calls for proposals could finance both developing and mature offshore technologies across all European sea basins.

[239] The CENELEC standards for GOs are currently updated to allow for any time stamp (even hourly). However, their utilisation is not compulsory. Thus, the possibility of entering an hourly time stamp should be given to all types of standards used in the EU and this should be enforced, respectively.

240 For RES plants featuring small capacities, generation of 1 MWh may last several hours, which implies that GOs would need to be resized, fractions of GOs are issued or plants are regionally aggregated. For more information, cf. Section 3.1.3 of Annex B.

C.2 – Option 0: No updates – Baseline scenario

Option 0 implies that current policies under RED II are maintained without modification. This refers in particular to Article 5 (Opening of support schemes for electricity from renewable sources), and Articles 8 to 13 (statistical transfers, joint projects, joint support schemes use on a voluntary basis).

C.2 – Option 1: Non regulatory measures – Commission guidance

Issue guidance the opening of support schemes and use of Cooperation Mechanism, including cooperation model agreement template (similar to 2013 COM Communication)

Regional cooperation between Member States is allowing to better plan and operate energy systems, and can reduce the overall cost of reaching ambitious RES/decarbonisation targets. While there are areas where good progress is being made on regional cooperation (notably the development of cross-border infrastructure via the CEF), efforts are still needed in others, and especially in mechanisms related to the facilitation of the deployment of RES technologies (cf. Sections 1.1 and 1.2).
In particular, there is currently a limited use of opening of support schemes and use of cooperation mechanism between Member States (see Option 0). High transaction costs due to coordination efforts and increased risks associated with renewable projects with a cross-border dimension (i.e., opening of support schemes, joint projects) are part of the key barriers to their emergence technologies (cf. Sections 1.1 and 1.2).

Option 1 aims at removing barriers to cooperation between Member States, incentivising the emergence of joint projects via joint tenders, joint support schemes, facilitating the emergence of capital-intensive projects that could not be supported by a single Member States, and reaching the RES and decarbonisation targets more cost-efficiently.

This option is a non-regulatory option based on the provision of guidance on the opening of support schemes, including on the analysis of costs and benefits related to regional cooperation and their allocation to Member States (cross-border cost allocation).

Under this option, the EC would provide:

- Guidance on relevant cooperation models and available EU financing instruments;
- Guidance and blueprints of bilateral/multilateral IGAs;
- Guidance on how to draft IGAs (checklist of processes to be handled, questions to be tackled regarding distribution of costs and benefits, regarding national legal, administrative, economic and political circumstances in participating countries, stakeholders to get involved, similar to the guidance attached to Communication on Delivering the internal electricity market and making the most of public intervention[241], i.e. SWD(2013) 440 final “Guidance on the use of renewable energy cooperation mechanism”);
- Guidance on how to approach the cost-benefit analysis of cooperation mechanisms and the allocation of costs and benefits (CBA and CBCA). This guidance shall focus on the definition of the scope of costs and benefits to be analysed (e.g., cost of support, evaluation of impacts on grids, statistical benefits) and on the provision of good practices in their calculation.

[241] European Commission. (2013). Delivering the internal electricity market and making the most of public intervention (SWD(3013) 440 final).

Sub-Option 1.1 Commission guidance for offshore wind

Issue specific COM guidance for offshore wind relating to tender design, IGA templates hybrid / joint projects / opening of support schemes, CBA and CBCAs for the development of hybrid / joint projects / opening of support schemes

This sub-option aims at facilitating the access to offshore projects to land-locked countries and increasing the deployment of hybrid offshore projects.

Under this sub-option, the Commission would provide:

- For hybrid assets, guidance on combining CBAs and CBCAs for generation assets with those for infrastructure assets as a basis for corresponding IGAs for joint and hybrid projects (how to allocate renewable energy target amounts, costs for renewable energy support, grid (inter)connection, grid reinforcement and grid integration)[242];
- Alternatively, for hybrid assets, provision of guidance on the calculation of costs and benefits from a Member State perspective (cost of support, cost of potential grid reinforcements and RES integration, statistical benefits), provision of guidance on coordination on maritime spatial planning and grid planning (complementing the "integrated network development offshore plans" foreseen in Art. 14 of the proposed revised TEN-E);
- Ultimately, the Commission may oblige Member States to jointly define and agree to cooperate on the amount of offshore renewable generation to be deployed within each sea basin by 2050, with intermediate steps in 2030 and 2040 (mirroring TEN-E proposal for grid deployment).

C.2 – Option 2: Obligations to implement a pilot cross-border project (cooperation mechanism)

Obligations to implement a pilot cross-border project (cooperation mechanism): Obligation for MS to "test" an opening of support schemes/ cooperation mechanisms via an obligation to implement a cross-border projects [until end of 2025], (unless MS can demonstrate why this was not possible). For such projects MS could choose from a partial opening of support schemes (Art. 5), statistical transfers (Art. 8), joint projects and support schemes (Art.9-13), the EU financing mechanism (Art. 33 Governance Regulation).

Given the previously stated barriers, Member States refrain from engaging in cross-border projects. This option considers an obligation for Member States to implement a cross-border project, which would reduce the perceived risk of cross-border projects by testing one of the mechanisms. They would also gain initial experience in the implementation which might subsequently be shared between Member States (as described under Option 1).

This option would be transposed in an additional article in RED II, requesting the implementation of a pilot cross-border project as stated in the option description.

C.2 – Option 3: Mandatory partial opening of support schemes

Mandatory partial opening of support schemes: Include a mandatory partial opening of support schemes (similar to the RED II proposal) of least 5 % from 2023 to 2026 and at least 10 % from 2027 to 2030.

Art. 5.1 of RED II states that "Member States may provide support RES-E which is produced in another MS - for an indicative share of the newly-supported capacity; indicative shares may, in each year,

[242] NSEC. (2020). Joint Statement of North Seas Countries and the European Commission.

amount to at least 5 % from 2023 to 2026 and at least 10 % from 2027 to 2030". Yet it is a non-binding rule, and only Germany and Denmark opened their support for bids from the other country yet.

This option would ensure the effective deployment of cross-border RES auctions between Member States, stimulate joint learning, and support the alignment of national support schemes.

The Revised Renewable Energy Directive recast would make it mandatory for Member States to partially open their national support schemes to cross-border participation, up to the indicative shares mentioned in Art. 5.1 of RED II (at least 5 % from 2023 to 2026 and at least 10 % from 2027 to 2030); it must be ensured that these levels are in line with physical cross-border interconnections.

The opening of support schemes shall be in line with Art. 13 of RED II in order to guarantee (i) reciprocity, (ii) no double-compensation, (iii) cooperation agreement to allocate support towards each Member States' renewables pledges.

Eventually, in line with Art. 13.4, the Commission shall disseminate guidelines and best practices by a given deadline (e.g., end of 2022) to facilitate this process.

C.2 – Option 4: Enhancing the Renewable Energy Financing Mechanism

Enhancing the Renewable Energy Financing Mechanism: Implementing additional tender rounds of the financing mechanism, financed through:

a. EU budget (enabling framework), rev. MFF (donor clause in different funding programmes)
b. Member States (A certain mandatory use of the REFM for MS)

The Renewable Energy Financing Mechanism is a bottom-up mechanism, based on voluntary participation from Member States, based on Article 33 of the Governance Regulation (EU) 2018/1999, and that is in force since January 2021. It is a match-making mechanism where contributing countries fund a European fund for EU-wide tenders.

Contributing countries can specify how their money should be used (e.g., technology-specific). Projects are developed in host countries, and statistical transfers are delivered to the contributing country for the renewable electricity produced in the host country.

The auction can be either technology-specific or for multiple technologies. Multi-technology auctions aim at achieving a least-cost selection across technologies, while a technology-specific auction aims at a least-cost deployment of the most acceptable technologies.

Private investors can contribute to the mechanism. An additional incentive to private contributors is the possibility to request guarantees of origins for the energy production that corresponds to their contribution. The entity may also indicate a preference for tender procedure for which its payment is intended, or a type of technology that it is willing to support.

This mechanism supports a cost-efficient development of renewables. In addition, EU countries can work more closely together to achieve their individual and collective renewable energy targets and cover gaps.

However, in its current version, the Mechanism can only be effective if contributing Member States are interested in using it. Without the Mechanism, joint projects can still be set up, but require the signing of cooperation agreements between Member States for resources and benefit-sharing and efficient RES deployment.

In its current formulation the mechanism facilitates the cooperation between Member States by removing the need for bilateral cooperation agreements. It offers a regional cooperation mechanism managed at the EU level that can help Member States meet their RE targets (thanks to resulting statistical transfers). By funding the Mechanism via the EU budget, additional tender rounds could be organised, leading to a further deployment of RES.

In this regard, the Commission should define clear rules on available funding, auction calendar, eligibility to participate in tenders and award criteria.

Sub-option 4.1: Enhancing the Renewable Energy Financing Mechanism specifically for offshore wind projects

Enhancing the Renewable Energy Financing Mechanism specifically for offshore wind projects where host countries are Member States with offshore potential and contributing countries are Member States who have a limited offshore potential or who want to benefit from lower support costs. Such calls for proposals could finance both developing and mature offshore technologies across all European sea basins.

Offshore wind development face two major issues:

- Land-locked countries cannot easily access (cost-efficient) offshore wind resources;
- Coastal countries often have an offshore potential larger than what they can exploit alone (i.e., with their level of investment).

Focussing on offshore wind with the Mechanism would enable a cost-efficient development of offshore technologies, with a better sharing of resources that would benefit both the host and contributing countries by increasing the cost-efficiency of investments and allowing landlocked states to contribute to offshore wind as well.

Host countries would receive additional local investment in offshore projects, and therefore enjoy the benefits in terms of local employment and lower pollution. An increased share of statistical benefits to compensate for significant grid reinforcement costs could be considered. Therefore, the Mechanism could launch technology-specific calls targeting at offshore technologies, both mature and developing (floating and ocean technology), and design a pipeline (or an EU-wide calendar) for these technology-specific calls in order to provide clarity and visibility both to national authorities (which would issue permits) and developers or the upstream value chain (to help investments materialise).

This option could go beyond by requiring a fast-tracking mechanism (for permits granting) for projects under REFM calls, to make sure national administrative rules do not block or reduce the probability of the project to materialise (especially in the case of projects with a cross-border dimension such as hybrid projects).

Mapping of potential impacts

This section presents an overview of the potential economic, environmental and social impacts identified for the different policy options to be assessed, summarising the following criteria as follows:

- **Direction:** Positive or negative;
- **Magnitude:** limited or significant;
- **Horizon:** Short to long term;
- **Affected parties:** following categorization indicated below.

C1: Promote power purchase agreements

This section presents an overview of the potential economic, environmental and social impacts identified for the different policy options to be assessed, summarising the following criteria as follows:

Figure 0-4 Options for C1

Option 0	Option 1	Option 2	Option 3
• Maintain current policies under REDII	• Non-regulatory measures: guidance on PPAs	• Introduce support at EU level	• Introduce more specific provisions in REDII

Table 0-4 Mapping of impacts per option

Option C1 - impacts map	economic	environmental	social
Option 0 (baseline)	D: Positive M: Limited H: Long-term A: MS governments, project developers, SMEs/PPA offtakers	D: Positive M: Limited H: Long-term A: Local communities hosting RES installations	D: Positive M: Limited H: Long-term A: Final electricity consumers
Option 1 (non-regulatory)	D: Positive M: Limited H: Mid-term A: MS governments, project developers, SMEs/PPA offtakers	D: Positive M: Limited H: Mid-term A: Local communities hosting RES installations	D: Positive M: Limited H: Mid-term A: Final electricity consumers
Option 2	D: Positive M: Limited H: Long-term A: Project developers, SMEs/PPA offtakers	D: Positive M: Limited H: Long-term A: Local communities hosting RES installations	D: Positive M: Limited H: Long-term A: Final electricity consumers
Option 3	D: Positive M: Significant H: Long-term A: Project developers, SMEs/PPA offtakers, RES-E manufacturers and supply chains	D: Positive M: Significant H: Long-term A: Local communities hosting RES installations, general public	D: Positive M: Significant H: Long-term A: Final electricity consumers, RES-E manufacturers and supply chains, general public

C2: Foster regional cooperation

Figure 0-5 Options for C2

Option 0	Option 1	Option 2	Option 3	Option 4
• Maintain current policies under REDII	• Non-regulatory measures: Commission guidance • Commission guidance for offshore wind	• Obligations to implement a pilot cross-border project	• Mandatory opening of support schemes	• Enhancing the Renewable Energy Financing Mechanism • Enhancing the REFM specifically for offshore wind projects

Table 0-5 Mapping of impacts per option

Option C2 - impacts map	economic	environmental	social
Option 0 (baseline)	D: Positive M: Limited H: Mid-term A: MS governments and NRAs	D: Positive M: Limited H: Mid-term A: General public	D: Positive M: Limited H: Mid-term A: Final electricity consumers
Option 1 (non-regulatory)	D: Positive M: Limited H: Mid-term A: MS governments and NRAs	D: Positive M: Limited H: Mid-term A: General public	D: Positive M: Limited H: Mid-term A: Final electricity consumers
Option 2	D: Positive M: Limited/medium H: Mid-term A: MS governments and NRAs	D: Positive M: Limited/medium H: Mid-term A: Hosting MS, general public	D: Positive M: Limited/medium H: Mid-term A: Final electricity consumers
Option 3	D: Positive M: Significant H: Long-term A: MS governments and NRAs, project developers	D: Positive M: Significant H: Long-term A: Hosting MS, general public	D: Positive M: Significant H: Long-term A: Final electricity consumers, RES-E manufacturers and supply chains, general public
Option 4	D: Positive M: Significant H: Mid-term A: MS governments and NRAs, project developers	D: Positive M: Significant H: Mid-term A: Hosting MS, general public	D: Positive M: Significant H: Mid-term A: Final electricity consumers, RES-E manufacturers and supply chains, general public

Analysis

The assessment of impacts in this section and the next will discuss each group separately.

Semi-quantitative and qualitative assessment

- *Options for C1: Promote power purchase agreements*

Option 0	Option 1	Option 2	Option 3
• Maintain current policies under REDII	• Non-regulatory measures: guidance on PPAs	• Introduce support at EU level	• Introduce more specific provisions in REDII

Overview of the identified policy options to be analysed

The following sections summarize some initial high-level assessment of the options to be analysed. These are:

- Option 0: Current policies (baseline): Maintain current policies under RED II (Member States to facilitate the uptake of PPAs);
- Option 1: Non-regulatory options: guidance on PPAs, including for example draft template contracts for both virtual and physical PPAs, which includes cross-border PPAs spanning across bidding zones. Investigate the use of blockchain technology and distributed ledger platforms, as an instrument of automatic tracing and contracting electricity;
- Option 2: Introduce support at EU level through for example financial instruments supporting in particular off-taker risk, including for multi-buyer / aggregated PPAs;
- Option 3: Introduce more specific provisions in RED II on the administrative and regulatory barriers to PPAs that Member States need to tackle.

In each section, the overall impacts of the promotion of power purchase agreements are analysed, followed by more specific assessments of each option.

Economic impacts

Impacts common to all options

A major barrier to investments in renewable energy generation is the lack of attractiveness implied by intermittency on variable income. Signing a PPA is an effective way of inducing a long-term, fixed-price source of financing for investors/generators, giving them security of income and reducing investment risks. Thus, facilitating the implementation of PPAs directly drives down the cost of capital, thereby enhances the project’s credit rating and makes the investment more attractive for lenders and investors and its realisation more likely. Reduced capital costs directly translate into savings related to overall energy system costs, and to total support costs if the given projects benefit from public support.

PPA development is taking place in a context of support schemes phase-out, as most of these technologies are reaching maturity. Thanks to income stabilisation brought by PPAs, investors have increased confidence in renewable technologies, enabling a swift and facilitated phase-out of support schemes, which are no longer needed to support investments. According to the EIB, if Feed in Premiums

for renewable electricity generators were phased out, PPA contracts would be necessary for 80% of unsupported projects, compared to 30% under the current Feed in Premiums[243].
The implementation of PPA contracts stimulates RES-E investments and reduces the funding gap of achieving RES-E targets, if the investments under PPA may be considered as additional. If MSs phase-out their support schemes in parallel, a simple financing shift from public support-schemes to PPAs may occur without necessarily triggering additional investments (the effect depends on the actual design of the support scheme and the PPA).

All other things being equal, accelerating the penetration of renewables in the European electricity mix could reduce the operation of carbon-intensive electricity generation, thus reduce carbon emissions and lead to a progressive decrease in the carbon price, if the emission reduction is not captured by the ETS Market Stability Reserve.

As off-market contracts, PPAs may reduce the electricity market efficiency by creating a second market for renewable electricity generation. Yet, most PPA contracts respect the additionality principle (additionality applies for physical PPAs, while virtual PPAs and PPAs under support schemes do not necessarily translate in an additional project), meaning that signing a PPA ensures that an additional project has actually been developed compared to the reference case (not signing one). This principle ensures that each euro invested through those contracts is directed towards the materialisation of the renewable installation, enabling a cost-effective RES deployment.

Sometimes, PPAs are set up for installations reaching the end of their support scheme eligibility, mostly after 20 years. These contracts enable facilities reaching the end of their lifespan to be covered for operational and maintenance costs in order to extend their activity, possibly including repowering costs.

The establishment of PPAs may trigger additional investments, thereby making technologies reach maturity more quickly (or further reduce the technology costs). This maturity stage is a key enabler in the decrease of support levels. However, the effect depends a lot on the extent to which PPAs ultimately ensure the financing of future RES-E projects.

Option 1
The availability of PPA **templates** allows to put in place PPAs more quickly. This reduces the conception periods for renewable projects and allows construction to begin earlier. The time saved can represent a reduction in the total cost of projects, meaning that investment needs (for the same number of projects) will decrease. Overall, as renewables would get cheaper, it will also lower the cost of support (cost efficiency).

If the **templates target in particular SMEs** and assuming that signed PPAs trigger investments in renewable power generation assets, which feature lower LCOE than conventional assets (if not yet paid off), these new investments may actually imply an effective reduction in energy system costs.

In particular **templates for cross-border PPAs** facilitate the investments in sites featuring more favourable weather and/or economic conditions, thus implying higher renewable power generation for

[243] European Investment Bank. (2020). Financial Instruments for Commercial PPAs in Europe.

a given amount of capacity and/or reduced capital expenditures, thus driving down system costs. If the EC's guidance on the implementation of Art. 15.8 actually triggers a thorough assessment and removal of barriers, PPAs may be used more broadly, thus reaping the benefits of PPAs outlined in the general section.

Some RES-E projects get stopped (or fail) at the administrative phase. A simplified procedure to sign a PPA facilitated via **templates or a knowledge sharing platform** for best practice would ease this barrier and increase the realisation rate (cost effectiveness). More projects would materialise, decreasing the funding gap of achieving RES-E target

The guidance on PPA contracts will allow a simplification of the financial procedures inherent to the renewable energy market, and remove obstacles to its accessibility. Many stakeholders, consumers or investors and in particular SMEs, who so far have not been expert enough to participate in the development of renewable energy, could obtain the possibility to enter the PPA market (an enabler for market access).

The facilitated procedures for signing PPAs for renewable installations added to the corporate willingness to consume green electricity to improve their Corporate and Social Responsibility will facilitate the translation of available funds into actual investments in green technologies.

The use of renewable electricity can be beneficial for many companies, both financially and in terms of compliance with environmental standards and internal CSR strategies. PPAs are one of the principal means of establishing contracts with generators. As the complexity of these contracts is the main reason for their slow implementation, in particular among SMEs, templates and knowledge sharing platforms could make PPAs more accessible, thereby raising the overall PPA market volume. This enhances competition in the PPA market and creates an increased demand for PPAs, allowing more generators to consider PPAs as alternative financing strategy.

Option 2

Credit guarantees may protect an energy seller against non-fulfilment of the contract by guaranteeing the revenue streams; this reduces the financing costs (at the expense of a premium) and would be directly mirrored in a reduction of energy system costs compared to a situation where the energy seller faces higher capital costs due to an elevated risk premium related to higher uncertainty of stable revenues. A study realised by Ecofys, Fraunhofer ISI, KEMA and Energo Banking[244] estimates public or private insurances covering risks that are so far not commercially insurable to drive down LCOE of vRES by some 2%. The investment risk being covered by the insurance will lower the risk premium and thus the WACC. Lower risks reduce the cost in structuring finance and thereby the CAPEX.

Credit guarantees may guarantee the long-term credit-worthiness of SMEs, thereby increasing the pool of potential off-takers; assuming that this results in additional RES-E investments instead of alternative energy sources featuring a higher LCOE, this may bring down energy system costs.

[244] Ecofys, Fraunhofer ISI, KEMA & Energo Banking. (2011). RE-Shaping - D16 Report: Towards triple-A policies: More renewable energy at lower cost.

In this option, no financial support is deployed but financial structures are put in place to better meet the needs of investors. By reducing investment risks and providing guarantees, these measures reduce the cost of capital and thus the total cost of support.

By removing several barriers to the access to PPAs (creditworthiness, length of contracts, difficulty to gather enough PPAs before the financial close for large scale projects...), the measures deployed allow a better access to the renewable energy market, lowering market entrance barriers for generators and off-takers and raising market efficiency.

It facilitates the setting-up of PPAs among stakeholders so far disadvantaged by the current system, e.g., SMEs or offshore energy generators. Offshore wind assets are an order of magnitude larger in scale than onshore wind and solar PV and require either exceptionally large off-takers or a larger number of PPAs which have weaker claims to additionality[245]. They will allow a larger number of stakeholders to enter the PPA market, and thus increase competition and lower market prices.

Option 3

Energy system costs could be reduced (cf. general section), if MS put in place effective policies to remove barriers for PPAs and facilitate the access for SMEs to PPAs; however, it remains uncertain to what extent this will actually happen; EC might need to enforce the updated Directive in case of non-compliance.

Assuming that Option 3 succeeds to remove barriers for accessing PPAs and thus facilitate the use of PPAs among SMEs, this could close the delivery gap identified in Section 1.2 by some 64 TWh. The estimation of benefits builds upon the assessment carried out in the Baringa study on behalf of the European Investment Bank[58]. This assessment distinguishes two scenarios which differ in terms of government support, for renewable power generation, merchant risk appetite among project developers and a remaining need for PPAs to meet the investment requirements. The need or appetite for PPAs among generators (considering an overall power generation from solar and wind of 1240 TWh) is contrasted with the potential PPA demand from offtakers and the difference between the two is the PPA gap that remains to be closed. Scenario A identifies a gap of 190 TWh vs requirements for commercial PPAs is expected to fall short of demand among offtakers by up to about 10 TWh in Scenario B.

The offtaker demand for PPAs in Scenario A exceeds the demand from Scenario B (290 vs 150 TWh). The stronger appetite from offtakers reflects more participation by large energy users who have the appropriate footprint to consider PPAs. Though at the upper bound, this estimate does not assume any major intervention to remove barriers but assumes a stronger green mandate among offtakers with 16% of non-domestic power demand being under PPA by 2030. Under Scenario B, there is limited additional demand from offtakers beyond large, listed organisations publicly committed to procuring renewables, resulting in less than 10% of non-domestic power demand being under PPAs by 2030.

The power generation considered in the assessment elaborated in the study for the European Investment Bank[246] is close to the respective renewable power generation projected under the latest Reference Scenario for 2030. This means, it is expected that MSs will reach this target with current

[245] European Investment Bank. (2020). Financial Instruments for Commercial PPAs in Europe.
[246] Ibid.

policies and new policies currently under way (which are likely to rely to a smaller extent on PPAs, given the little attention paid to this topic in MSs' NECPs). Yet, one might assume that the gap identified in the report remains when it comes to the closure of the overall delivery gap identified in Section 1.2 (and both are quite in line with 190 TWh vs a 150-190 TWh delivery gap).

The Baringa report for the European Investment Bank[67] states that Scenario A reflects more participation by large energy users who have the appropriate footprint to consider PPAs, yet it does not assume any major intervention to remove barriers. Under Option 3, it might be expected that SMEs also enter the market for PPAs and become offtakers. Within the commercial sector, SMEs (i.e., companies with less than 250 employees) represent roughly 40% to 50% of European electricity demand (some 320 TWh). Incentivising SMEs to opt for PPAs could lower the gap. Assuming that the more ambitious share of offtakers for PPAs from Scenario A would also be applied to SMEs (16% of non-domestic demand equals 20% of electricity demand from large commercial and industrial suppliers), this would close the financing gap by some 64 TWh. Thus, targeting SMEs represents a reasonable strategy to partially close the RES-E gap.

Provided sufficient demand, GOs featuring an hourly timestamp could exhibit increased prices in hours of low RES generation (scarcity), thereby increasing the revenue for RES generators. In compliance with Art. 19.2 of RED II, generators are required to factor these revenues in when applying for public support, thus reducing the costs of support.

In order to determine the **frequency of situations featuring a potential future shortage of hourly renewable GOs** compared to an hourly demand, we contrasted hourly renewable power generation for a set of selected countries (relying on the generation figures from the MIX55 scenario in 2030 and generation profiles from METIS) with different shares of electricity demand aspiring for renewable GOs. We distinguish shares of 5%, 10%, 20% and 30% of national electricity demand. The shares are directly applied the shares to the national consumption profile, considering that the appetite for renewable electricity purchase is homogeneous across all sectors (with residential and small commercial consumers purchasing hourly GOs indirectly via an electricity supplier). The aggregated renewable power generation profiles[247] represent the volume-weighted total renewable power generation, including hydro.

The upper part of Figure 2-1 illustrates the comparison of renewable power generation and different levels of GO demand for the example of Germany in January and July. The match between both depends on various factors. While renewable power generation in January is more characterised by wind-based power generation, the summer profile in July exhibits a stronger day-night variation due to a more important contribution from solar PV. In terms of magnitude, renewable power generation in summer time may occasionally exceed the generation in winter time, at least during a few consecutive hours around midday. The demand for GOs features a higher level in winter than in summer time (due to a higher overall electricity demand that is notably triggered by enhanced demand for heating, lighting etc.). In addition, there is a stronger day-to-day variation, which is likewise primarily driven by temperature-dependent heating-related power demand.

[247] The respective scenarios originate from the METIS database (European Commission, 2021) and have been calibrated on PRIMES model results.

Subtracting the demand for GOs from the renewable power generation provides the net renewable power generation.[248] The lower part of Figure 2-1 shows the daily profile of the mean net renewable power generation. It reveals substantial renewable oversupply during daytime and situations of limited abundance of renewable power generation (and thus GOs) during the early evening (when solar PV generation fades out and the evening consumption peak occurs) as well as in morning hours during winter time.

[248] This concept can be understood as the counterpart to the concept of net or residual load.

Figure 2-1: Comparison of renewable power generation with varying GO demand levels (top) and resulting mean daily net renewable power generation (bottom). Source: own calculations

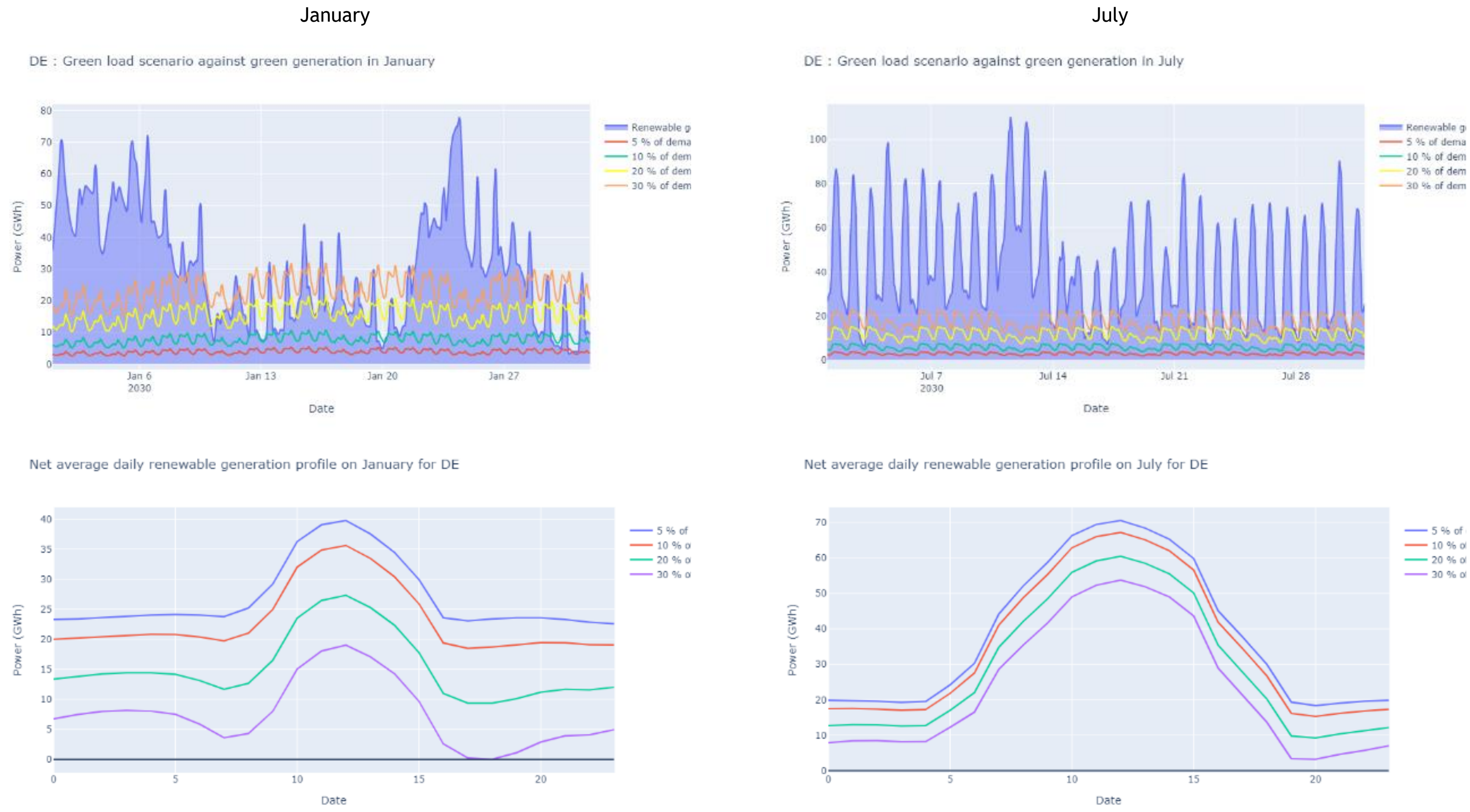
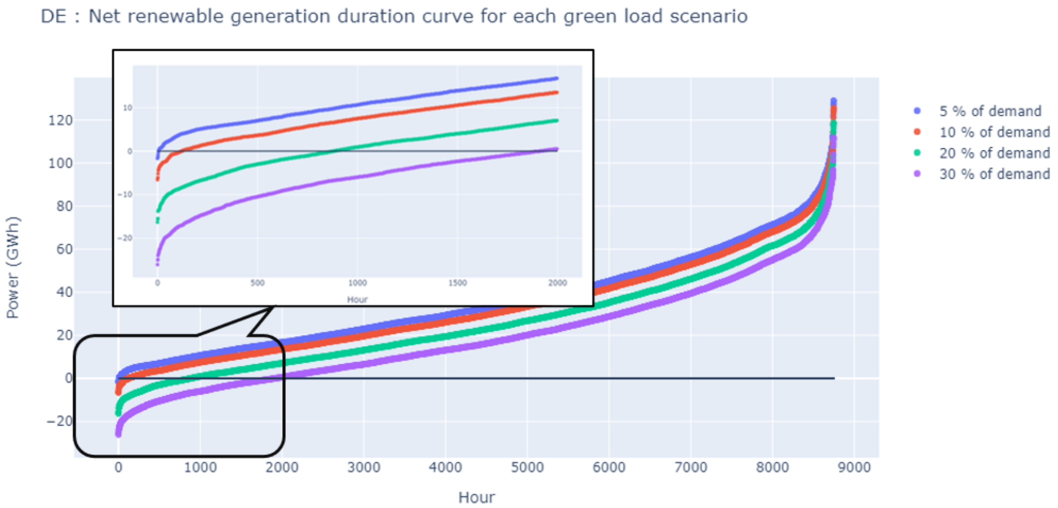


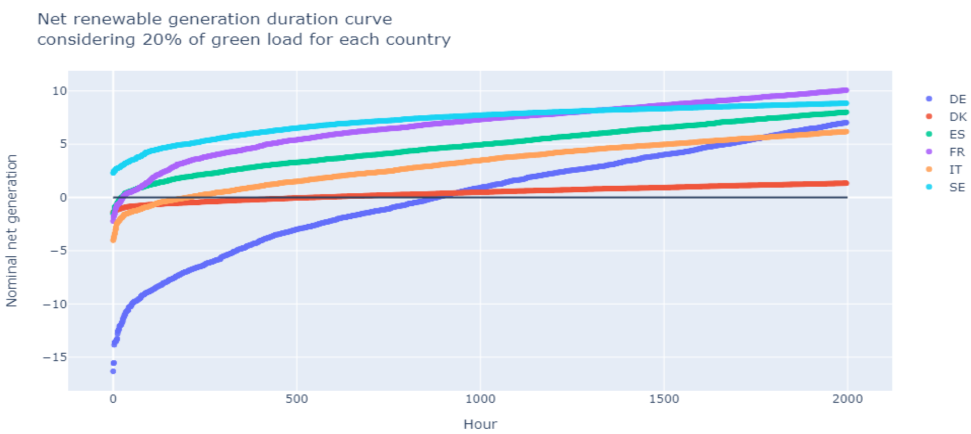
Figure 2-2 illustrates the sorted net renewable power generation curve for Germany under different levels of GO demand. A potential scarcity in GO supply hardly occurs when demand is very low. For demand levels of 5% and 10%, the number of hours with insufficient renewable power generation equals 6 and 110 hours. However, if the demand for hourly GOs would rise to 20% or 30% of the overall national demand, a lack of renewable power generation (and GO supply) would occur during 880 and 1920 hours, respectively, during the year. Assuming that in such situations the lack in GOs would result in scarcity prices that would for instance imply an increase in the GO price by a factor of 10 (while prices in all hours of the year remain constant), this would increase the overall revenues from GOs for the power generator by 90% and nearly 200%, respectively.

Figure 2-2: Sorted net renewable power generation curve for Germany in 2030. Source: own calculations



It is important to note that the occurrence of situations of scarcity depends on the actual characteristics of the actual power mix and demand profile in a given country. Figure 2-3 indicates the sorted net renewable power generation curve for a set of countries under a 20% GO demand. While some countries, such as Sweden, Spain or France are less concerned by a lack in renewable power generation and GO abundance (notably related to an important contribution from baseload hydro power generation), Italy and Denmark face similar situations of a potential GO scarcity during 200 and 540 hours per year.

Figure 2-3: Sorted net renewable generation curve for selected MSs in 2030, considering a 20% share of GO demand. Source: own calculations



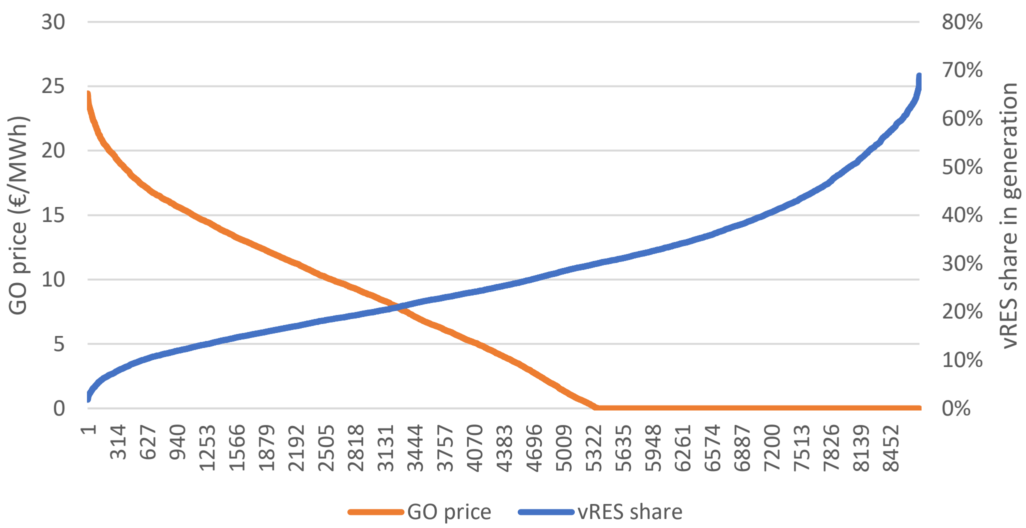
Finally, it should be noted that the picture would be very different in a situation of full GO disclosure and obligations on electricity consumers to comply with minimum renewable shares at hourly time step (cf. text box on GOs in the definition of C.1 – Option 3: Introduce more specific provisions in) as this would create an explicit demand for GOs and a liquid GO market which would ultimately reflect meaningful price signals valuing the green attribute and thus represent a significant secondary source of revenues for RES generators.

In order to estimate the potential economic impacts of an hourly GO scheme, an **in-depth assessment relying on the EU energy system model METIS** was carried out.[249] As a tradeable certificate on electricity markets, hourly GOs would feature a market price resulting from the balance of supply and demand. When renewable generation decreases, competition for GOs increases and their prices rise. As consumers would be exposed to this hourly GO price signal (in addition to the price signal from the wholesale electricity market), they could adapt their consumption patterns (also referred to as demand side response, DSR or DR) to minimise their electricity bill (including GO payment).

In order to account for consumer response to the hourly vRES share in electricity generation, an indirect representation of hourly GOs and its associated price is integrated into METIS.

In the present assessment, the hourly GO price is assumed to vary as a piecewise linear function of the hourly vRES share. When the vRES generation exceeds a given threshold, the GO price falls to 0 due to oversupply conditions. The threshold is set at a 30% RES share in power generation in this analysis. However, when renewable generation is lower than the specified threshold, offtakers are competing for GOs. For this model run, the price is assumed to rise linearly with the decrease in vRES generation, until reaching a maximum when almost no renewable generation is available. For this exercise, this maximum is called scarcity price.

Figure 2-4: vRES share against GO price duration curve - FR - medium demand scenario. Source: own calculations



249 The full description of the analysis can be found in a separate modelling note that was prepared by Artelys for the assessment of Topic B2 (Promote RES based electrification by better integrating RES electricity in H&C and transport), Option 2 (Demand response measures: Include grid electricity real time market signals to consumers)

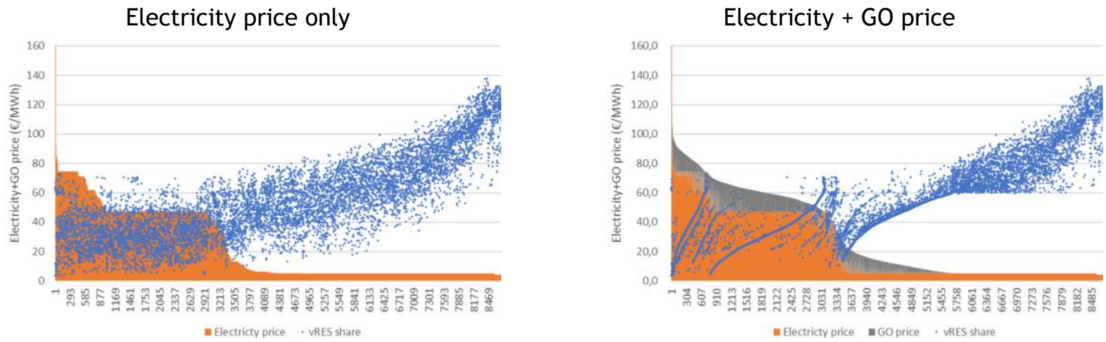
Setting this scarcity price defines the overall shape of the GO price curve as function of the renewable share in power generation. Considering the hourly vRES-share extracted from the high-DR model run (cf. modelling note), one can compute the average GO price over the year. This annual GO price is expressed in comparable terms with respect to current GO prices, which can be cancelled within a year. In total, three model runs are considered in which the scarcity price varies in order to reach different average GO prices (cf. Table 2-1). The average GO prices equal 2, 4 and 10 €/MWh, in contrast to the mean wholesale electricity price of 46 to 50 €/MWh under the MIX55 scenario in 2030.

Table 2-1: Assumptions for the three METIS model runs on hourly GOs

	Low GO demand	Medium GO demand	High GO demand
Scarcity GO price	13 €/MWh	26 €/MWh	65 €/MWh
Average GO price	2 €/MWh	4 €/MWh	10 €/MWh
Average electricity wholesale price	46 – 50 €/MWh		

Figure 2-5 illustrates the correlation of the vRES share with the electricity (left) and the total price duration curve (right). One may observe an enhanced correlation in specific wholesale market price segments thanks to the introduction of the GO price signal.

Figure 2-5: vRES share against electricity (+GO) price duration curve - FR - medium GO demand scenario; Source: own calculations.



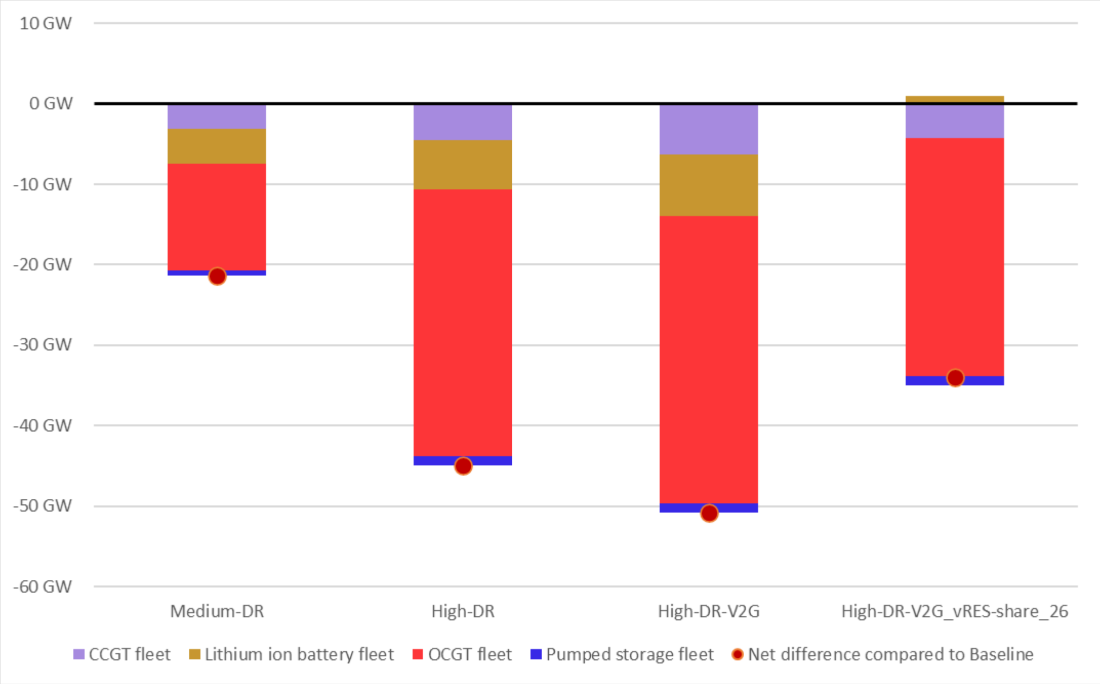
The METIS-based analysis determines the cost-optimal operation of flexible power consumers (i.e. electric vehicles and heat pumps) based on the given price signals and the resulting effects on the capacity needs for additional flexibility solutions (i.e. flexible power generation and storage). The optimisation takes place for a single year at hourly time resolution, representing each MS as a single node.[250]

To gain a better understanding of the economic effects of an hourly GO system, it is important to analyse in a first step the impacts on investments in flexibility capacities (Figure 2-6). For the two scenarios with *medium* and *high DR* share (i.e. 30% and 70%, respectively, of all EVs and heat pumps operating in a smart, price-sensitive manner), the introduction of DR avoids investment in some 13 to 33 GW of gas turbines (OCGTs) and to a limited extent in CCGTs and batteries, compared to the baseline case (i.e. the MIX55 scenario without DR) and disregarding the GO price signal.
This effect is even reinforced in the case with V2G (cf. *high-DR-V2G* scenario). However, under a DR strategy combining the hourly wholesale and GO price (cf. *high—DR-V2G_vRES-share* scenario), the reduction in gas turbine capacity investments turns out to be less significant as part of the capacity is

[250] For further information, please, refer to the detailed description of analysis results under Annex B, B2 (Promotion of RES-based electrification), Option 2 as well as Annex 1 of the present document.

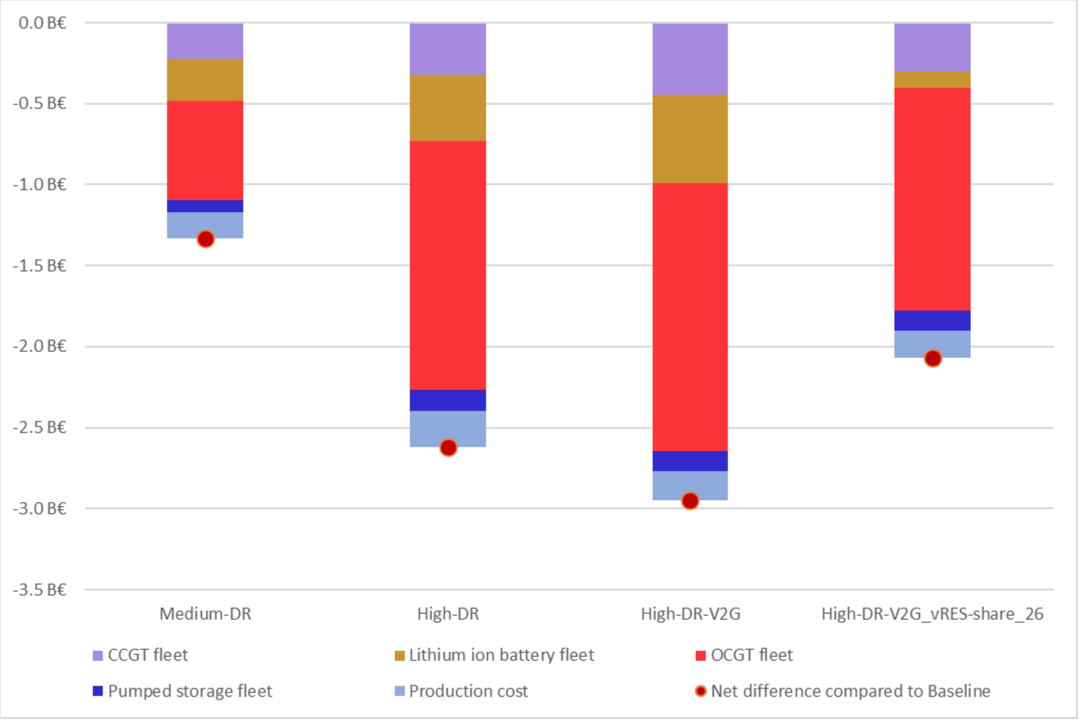
required when electricity demand is shifted into hours where gas-based power generational represents the marginal generation unit. Additional batteries are required in order to shift low-cost electricity into the same hours as demand is shifted (i.e., the hours featuring higher RES-E shares, from night-time to day-time).

Figure 2-6: Investments in flexibility solutions, compared to Baseline. Source: own calculations with METIS



The introduction of demand side-related flexibility may significantly reduce system costs, cf. Figure 2-7. The cost savings (in comparison to the baseline without DR) are primarily triggered by avoided investments in additional flexibility solutions. Similar to the avoided capacity investments, cost savings are highest in the case with high DR share and V2G. In the case of an hourly GO system (cf. *high-DR-V2G_vRES-share* in Figure 2-7), investment-related savings are lower than in the pure high-DR-V2G case. However, the GO price-based optimisation of the operation of flexible consumers reduces the production costs. This leads to annual net savings of about € 2 Bn compared to the baseline without DR.

Figure 2-7: Total system costs, compared to Baseline. Source: own calculations with METIS



Ultimately, it can be concluded that as long as there is an oversupply of GOs, there will be no direct impact on the funding gap; however, assuming increased revenues from GOs may further drive down generation costs and thus increase the financial attractiveness of RES-E, they may indirectly contribute to an enhanced deployment (depending on the demand for hourly certificates and the willingness-to-pay of consumers when GOs are scarce).

Hourly timestamps on GOs empower consumers to make informed purchase decisions, meeting the specific demand in specific hours of the year (even though the trading may take place afterwards); hourly GOs provide a price signal in situations with low RES generation, thus incentivizing flexible power consumers to shift their load into hours with lower GO prices, thereby facilitating RES integration - provided that the GO price signal is properly reflected in end-consumer's hourly purchase prices (subject to the availability of time-varying tariffs and bidirectionally communicating metering infrastructure).

Security of supply

The variable nature of wind and solar energy may put at risk the stability of energy networks and the security of electricity supply (e.g. a late cold spell in winter, with low solar and wind generation), if no measures (e.g. additional sources of power system flexibility, like storage, demand-side response of flexible back-up generation) are put in place.

Environmental impacts

Impacts common to all options

PPAs foster the development of renewable energies, which replace carbon-intensive electricity generation means and consequently reduce greenhouse gas emissions and improve local air quality. However, renewable energies require a significant quantity of materials, the extraction of which can have consequences on the local environment. In addition, renewable energies have a large footprint on the ground and their impact on flora and fauna can be locally significant.

Option 3

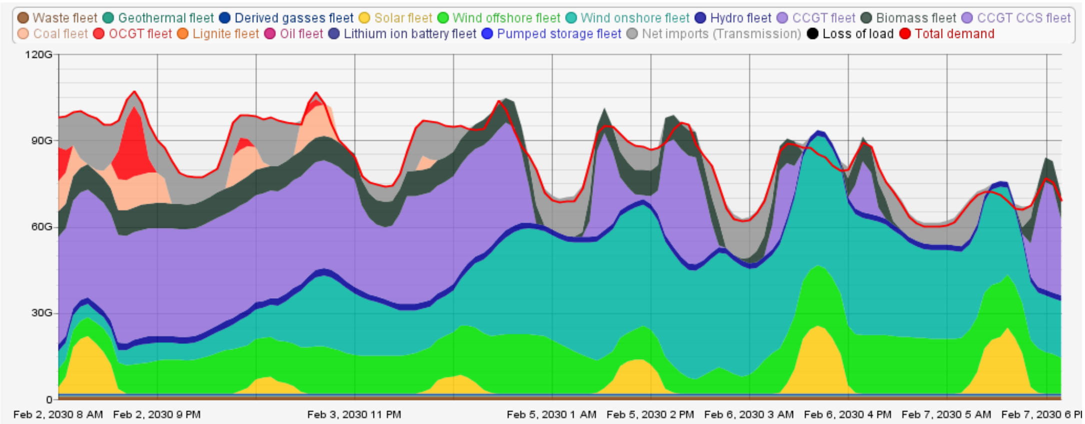
PPAs

As indicated above, regulatory measures tackling the removal of barriers for SMEs (in combination with financial instruments presented under Option 2) could increase PPA demand by 64 TWh. Building on the MIX55 distribution of vRES technologies, this additional PPA demand would translate into 17 GW of PV, 15 GW of onshore wind, and 3.3 GW of offshore wind additional capacity (an overall 35 GW of additional capacity), or about 33 to 44% of the delivery gap identified in Section 1.2. In comparison, Europe counted in 2018 163 GW onshore wind (325 TWh production), 19 GW offshore wind (59 TWh production) and 119 GW of solar PV (127 TWh production).

In order to better understand environmental benefits brought by these regulatory measures, a model run integrating these additional capacities has been performed with METIS. Thanks to its hourly granularity over a year, METIS can capture the reduced operation of thermal plants (and thus the reduction in marginal emissions, cf. Figure 2-8), considering the hourly generation profile of vRES technologies. It is estimated that the increase in vRES generation by 64 TWh can reduce CO_2 emissions by 11.4 Mt CO_2 or about 6%, which corresponds to an average CO_2 emission decrease of 178 kg CO_2/MWh triggered by the additional PPA demand.

In comparison, total greenhouse gas emissions in the EU stood at 4,228 million tons of carbon dioxide equivalent (CO_2eq) in 2018 (without LULUCF, incl. indirect CO_2). The most optimistic scenario would result in a 0.2% reduction of emissions.

Figure 2-8: METIS models the hourly supply and demand equilibrium, enabling to capture the reduction in CO_2 emissions due to increased vRES generation. Source: own calculations with METIS

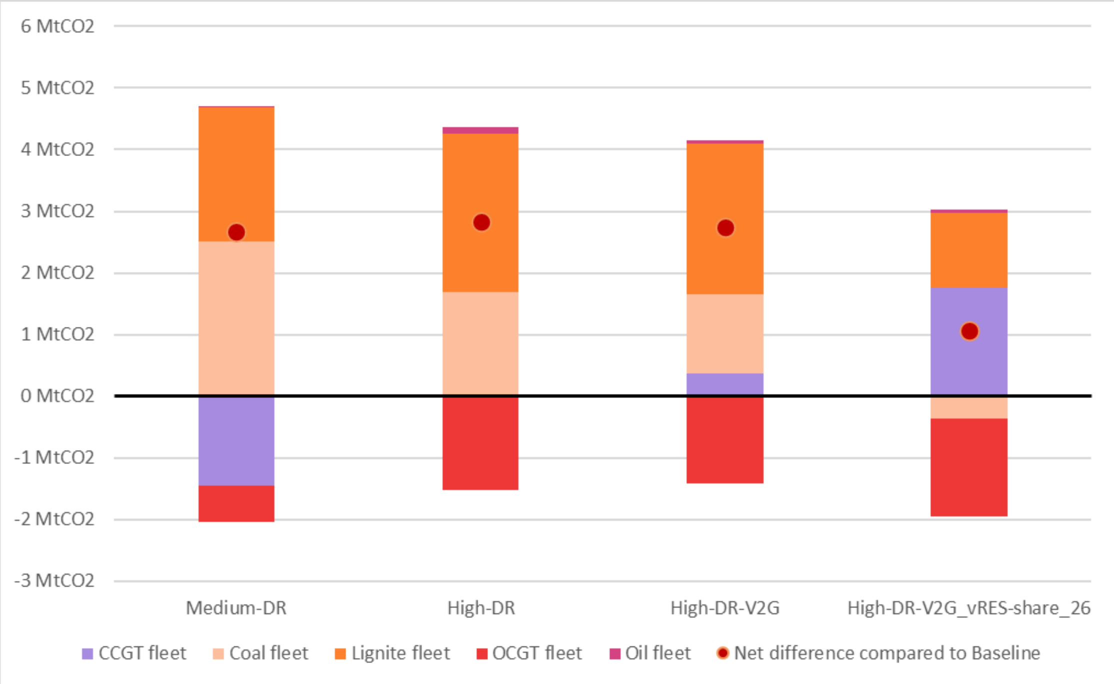


GOs

As long as there is low demand for GOs, no impacts on renewables penetration are to be expected; however, if demand rises (in particular in hours when GOs are scarce), this may trigger additional RES investments and thus further reduce emissions.

In addition, the METIS-based analysis reveals that DR (without GOs) tends to increase the utilisation of carbon-intensive base load capacities, such as lignite, if the carbon price signal is not sufficiently high to trigger a fuel switch from lignite to gas (cf. Figure 2-9). Introducing an hourly GO system may partially offset this effect as the GO price signal provides additional incentives to shift demand not only into hours with low-cost power generation (which includes lignite) but into hours with low-cost power generation and high RES shares.

Figure 2-9: CO_2 emissions, compared to Baseline. Source: own calculations with METIS



Social impacts

Impacts common to all options

Achievement probability of 2030/2050 targets

PPAs reduce the cost of capital, thereby incentivising additional investments and thus increasing the chances of achievement for various climate objectives.

However, the increase in renewable energy generation actually depends on whether an additional project has materialized thanks to PPAs, i.e., whether the PPA has clearly incentivized investments that would not have been made otherwise (additionality principle). Additionality applies to physical PPA contracts as they allow the producer to find a direct source of investment for the project development. In addition, the electricity consumed by the off-taker has been directly produced by the generator. On the contrary, virtual PPAs do not necessarily imply additionality as they may only be used as a hedging strategy with existing facilities. Projects benefiting from support schemes may not claim additionality either, as the support could already justify the investment.

In addition to the additionality principle, PPAs unfold highest effectiveness with respect to the achievement of renewable targets when the PPA off-taker also purchases and cancels the related (bundled) GOs, thereby removing them from the market and disabling other suppliers to relabel grey into green electricity.

Job creation and growth

PPAs and investments in renewable energies have definitely an effect on job creation. This impact varies depending on the type of technologies developed and on potential job losses in the existing energy park.

Currently, only a small share of the existing conventional electricity is being dismantled with the emergence of renewable production means, and thus only few jobs are being suppressed (major reason: conventional assets are kept to serve as backups for the variable generation of renewable power generation).

In the end, estimates anticipate a general increase in the number of jobs. Estimates based on a gross input-output approach in 10 European MSs by COWI and CEPS[251] show that new renewable electricity installations associated with corporate sourcing will create 4,600 to 221,200 additional full-time equivalents employments up to 2030 (ranging from 0.8 jobs/MW for wind onshore, over 0.96 jobs/MW for solar PV to 1.7 jobs/MW for wind offshore[252]. The cumulative gross added value would range between €12 billion and €758 billion.[65]

Property rights

Solar and wind energy have a large land footprint and can only be deployed in suitable geographical areas. This often involves privately owned land and the deployment of installations faces a lack of acceptability to owners. Plus, additional RES capacities (triggered by PPAs among other things) require to be connected to the grid if not used for self-generation. The construction of new transmission lines is a major topic of acceptability and property rights are an increasingly relevant issue when it comes to the planning and construction of new lines.

Distributional effects

Option 1

Currently, there is no specific regulatory framework for the support or promotion of PPAs at the level of European law, and no standardisation of contracts across the EU. Nevertheless, the provision of draft templates and guidance on how to implement Article 15.8 is a straightforward exercise. It does not require any regulatory amendments, which are complicated to implement, and can have far-reaching beneficial effects on the development of PPA contracts and renewable energies.

Standard forms of PPA contracts have for instance already been published by EFET (European Federation of Energy Traders) in June 2019 with guidance notes for their application in different states and companies in the RE100 group have endorsed them as a basis for their contracts since then. The French FEE Association also established first draft contracts for offsite energy PPAs. It was drawn up in only one year with the participation of all stakeholders in the energy sector: producers, consumers, lenders, investors, consultants, lawyers, tax specialists, etc. The publication of templates on this same basis by the European Commission would be a relatively ease and low-cost measure.

[251] COWI & CEPS. (2019). Competitiveness of corporate sourcing of renewable energy.
[252] Cameron, L., & Zwaan, B. v. (2015). Employment factors for wind and solar energy technologies: A literature review. Renewable and Sustainable Energy Reviews.

In terms of platforms, examples exist too. For instance, SolarPowerEurope, WindEurope, RE100 and wbcsd have jointly founded the RE-source platform[253], providing reports/webinars/events/a buyers toolkit and complementary material to generators and suppliers in order to facilitate the uptake of PPAs (amongst others). A similar platform (co-)organized/initiated by the EC and targeting not only industry but also MSs, could prove an effective and easy-to-implement measure to raise awareness and facilitate the deployment of PPAs.

From the corporate viewpoint, a centralization of the guidelines to be followed in the framework of a PPA contract will significantly simplify the administrative needs and delays, notably for SMEs but also for entities planning to set up cross-border PPAs. Currently, only large companies have sufficient legal resources and experience to develop this type of contract, but this is not the case for SMEs, for whom the complexity of PPAs is a major barrier.

Standardised templates at European level and including cross-border PPAs will facilitate exchanges within the EU. In particular, it will foster the deployment of cross-border PPAs. However, Member States national regulatory divergences may force cross-border contract templates to be more flexible and to adapt to each regulation. In the case of the EFET template, guidance is available to fit in the different Member States regulations. The creation of a forum for sharing best practices will facilitate communication between MS and foster regional cooperation where it is beneficial and where MSs have in intrinsic interest in going for cross-border PPAs.

Option 2

The different structures proposed are inspired of cases tested in different Member States (GIEK, Norwegian case), or suggested by the EIB[254]. Their implementation at the European level requires an in-depth study of these structures in the countries that have set them up, and their centralisation on a dedicated platform. If the EIB would provide credit guarantees, this would require the setup of a dedicated mechanism which may take some time. If the responsibility is transferred to national public banks, the implementation costs would in total be more important and MSs would need to cope with the additional administrative burden. At the same time, the implementation might happen quicker than at the EU level, at least in front runner countries.

The creation of new financial structures certainly favours the use of PPAs and increases the range of tools available to companies, but it further complicates the implementation of such contracts. In case of limited information sharing on this subject, such structures bear the risk of remaining unknown to the least expert companies on the subject. Credit worthiness insurance is, for example, intended to promote PPAs access to SMEs, but these small enterprises still need to be aware of this tool if it is deployed.

In addition, providing a guarantee is likely to come at a cost, as a premium is typically charged by the insurer (cf. the Norwegian model), which would depend on the buyer's creditworthiness (credit rating), the contract's duration, volume and price of electricity, the buyer's loan for advance payment (size and repayment period).

[253]RE-Source, European platform for corporate renewable energy sourcing. (n.d.). Available at: https://resource-platform.eu/
[254] European Investment Bank. (2020). Financial Instruments for Commercial PPAs in Europe.

It should be noted that investors (and PPA off-takers) will need sufficient financial and legal staff to handle the different business models and financing options.

In addition, there is a need to publish some guidance along with designing and setting up the financial tools, be it at EU and/or national level.

Eventually, making PPAs accessible to market actors (notably SMEs) so far refraining from PPAs, could trigger additional RES-E investments. Up to 2030 the generators requirement for PPAs will outrange the appetite for PPAs among off-takers (between 150 and 290 TWh appetite from off-takers against 140 to 480 TWh requirement of generators for PPAs), which would constrain the market[255]. Opening the PPA market to new off-takers will allow generators to find more financing sources and the renewable energies market to expand, thus increasing the probability for target achievement.

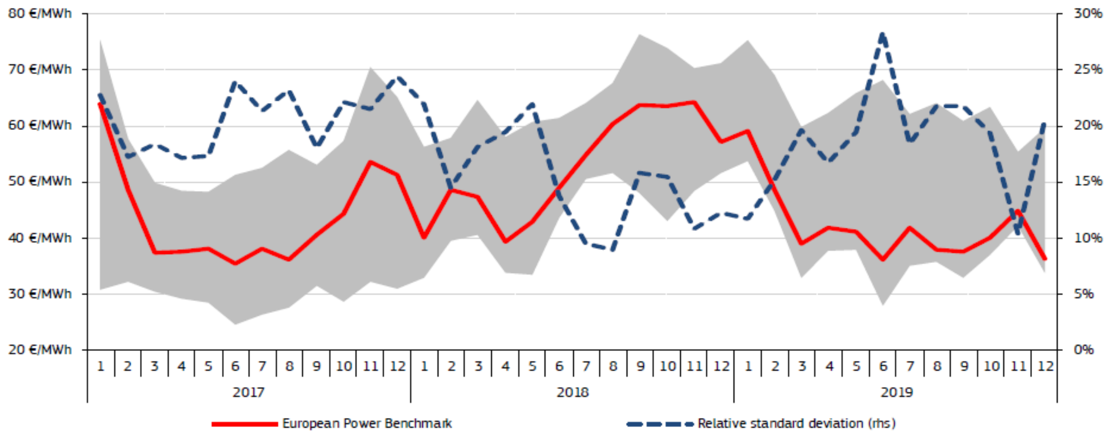
Option 3

The EC may introduce additional reporting requirements on PPAs by merely extending Paragraph 2 of Article 15.8. This also applies when calling MSs to facilitate the use of PPAs for SMEs. At the MS-level, reporting obligations on PPAs (identified barriers and policies) in NECPs and NECP progress reports are already required by the current RED II. Additional effort is merely limited to the analysis of the national PPA landscape with a specific focus on SMEs.

Assuming that PPAs reduce the cost for support schemes, this would ease the financial burden on the consumers.

Quantifying the potential savings in costs for support schemes due to PPAs is relatively difficult, as these costs are subject to different drivers: the evolution of wholesale electricity market prices, the development of power generation costs (i.e. LCOE) and the design of the actual support scheme. Market prices are difficult to estimate but ranged in the past (pre-Covid 19 period) between 40 and 60 €/MWh (cf. Figure 2-10)[256].

Figure 2-10: The evolution of the lowest and the highest regional wholesale electricity prices in the EU day-ahead markets and the relative standard deviation of the regional prices. Source: European Commission (2020)[69]



Source: Platts, European power exchanges. The shaded area delineates the spectrum of prices across EU regions.

[255] Ibid.
[256] European Commission. (2020). Quarterly Report on European Electricity Markets.

The LCOE for renewable power generation has reached new lows in the recent past. Generation costs for wind onshore range nowadays between 48 and 62 €/MWh in Europe (depending on plant location), solar PV between 70 and 85 €/MWh and wind offshore between 80 and 145 €/MWh[257]. This cost range is confirmed by the latest auctioning results[258].

This means that in particular the generation costs of onshore wind and solar PV are close to market price levels already today. This trend will intensify in the coming years, with CAPEX and thus LCOE further declining. Goldman Sachs estimates the LCOE of solar PV to further drop by 30% to 50% until 2030, reaching levels between 20 and 40 €/MWh.[259] IRENA expects the LCOE for offshore wind to fall by 30% to 60% until 2030 (compared to 2018 values), reaching LCOEs of 44 to 77 €/MWh[260].

This implies that the costs for support of new RES-E installations may be expected to diminish automatically, thus driving down the related costs for support schemes (assuming that market prices remain in the range between 30 and 50 €/MWh). Nonetheless, support schemes will still play a role to reduce risks for investors and to make RES-E technologies penetrate markets in regions where they are not yet fully competitive (e.g., solar PV in Nordic countries or onshore wind at less favourable sites).

Assuming that support for future investments could be limited to less than 5 €/MWh on average for new installations (compared to an average support level of 96 €/MWh in 2017 for all existing installations[261], and applying this cost factor to the delivery gap identified in Section 1.2, reveals potential additional annual support scheme costs of 750 to 950 M€ annually.

If a part of this power generation could be accommodated by PPAs additionally contracted under Option 3, cost savings related to support schemes of about 320 M€ annually could materialise. However, it is important to note that this basically only shifts the costs from the final consumer bill towards the PPA offtaker, while overall system costs remain unaltered (so a pure distributional effect).

Adding an hourly timestamp to GOs may require an adaptation of metering infrastructure of production devices in order to track the hourly production and potentially an update of the verification process for meter readings[262]. Thus, it could be considered to apply an hourly timestamp only as a label, e.g., to power generators exceeding a certain installation size and thus featuring the necessary metering infrastructure. The GO issuers need to take into account the additional information on the production time (which implies an increase in data volumes to be treated). Otherwise, the effort is limited to the integration of additional information in GOs.

If suppliers would like to go for a specific green share for every hour of the year, the purchase of the respective GOs may turn out to be more complicated; however, once a critical number of consumers face this problem, technology solutions will appear automatically (such as the current service provider Flexidao[263]).

[257] BNEF, (2020), New Energy Outlook 2020.
[258] AURES. (2021). Database - AURES II. Available at: http://aures2project.eu/auction-database/
[259] Goldman Sachs. (2018). Solar to transform Europe's energy mix.
[260] IRENA. (2019). Future of wind.
[261] CEER. (2018). Status Review of Renewable Support Schemes in Europe for 2016 and 2017.
[262] RECS. (2021). How time-stamping works in EAC markets.
[263] FLEXIDAO. (n.d.). Available at: https://www.flexidao.com/

Based on the MRV obligations introduced in Art. 15.8 of RED II and the provisions outlined in Art. 13 and 17 of the Governance Regulation, the Commission may call MSs to meet their obligations.

Effectiveness

Option 1

The publication of contract templates and guidance on how to implement Art 15.8 is fully in line with the objectives of reducing the complexity and time needed to set up PPAs. However, given the non-regulatory character of this option, it may turn out that major barriers persists and PPAs do not experience an enhanced deployment.

Option 2

The different structures proposed are all inspired by cases tested in different Member States (e.g., GIEK[264] for reducing the risk of losses for Norwegian suppliers and assuring bank loans for off-takers), or suggested by the European Investment Bank[265] and respond directly to the main barriers identified among companies willing to subscribe to renewable supply contracts.

Option 3

Effectiveness depends on compliance of MSs with the updated provisions in Art. 15.8 and the enforcement through the EC; little activities on this topic in the first NECPs might be an indicator of little responsiveness.

Enhancing GOs by adding an hourly time-stamp can be considered as an effective step towards an effective and liquid GO market that represents an actual revenue source for RES generators, thereby reducing the burden from public support schemes; however, this is only a very first step that requires subsequent ones (cf. text box above) and/or the uptake of the more granular GOs by front-runners that aim for 24/7 green electricity. Dedicated intelligent trading platforms for GOs as products may be considered as additional enabler to increase market liquidity (see also Option 7 in B3, Annex B).

Efficiency

Option 1

This is a rather quick and low-cost solution to be implemented by the European Commission, which will have a definite impact on the development of renewable energies. As indicated above, the benefits are uncertain. However, given the low costs for implementation, the option can be considered as no-regret.

With support schemes tending to phase out in the mid-term future, renewable installations will face revenue uncertainty in the coming years if no stabilization mechanism is set up. PPAs will have a key role to play and guidance on implementation represents a cost-efficient measure to facilitate their deployment.

Option 2

The provision of financial tools by the EIB can be complex and implementation costs tend to be elevated. However, some tools have already been developed and made available by various private or national banks which could be used as a model. Others are suggested by the EIB itself. Given the

[264] www.giek.no/power-purchase-guarantee
[265] European Investment Bank, (2020), Financial Instruments for Commercial PPAs in Europe.

significant positive impact of credit guarantees, it is assumed that this option is considered to be an efficient solution in order to enhance RES-E deployment.

Option 3

The effort related to a strengthening of Art. 15.8 are very limited, thus they may be considered proportionate in relation to the expected outcome. Costs tend to exceed benefits if further plans to enhance the GO system are abandoned; otherwise, they may be considered as proportionate considering that additional measures will be put in place.

Coherence

Option 1

This measure is in line first with RED II, which advocates for the development and standardization of PPA contracts. Such measure does not require any amendments to the still recent RED II, which is an advantage in terms of speed and ease of implementation.

Options for C2: Foster regional cooperation

Option 0	Option 1	Option 2	Option 3	Option 4
• Maintain current policies under REDII	• Non-regulatory measures: Commission guidance • Commission guidance for offshore wind	• Obligations to implement a pilot cross-border project	• Mandatory opening of support schemes	• Enhancing the Renewable Energy Financing Mechanism • Enhancing the REFM specifically for offshore wind projects

Overview of the identified policy options to be analysed

The following sections summarize some initial high-level assessment of the options to be analysed. These are:

- Option 0: Current policies (baseline): Maintain current policies under RED II (Art. 5, 8-13 on opening of support schemes and use of the Cooperation Mechanisms on voluntary basis);
- Option 1: COM guidance (Non-regulatory option): Issue guidance the opening of support schemes and use of Cooperation Mechanism, including cooperation model agreement template (similar to 2013 COM Communication);
- Sub-option 1.1: COM guidance for offshore wind: Option 1 + issue specific COM guidance for offshore wind relating to tender design, IGA templates hybrid / joint projects / opening of support schemes, CBA and CBCAs for the development of hybrid / joint projects / opening of support schemes;
- Option 2: Obligations to implement a pilot cross-border project (cooperation mechanism): Obligation for MS to “test” an opening of support schemes/ cooperation mechanisms via an obligation to implement a cross-border projects [until end of 2025], (unless MS can demonstrate why this was not possible). For such projects, MS could choose from a partial opening of support schemes (Art. 5), statistical transfers (Art. 8), joint projects and support schemes (Art.9-13), the EU financing mechanism (Art. 33 Governance Regulation);
- Option 3: Mandatory partial opening of support schemes: Include a mandatory partial opening of support schemes (similar to the RED II proposal) of least 5 % from 2023 to 2026 and at least 10 % from 2027 to 2030;
- Option 4: Enhancing the Renewable Energy Financing Mechanism: Implementing additional tender rounds of the financing mechanism, financed through: EU budget (enabling framework),

i.e., rev. MFF (donor clause in different funding programmes); or Member States (a certain mandatory use of the REFM for MS);

- Sub-option 4.1: Enhancing the Renewable Energy Financing Mechanism specifically for offshore wind projects where host countries are Member States with offshore potential and contributing countries are Member States who have a limited offshore potential or who want to benefit from lower support costs. Such calls for proposals could finance both developing and mature offshore technologies across all European sea basins.

In each section, the overall impacts of increased regional cooperation are analysed, followed by more specific assessments of each option.

Economic impacts

Impacts common to all options

Energy system costs, investment needs and total costs of support

Increased regional cooperation can lead to a **decrease in investment needs**, thanks to a shift of investments towards sites featuring more favourable conditions (lower cost of capital and better financing conditions, and/or higher full load hours). This would imply less capital expenditures to install a given amount of renewable capacity or a higher amount of power generation (cost-efficient).

According to a report by Ecofys and Eclareon[266], regional cooperation can allow to exploit the best sites (as mentioned above) but also select countries with lower administrative, grid connection and financing costs (e.g., for Belgium and Germany, where these costs are estimated at 26 and 12 €/MWh respectively). Similarly, according to a study by COWI[267], competitiveness of offshore wind varies considerably between regions because of wind conditions, connection costs and market values, meaning that most attractive conditions (from an investor point of view) is not always equivalent to more full load hours.

Some estimates of the impacts of joint support schemes are available in the literature. For instance, in the context of the AURES II project[268] an analysis of joint support schemes between Hungary and three other countries was performed. The reduction of the total cost of support to reach RES targets is estimated, depending on demand level:

- With Austria, between 7% and 31%;
- With Romania, between 87% and 89%;
- With Slovakia, between 6% and 13%.

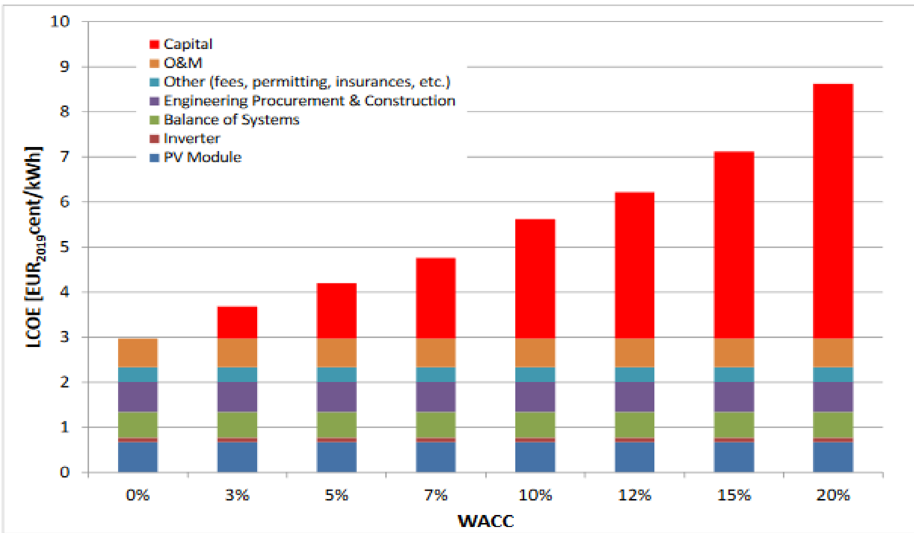
COWI[80] estimates that regional cooperation could lead to cost decreasing by 700-900 M€/year at the 2050 horizon. However, regional cooperation at the 2030 horizon is more expensive (by 200-400 M€/year) considering the building of offshore hubs (not yet generating benefits at this horizon).

A 2019 study by Roland Berger[269] focuses on hybrid projects connecting offshore wind farms to multiple countries. It estimates cost savings of the order of 5% to 10% by implementing hybrid projects instead of alternatives (corresponding to 300 M€ to up to 2.5 B€ for the NSWPH project). These cost savings are mainly related to the reduction of cable length and elimination of transformer stations.

[266] Ecofys & eclareon. (2018). Cross-Border Renewables Cooperation. Study on behalf of Agora Energiewende.
[267] COWI. (2019). Study on Baltic offshore wind energy cooperation under BEMIP.
[268] AURES II. (2020). Proposal for a cross-border auction design for Hungary.
[269] Berger, R. (2019). Hybrid projects: How to reduce costs and space of offshore Developments.

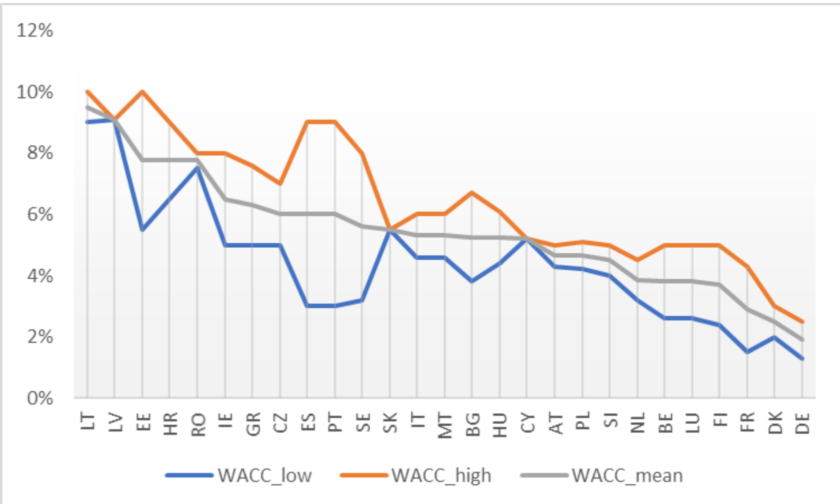
Figure 2-14 illustrates the theoretic potential savings in LCOE between a financing country (listed horizontally) and a host country (listed vertically) due to differences in WACC and technology-specific load factors. The upper part of the figure illustrates the isolated effects. Savings related to WACC differences may exceed 40%. This is due to the fact that a WACC of 10% implies that capital costs equal all other costs and thus double the LCOE (cf. Figure 2-11), while a WACC of 2% merely increases the LCOE by about 15%.[270]

Figure 2-11: Influence of WACC on LCOE illustrated for solar PV; Source: JRC (2019)[271]



The main countries featuring nowadays low cost of capital include Germany, Denmark, France and Finland (cf. Figure 2-12).

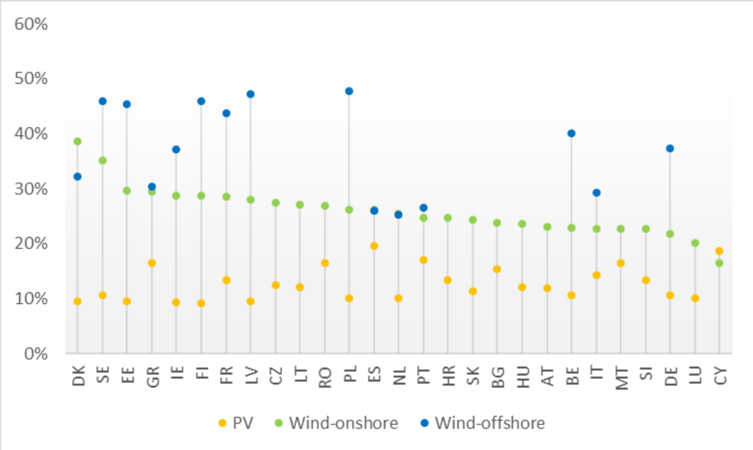
Figure 2-12: WACC data for onshore wind in 2019, based on eclareon (2020)[272]



[270] The WACC figures considered in the current calculations represent the national average values of the data indicated by (eclareon, 2020) for onshore wind in the year 2019.
[271] JRC. (2019). PV Status Report 2019.
[272] eclareon. (2020). Trends and evolution of the Costs of Capital in RE Financing (AURESII project).

The isolated LCOE savings related to differences in national RES-E load factors may reach up to 50% given the significant heterogeneity in climatic conditions across all EU Member States.[273] As indicated in Figure 2-13, the load factor of Denmark is nearly twice as high as the one in Cyprus. Other countries featuring very favourable onshore wind conditions include Sweden, Estonia, Greece, and Ireland. For solar PV, the countries featuring the highest load factors include Spain, Cyprus, Portugal and Greece.

Figure 2-13: National load factors as integrated in the METIS database, based on latest version of the MIX55 scenario for 2030.



By taking advantage of the differences in WACC and natural resources across EU MSs, LCOE savings of up to 60% may be realised (cf. lower part of Figure 2-14). For solar PV, the most beneficial hosting countries under the given assumptions include Cyprus and Spain, as they feature high capacity factors and favourable WACC conditions. For onshore wind, the most attractive hosting countries are the Nordic countries (Denmark, Sweden, Finland) as well as France.

If the cooperation between MSs would be restricted only to directly interconnected EU countries (in order to ensure that the respective amounts of renewable power generation could be ensured through actual physical power flows), the LCOE savings would be restricted to those values illustrated with a black border in Figure 2-14. Thus, substantial savings could notably materialise in case of a cooperation between Belgium/Luxemburg/Ireland/Spain (as financing countries) and France (as hosting country), Lithuania and Poland, or Estonia and Finland around onshore wind. For solar PV, cooperations between Belgium/Ireland/Luxemburg (as financing countries) and France (as host country) and between the Netherlands/Poland and Germany feature significant synergies.

It is important to note that the previous assessment is purely based on the economic and climatic conditions in the individual Member States (which are subject to major uncertainty notably related to the future economic evolution with regard to the potential convergence of WACC across EU MSs). In addition, the previous analysis disregards completely costs related to the integration of the RES investments in the host country, the actual availability of RES resources in the host country, the potential need for additional interconnector capacity between the financing and the host country in order to accommodate the additional power generation in the EU power system[274] . Such aspects are adequately taken into account in the dedicated METIS-based assessment of Option 3. Nonetheless, the

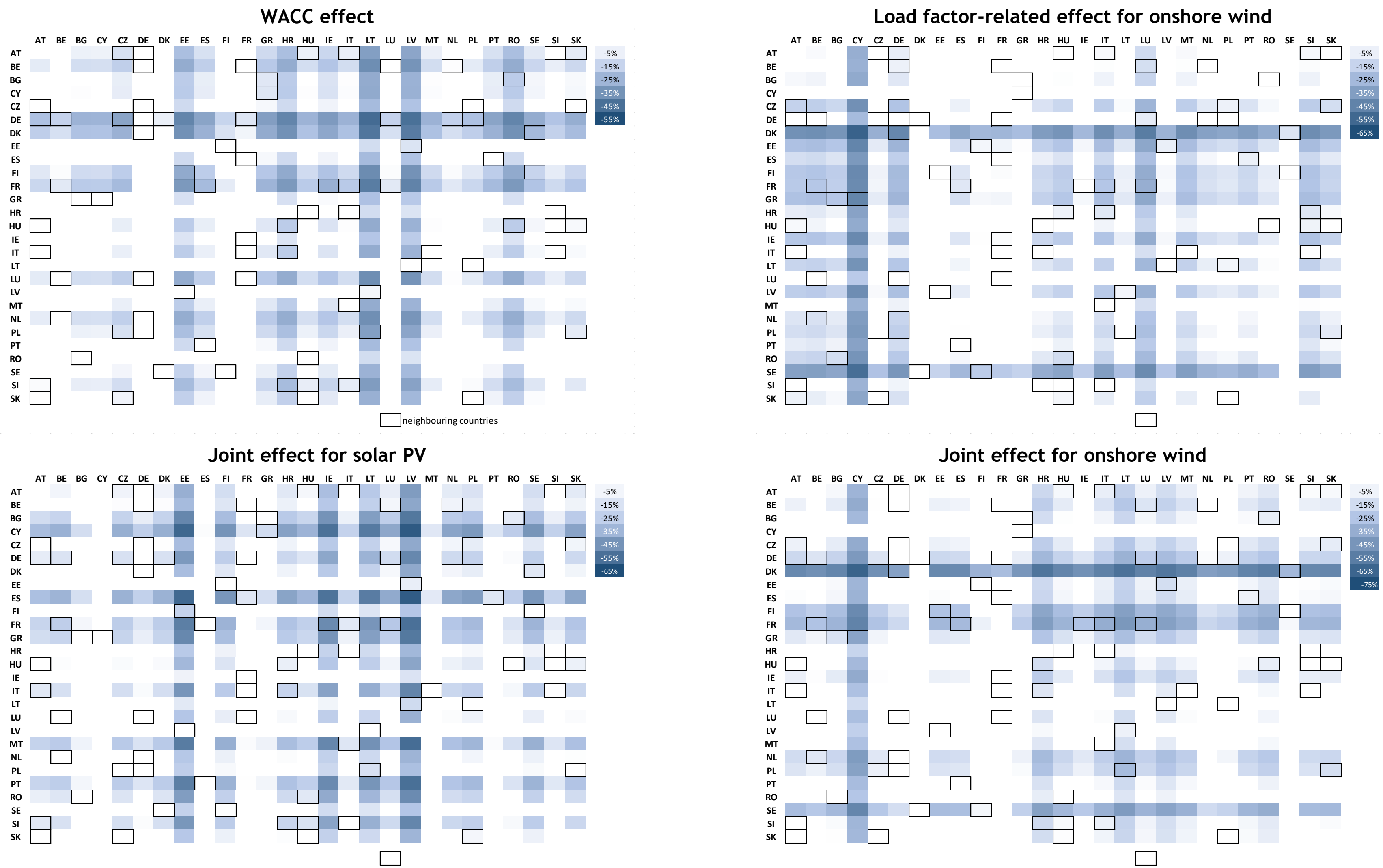
[273] The isolated LCOE savings related to differences in national load factors were calculated by applying a constant WACC of 5.4% across all EU MSs and considering the national LFs as determined in the METIS database based on the latest 55MIX scenario results (cf. Figure 2-13).

[274] See for instance Ecofys & eclareon. (2018). Cross-Border Renewables Cooperation. Study on behalf of Agora Energiewende.

current exercise reveals that there should be a clear interest among MSs to investigate the benefits of regional cooperation which are significant due to the heterogeneous economic and climatic conditions in the EU.

It is further important to note that the potential savings in LCOE may have a direct impact on the support costs, thereby making additional budgets available which could be dedicated to additional RES investments, hence closing the delivery gap. These additional RES investments are estimated in the METIS-based assessment of Option 3.

Figure 2-14: Potential LCOE savings related to differences in MS-specific WACC figures and load factors (financing countries listed horizontally, host countries vertically).



Regional cooperation allows to **mobilise larger investments** than what a single MS would have brought on its own. It enables larger projects (important offshore wind parks, hybrid projects) and riskier RE projects (e.g., applying less mature technologies, such as floating offshore wind) to materialise that would not necessarily be financed by a single MS. Risk sharing between MSs and exploitation of cost-effective potentials drives down costs.

By increasing cooperation between Member States, and in particular by providing a **"virtual" access to offshore wind to land-locked countrie**s (and thus activating the respective support schemes for offshore wind), the **overall cost of reaching the RES targets would decrease**. Accordingly, the level of support is also expected to decrease, even factoring in the additional support for higher-risk projects, as this support will enable economies of scale (learning by doing) and eventually lead to a lower-cost and lower-support achievement of RES/decarbonisation targets. The actual effect on support costs is difficult to quantify as it depends on the amount of renewable capacities under support scheme by 2030 (vs PPA or merchant risk), the evolution of market prices and the need for actual financial support (in addition of just providing a revenue guarantee which lowers the investor risk), depending on the technological development (cf. also Social impacts of policy options on PPAs).

At the country level, a Member State financing projects in a host country featuring higher RES market values (driven by the wholesale price level and the RES generation profile of the host country) would see its support scheme costs likewise reduced. At the same time, in the host country, the reduction of wholesale prices due to the integration of RES-E featuring close-to-zero marginal generation costs implies an increase of the support scheme costs that could impact all the technologies (in case of a sliding premium for example).

ETS carbon price evolution

Assuming that the overall volume of renewable power generation remains unaltered but is only shifted between MSs in order to bring down costs (e.g., between countries featuring similar meteorological conditions but different capital costs), the ETS price is not expected to be affected.

However, if regional cooperation also implies an increase in renewable power generation due to higher load factors in the host country (i.e. the tendered amount of capacity results in a higher power output), this could push more carbon-intensive power generation out of the market (depending on the supply mix of the host country), thereby reducing carbon emissions, liberating allowances and ultimately driving down the carbon price; however, this effect can be considered marginal as related emission volumes are comparatively small compared to the overall amount of EUAs in circulation (around 1.4bn in 2020); further, if the ETS Market Stability Reserve captures the liberated allowances, the price effect would be null.

Option 1

Issuing guidance to facilitate regional cooperation directly entails the above-mentioned effects, on energy system costs, investment needs, and impacts on total costs of support.

The issuance of guidance will reduce the barriers to the opening of support schemes, and will allow more cost-efficient projects to materialise. As a result, the RES targets could be reached earlier and at a lower overall cost. It will not impact the total amount of funding at the disposal of Member States, however, it will increase the efficiency of the use of the available funding.

The issuance of guidance will also incentivise investments in projects that cannot be supported by a single Member State due to their investment scale or attached level of risks. Therefore, this option will result in an increased competitivity of these technologies, will trigger innovation as their deployment increase, and will result in cost reduction leading to a wider market uptake.

Option 2

Given the pilot character of the cross-border projects, only marginal impacts in addition to the ones identified under Option 1 are expected on energy system costs. In the past, regional cooperation agreements comprised very limited amounts of electricity. Statistical transfers amounted to 700/400 GWh from Lithuania/Estonia towards Luxemburg, 100 GWh statistical transfer from Estonia towards Malta, and 8 TWh from Denmark to the Netherlands. These transfers were notably triggered by the potential risk that Luxemburg, Malta and the Netherlands run short of their renewables target. The joint support scheme between Denmark and Germany involved cross-border tenders of some 52 MW, which corresponds to a renewable power generation of approximately 50 GWh. This compares to a total renewable electricity generation in EU27 in 2019 of 984 TWh.

Imposing pilot projects for cross-border projects on MSs that do not face the risk of lagging behind their renewables target is likely to involve only limited amounts of RES-E capacities (such as in the Danish-German case) thus implying marginal economic benefits. In the theoretical case that EU MSs would for instance open their support scheme and successfully tender 50 MW to a partnering country (i.e. realised in 14 cross-border projects out of 27 Member States) featuring a 20% lower LCOE (which is the mean value based on the analysis introduced above), this would imply for the related 1460 GWh of generated renewable electricity cost savings of 12 M€ per year (considering the weighted average of the load factor and of LCOEs).

Effects and savings (including the ones related to costs for support schemes) are accordingly higher in the case of a more important average size of pilot cross-border projects. The only major impact could be considered if two MSs partner up to realise a major joint project, such as a joint offshore wind park.

Option 3

The economic impacts of Option 3 actually depend to a certain extent on the precise support scheme design[275]. Yet, countries can use cross-border auctions to increase competition in their domestic scheme and decrease the risk of collusion.

A METIS-based assessment has been carried out to quantify the economic benefits brought by the compulsory opening of support schemes, and identify the drivers. Considering a 10% mandatory opening of support schemes between 2025 and 2030, the model may determine the cost-optimal reallocation of 10% of the RES-E investments undertaken between 2025 and 2030 across the EU27.[276]

[275] Cf. for instance Navigant, Fraunhofer ISI & DTU. (2019). AURESII D6.1: Design options for cross-border auctions.

[276] It should be noted that the 10% rule was applied to the additional investments occurring from 2026 to 2030, as indicated by the PRIMES results for the MIX55 scenario. This is not fully coherent with the design of the policy option as the 10% rule is expected to be applied only from 2027 to 2030, and a 5% share from 2023 to 2026. However, as there is no information available about the annual capacity investments, the utilisation of the aggregated capacity investments of the years 2026 to 2030 was considered suitable as it incorporates implicitly also the capacities under the 5% rule.

A detailed description of the scenario, the investment in renewable capacities and the reallocation across EU countries is available in Annex 4.1. The MS-level reallocation of vRES capacities is as follows:

Figure 2-15: PV investments across the EU27, with and without regional cooperation. Source: own calculations with METIS

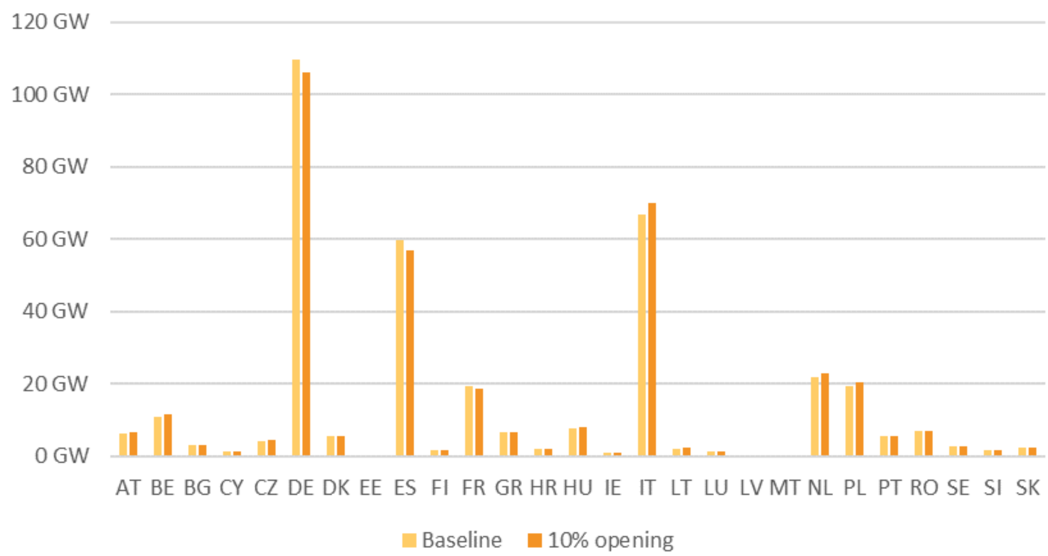


Figure 2-16: Offshore wind investments across the EU27, with and without regional cooperation. Source: own calculations with METIS

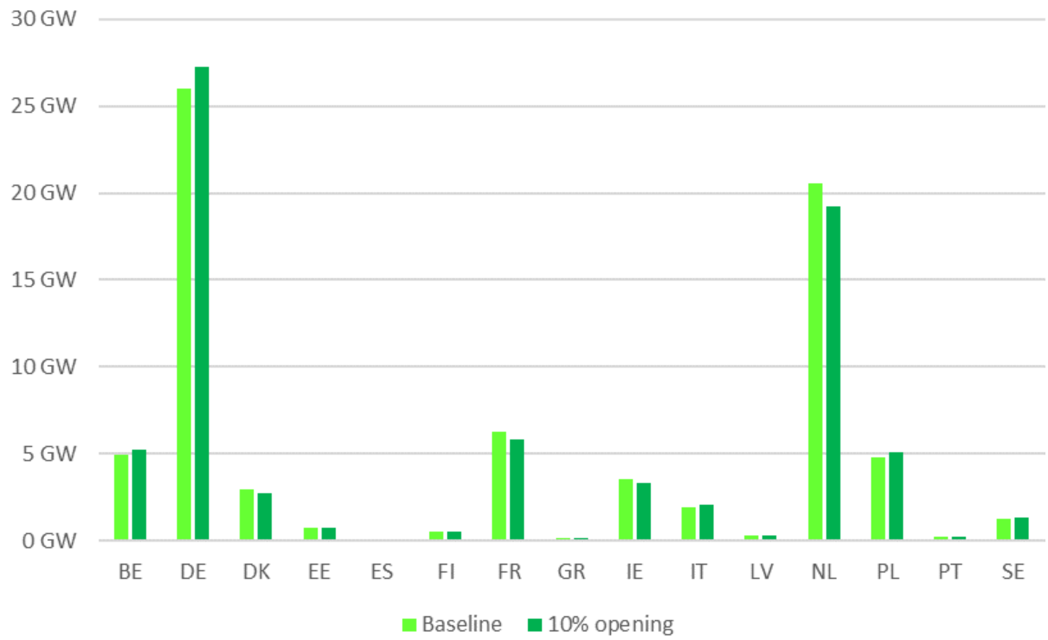
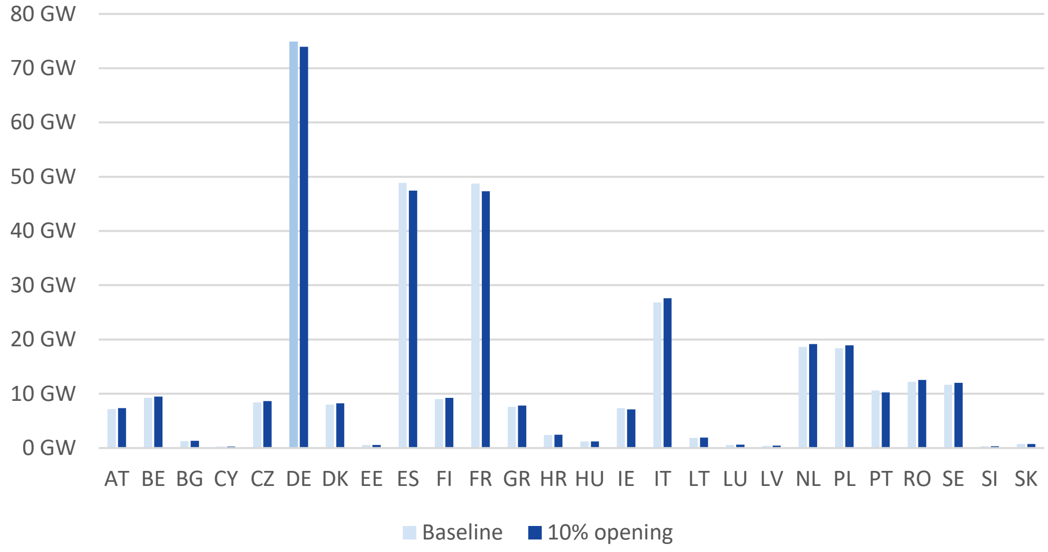
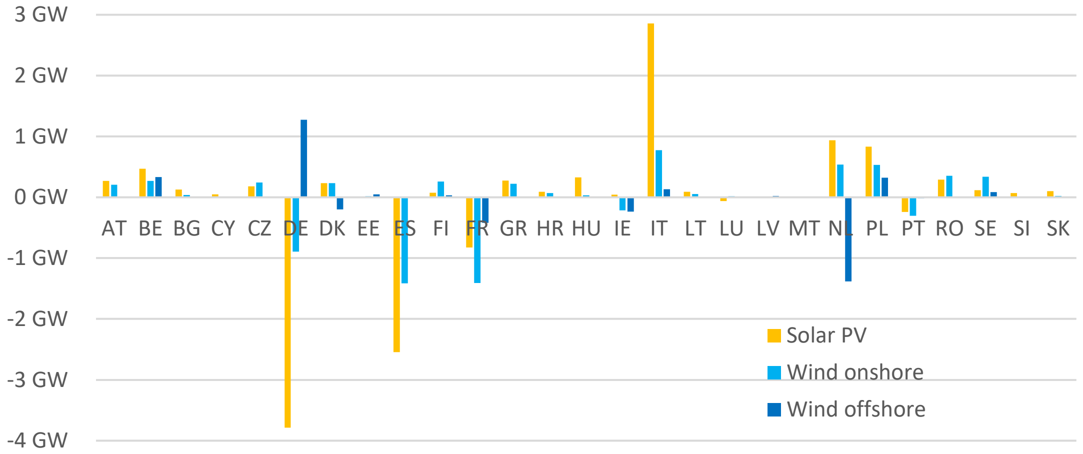


Figure 2-17: Onshore wind investments across the EU27, with and without regional cooperation. Source: own calculations with METIS



The cumulated effects are depicted in Figure 2-18.

Figure 2-18: Reallocation of capacity between MSs (in MW) in case of 10% compulsory support scheme opening compared to a Baseline without opening. Source: own calculations with METIS



It should be noted that the reallocation of vRES capacities is done on a cost-optimal basis, meaning that two main drivers are considered:

- How the new allocation exploits sites with more favourable conditions in terms of wind exposure and solar irradiance, i.e., higher load factors and increased vRES generation;
- How the new allocation reduces the system integration costs, in terms of investments and operation of flexible technologies.[277]

The vRES total generation resulting from a 10% opening of support schemes varies slightly from the Baseline: the offshore wind generation increases by 1.6 TWh, the onshore wind generation by 0.1 TWh and

[277] It is important to note that the present modelling exercise with METIS considers the same WACC for RES investments across all EU Member States. Thus, a reallocation of capacities would not be driven by deviating economic conditions in terms of cost of capital.

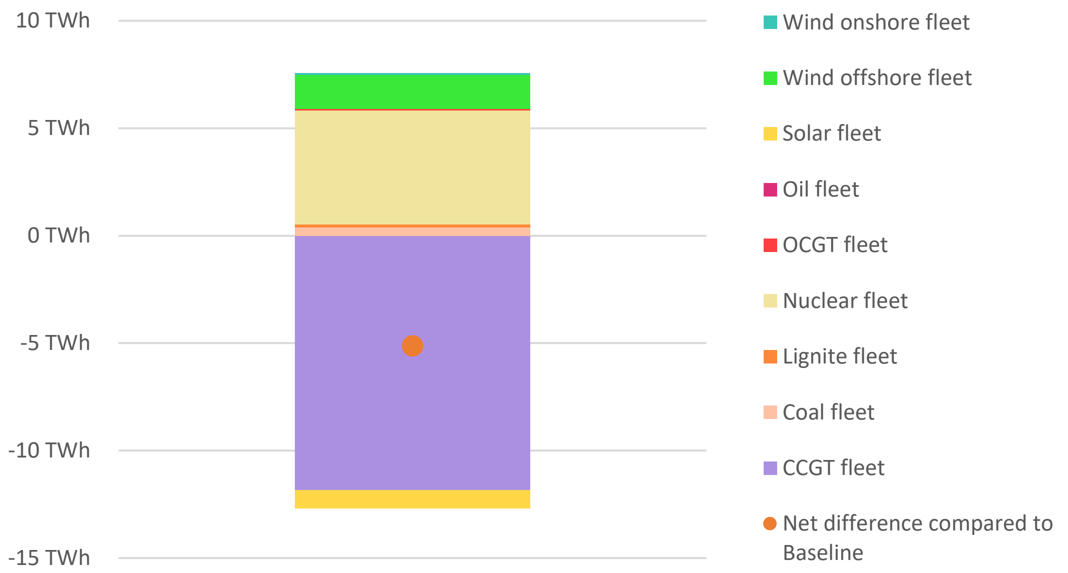
the solar generation decreases by 0.6 TWh. This variation in vRES generation demonstrates that especially in the case of PV generation, system integration costs are stronger drivers for the reallocation than the increase of load factors.

Figure 2-18 displays variations in installed capacities at the MS-level. Some countries, such as Spain, see a decrease in their PV installed capacity despite their high load factor (20%). This is explained by the large flexibility needs required to integrate further PV generation in a country featuring an already large installed capacity (60 GW). On the other hand, the relocation of offshore wind from the Netherlands to Germany is driven by the exploitation of a more favourable load factor (cf. also Figure 2-13).

Figure 2-19 displays the net changes in the electricity production mix resulting from the opening of support schemes. Even if renewable generation slightly increases (+0.9 TWh), the major change is an increase in nuclear generation (+5.3 TWh) and a significant decrease in the operation of gas turbines (-11.8 TWh). The latter are generally used as flexible counterparts to renewable power generation. This reduced operation of gas turbines translates into a 19 TWh decrease in gas consumption, and allows investments in CCGTs to be reduced by 1 GW. Ultimately, the reduced gas consumption saves 3 Mt of CO_2 emissions.

It should be noted that the opening of support schemes also reduces renewables curtailment by 2 TWh or 20% compared to 10 TWh of curtailment in the Baseline.

Figure 2-19: Net changes in electricity generation compared to Baseline, EU27. Source: own calculations with METIS



Overall, the increase in renewable power generation, the reduction in curtailment and the reduced flexibility needs (translated in terms of lowered natural gas consumption, reduced CO_2 emissions and avoided investments in gas turbines) decrease the system costs by 520 M€/year.

These savings could trigger additional vRES investments of around 6 GW if following the current distribution across the three technologies. This additional capacity would generate some 10 TWh of additional renewable electricity.

Table 2-2: Additional vRES investments triggered by the opening of support schemes

	PV	Onshore wind	Offshore wind	Weighted
Capacity 2030 (GW)	384	349	77	
Average cap. factor (%)	13%	26%	38%	21%
Add. investments (GW)	9	5	3	6
Add. generation (TWh)	11	11	8	10

Option 4

The REFM enhances effects of regional cooperation: MS with expensive renewable resources can contribute to the Mechanism and help finance a renewable energy project in another MS, at a lower cost than on their own resources (cost-efficient), consequently decreasing total investment needs across the EU[278].

Implementing additional tender rounds of the Mechanism (enabling framework) still ensure the cost-efficient deployment of renewables across the Union, as EU-wide tenders should reveal what the cheapest projects are. In addition, these tender rounds provide visibility and certainty to project developers, investors and the upstream value chain, thus further decreasing the cost of capital and investment needs.

As several MS (and private investors) can contribute to the Mechanism, and potentially also the EU via the EU Budget, they bring together larger investments than what a single MS (or two MS under a cooperation agreement) would have brought on its (their) own. Therefore, the Mechanism may help large RE projects materialise in host MS that could not have financed such projects alone (cost-effective). In particular, this applies to offshore windfarms which are generally larger in size (both number of turbines and turbine capacity) than onshore ones and featuring higher CAPEX (in particular in the case of floating offshore wind). These aspects lower the energy system costs and the total investment needs.

In addition, under Option 4.1, the Mechanism should encourage landlocked countries to access offshore wind resources. Offshore wind resources are abundant, the potential is much more than what coastline Member States can exploit for their own needs (increased effectiveness)[279].

Technology-specific auctions also bring certainty/visibility to short and long-term investments. Increased investment certainty may help both to upscale the upstream value chain and to lower the cost of capital (consequently, the investment). In this regard, tenders targeting offshore technologies should be considered.

Security of supply

A lower domestic generation capacity in the financing country might imply reduced access to generation capacity that can contribute to the national supply-demand equilibrium; however, the additional annually capacities developed under regional cooperation projects can be expected to represent a minor share of the overall national capacity mix.

Yet, a lower domestic generation capacity also reduces the share of renewable power generation which requires (due to its variable/stochastic generation characteristics, notably in the case of solar PV and wind, but also tidal) enhanced flexibility services (incl. redispatch and remedial measures) and thus higher RES system integration costs.

[278] AURES II. (2020). The new renewable energy financing mechanism of the EU in practice.
[279] Wind Europe. (2020). Renewable Energy Financing Mechanism - Response to the Public Consultation.

Environmental impacts

Impacts common to all options

Regional cooperation allows a Member State to make use of better natural resources of the cooperation Member State if more favourable sites in terms of natural resources (i.e. load factor) are exploited; i.e. a given amount of generated electricity (MWh) requires less installed capacity (MW), which directly translates into a higher resource efficiency.

Then, less capacity need reduces land use, be it on land (reduced sealing/coverage of natural ground, e.g., in case of wind onshore or ground-mounted PV) or offshore. Less capacity also enhances the efficient use of resources being rare or being exploited with major environmental impacts (e.g., neodym and dysprosium, two types of rare earth elements being used in the permanent magnets integrated in the generators of wind power plants, and that are extracted from ground primarily in PRC under contentious environmental conditions).

Eventually, reduced RES-E capacity installations due to higher full load hours avoid GHG emissions related to the production of the avoided capacities[280].

Option 1

Option 1 does not entail any additional effects compared to the aforementioned general effect of increased regional cooperation.

However, the specific provisions under Sub-Option 1.1[281] may imply environmental impacts. A joint planning of offshore renewable energy projects could result in significant environmental benefits. Offshore renewable energy projects could be optimised regardless of territorial borders. This would enable planners to better take into account environmental concerns in the siting decisions, e.g. impacts on seabed, biodiversity and environmental protection areas. It can incentivise the choice of places and approaches benefitting also biodiversity, in line with the Biodiversity Strategy. Purposeful siting may among many criteria be driven by the type of foundation which may have different environmental effects.[282] For instance, the selection of deeper sites (typically above 60m sea-depth) implies the use of floating turbines featuring smaller footprints and thus reduced seabed disturbance during construction compared to monopiles or gravity foundations. Similarly, floating foundations can be installed by pile driving, reducing the underwater noise and pressure waves related to foundation installation.

In addition, the joint planning and realisation of offshore projects (e.g., via joint projects in compliance with Art. 9 of RED II) may facilitate the selection of least-cost sites, implying reduced power generation costs.

Coordinated planning and joint projects may further mobilise larger investments than what a single MS might take on its own. It enables larger projects (e.g., important offshore wind parks, hybrid projects) and riskier RE projects (e.g., applying less mature technologies, such as floating offshore wind) to materialise

[280] See for instance UBA. (2018). Emissionsbilanz erneuerbarer Energieträger.
[281] Obligation for Member States to jointly define and agree to cooperate on the amount of offshore renewable generation to be deployed within each sea basin by 2050, with intermediate steps in 2030 and 2040 (mirroring TEN-E proposal for grid deployment)
[282] BOEM. (2020). Comparison of Environmental Effects from Different Offshore Wind Turbine Foundations

that would not necessarily be financed by a single MS. Risk sharing between MSs and exploitation of cost-effective potentials drives down costs.

Ultimately, lower power generation prices (enhancing the competitivity of renewable power generation) and increased offshore capacities feature an indirect positive impact on the environment as more carbon intensive power generation could be displaced, reducing carbon emissions (if the emission reduction is captured by the ETS Market Stability Reserve).

Additionally, the joint planning of offshore renewable energy projects encourages the coordination among MSs regarding a joint planning of offshore renewable energy and grid projects, potentially entailing the development of hybrid assets. If grid planning is taken into account as proposed by the Commission in the revised TEN-E Regulation, the required grid expansion related to the new offshore projects can be made in an environmentally optimal manner. Joint offshore energy planning per sea basin could make more sites available for renewable energy expansion while respecting the environment and biodiversity objectives.

In addition, hybrid assets come with the advantage of reduced need for space. The combined use of (new) offshore transmission lines as cross-border interconnector and as network connection of offshore wind farms allows to reduce the length of required lines, thereby minimising the impact on the seabed[283]. Reduced space for grid connection implies reduced environmental impacts at different stages of project lifetime[284]:

- Reduced seabed habitat loss, degradation and transformation during grid construction;
- Reduced mortality, injury and behavioural effects associated with vessels during grid construction;
- Reduced pollution, such as dust, light, and solid/liquid waste during construction;
- Reduced electromagnetic fields of subsea power cables and related behavioural effects on fishes and benthic organisms during grid operation.

Finally, the 2019 Roland Berger study[285] indicates that hybrid projects connecting offshore wind farms to multiple countries may result in cost savings of the order of 5% to 10% by implementing hybrid projects instead of alternatives (corresponding to 300 M€ to up to 2.5 B€ for the NSWPH project). These cost savings are mainly related to the reduction of cable length and elimination of transformer stations. Similar to the optimal siting of offshore wind farms, such cost reductions directly enhance the market competitivity of offshore wind compared to more carbon-intensive power generators, thereby facilitating an enhanced market uptake and lower carbon emissions.

Finally, if joint planning includes the consideration of power-to-gas, the on-site conversion of electricity into synthetic gases (hydrogen, methane or others) represents an opportunity to make use of existing gas pipelines in order to transport the energy to the shore. Given that existing pipelines represent frequently cross-border assets, a joint planning approach may facilitate the use of existing infrastructure, thereby minimising the need for additional grid connection and the related environmental impacts.

Option 3

[283] Berger, R. (2019). Hybrid projects: How to reduce costs and space of offshore developments.
[284] IUCN. (2021). Mitigating biodiversity impacts associated with solar and wind energy development
[285] Berger, R. (2019). Hybrid projects: How to reduce costs and space of offshore developments.

In case of opened support schemes, the hosting MS benefits from enhanced air quality (or reduced emissions, depending on the national emission factor), while the auctioning/paying MS reaps the benefits of avoided land sealing and other secondary impacts of RES installations on landscape and environment.

If the opening of support schemes implies that the injected renewable power generation in the host country replaces power generation featuring a higher emission factor that the generation that would be displaced in the tendering country, this could be translated into a CO_2 emission reduction; however, the EU ETS cap would imply that the emission reduction would be compensated elsewhere (so-called “waterbed effect”), if the emission reduction is not captured in the ETS Market Stability Reserve (cf. also remarks on impacts on the EU ETS price).

The METIS model runs capture the system-wide reduction in CO_2 emissions related to the opening of support schemes. The latter leads to a significant decrease in gas turbine operation (-11.8 TWh), consequently reducing primary energy needs by 19 TWh and lowering natural gas demand by 3%. Eventually, the reduced gas consumption saves 3 Mt of CO_2 emissions (-2% compared to the Baseline).

Social impacts

Impacts common to all options

Distributional effects

Increased regional cooperation (notably in the case of opened/joined support schemes or joint projects) may trigger changes in the projects being supported by Member States and thus the location where projects materialise:

- It provides a more even access to renewable energy potentials over Europe, and limits. discrepancies between MSs in investment needs to meet their national RE target[286] (e.g., thanks to statistics allocation);
- Regional cooperation allows to exploit least-cost RES sites, hence reducing support costs in the financing country;
- In particular, more offshore RES projects (and notably hybrid projects) could emerge, for example supported by land-locked countries. Yet it may imply grid reinforcement needs (as experienced in Germany), which are a priori not borne by land-locked/supporting countries;
- Regional cooperation relocates renewable power generation featuring close-to-zero marginal generation costs to the hosting country, reducing wholesale market prices in the latter (and not necessarily in the financing country);
- Regional cooperation implies a shift in the national electricity generation mix of the hosting country, which may translate into additional flexibility needs but also changes in local pollution;
- RES investments in the hosting country require efforts to connect new installations to the grid and adapt the grid if deemed necessary;
- Allocation of benefits in terms of learning/capacity building; ability to attract more investments in the long term; local jobs (O&M as a start, then triggering investments in manufacturing facilities for instance); green electricity mix and less pollution; income of taxes on the wind farms, could be impacted.

[286] European Commission. (2016). Impact Assessment on RED II - Accompanying document (SWD(2016) 418 final).

These effects need to be carefully considered as they may discourage a MS from participating in regional cooperation projects.

Political impacts

Increased regional cooperation will improve the probability of achieving the 2030 and 2050 targets by:

- Decreasing the risks and costs of projects that are currently too expensive / risky for a Member State to undertake alone;
- Increasing the cost-efficiency of the deployment of RES;
- Facilitating the establishment of the internal energy market.

Option 1

Issuing guidance on regional cooperation comes with some additional effects in comparison to the overall increased of regional cooperation.

In particular, it should be noted that this option does not imply any barriers to implementation, as it only requires the EC to publish guidance. Similarly, there is no additional burden put on operators and no additional costs linked with the issuance of guidance by the EC. The availability of the guidance material can be promoted in various fora. However, as this is a non-regulatory option, it is up to Member States to decide whether or not to open their support schemes.

The issuance of guidance would increase the cooperation between Member States. However, such cooperation was already foreseen in the current RED II. Therefore, no political obstacles linked with this option are to be foreseen. Besides, it will improve the probability of achieving the 2030 and 2050 targets by accelerating the deployment of RES by providing clarity on potential cooperation mechanisms and by providing blueprints.

Option 2

It may be expected that administrative and transaction costs are relatively high, as MSs need to screen with which MS to partner up with and under which form. Once a project form was decided upon, an IGA needs to be establish with the partnering MS in order to specify the nature and framework conditions of the cooperation and an allocation mechanism for related benefits and costs; this is a time-consuming process.

Option 3

MSs will need to undertake a significant effort in order to identify the MSs to partner up with when it comes to the opening of the support scheme; even if the MS decides to go for a unilateral or mutual cross-auction (i.e. the MS defines the support scheme design of the opened auction individually, in contrast to a joint support scheme[287], rules regulatory and market conditions of the country apply in which the installation is to be implemented (e.g. in terms of taxes), a thorough screening of the framework conditions in potential partner MSs is necessary. Yet, the option is considered politically feasible[288].

In order to obtain optimal results from the opened support scheme, participation conditions should be aligned between the auctioning and the host MS, e.g., in terms of prequalification requirements, deadlines and penalties, implying a significant effort of coordination.

[287] Navigant, Fraunhofer ISI & DTU. (2019). AURESII D6.1: Design options for cross-border auctions.
[288] European Commission. (2016). Impact Assessment on RED II - Accompanying document (SWD(2016) 418 final).

The opening of support schemes towards another MS requires the establishment of some kind of IGA; cooperating countries need to define basic requirements for the implementation, e.g., in terms of proof of physical import of electricity, reciprocity of cooperation.[100]

As opened support schemes involve two electricity markets with two different electricity prices, this can complicate the calculation of support payments for the regulator and thus increase administrative and transaction costs. [100]

Opening the support scheme to another MSs implies that investments (and thus also the funds used to support them) may materialise outside the national territory; this implies a (relative) loss in jobs for installation and maintenance and potentially also manufacturing; considering direct employment factors (ranging from 0.8 jobs/MW for wind onshore, over 0.96 jobs/MW for solar PV to 1.7 jobs/MW for wind offshore[289]; the job effect remains nonetheless relatively small (for example, in the case of the DE- DK joint support scheme, the annual amount of tendered capacity equalled around 250 MW, i.e. involving less than 250 jobs, considering the previously mentioned job factors).

Regional cooperation leads to a more balanced distribution of investments across MSs. The RED II IA indicates that the share of investments in the top three MSs drops from 67% in the former Baseline Scenario to 58% in the case of regional cooperation, while the share of the smallest contributors increases[101].

The RED II IA revealed that the mandatory partial opening of support scheme implies a shift from offshore wind towards solar PV capacities, as the latter features more cost-efficient potentials under the right financing costs. Despite the fact of converging WACC between MSs, this phenomenon is likely to persist.

Option 4

First, it should be noted that there are some possible barriers to the Mechanism uptake, even under the current format. The Mechanism is already in place, yet the major risk is a low uptake due to limited interest from MS to participate as a host or contributing country. Possible limitations are:

- Limited interest in financing a project abroad, despite obtaining the corresponding statistics (in the reference case, 80% of them). Indeed, investments usually bring additional benefits, too. E.g., they do not get the electricity generated in the host country, the contributing country should rely on a more intensive use of existing electricity generation means (or imports) or even invest in additional generators[290];
- On the other side, the benefits to the host Member State should be made clearer: learning/capability building; ability to attract more investments in long term; local jobs (O&M as a start, then triggering investments in manufacturing facilities for instance); green electricity mix and less pollution; income of taxes on the wind farms[291];
- There is a lack of visibility on:
    - Auction planning – as a demand-driven mechanism, it is difficult to define an auction planning without having received interest for MS;
    - Auction progress: some guidance is needed on the auction functioning, with respect to ceiling prices, handling of equal bidding prices;

[289] Cameron, L., & Zwaan, B. v. (2015). Employment factors for wind and solar energy technologies: A literature review. Renewable and Sustainable Energy Reviews.
[290] AURES II. (2020). The new renewable energy financing mechanism of the EU in practice.
[291] Wind Europe. (2020). Renewable Energy Financing Mechanism - Response to the Public Consultation.

  - Cost benefit allocation: is the Commission expected to deviate from the indicative 20%/80% allocation of the statistics between the host and contributing countries? Is the statistics share delivered to the host country balancing the other costs (e.g., reinforcement costs, balancing or frequency needs)?
- Low interest by contributing MSs would:
  - Limit the effectiveness of the Mechanism;
  - Limit the ability for the Commission to direct funds/tenders in line with preferences expressed by contributing MS. Besides, the Commission may be limited in its ability to set-up technology specific tenders targeting offshore technologies.
- Rules of the host MS apply, either in terms of GOs or permitting. Lack of clarity on the host MS rules (if not unified enough across the EU) may refrain MS (or private investors) to contribute to the Mechanism;
- Interaction with permitting: as a strong barrier for project development (in terms of realisation probability, increased investment needs and increased project duration), uneven permitting rules may create a bias in the preferences for projects location, favouring MS with the most favourable/streamlined permitting procedures, despite possibly higher renewables cost. Such behaviour would limit the Mechanism overall efficiency. Besides, currently, the Mechanism does not provide any guarantees on the permit granting with respect to the host MS administrative rules. If a fast-tracking procedure was investigated for projects promoted under the Mechanism, the Commission should ensure that fast-tracked projects are not balanced against national projects. The Commission could also require from host countries that permits are ready to be delivered when the project is awarded.

Yet the Mechanism is an opportunity for the EU to investigate more ambitious regional cooperation tools, and to clarify remaining issues on cost and benefits allocation. If such conditions were to be clarified, it would pave the way for a more integrated European cooperation instrument, such as increased opening of support schemes.

Implementing additional tender rounds solves some of the issues reported above, e.g., designing an auction planning, possibly low uptake due to low interest by MS, yet it comes with its own implementation challenges:

- In particular, it should be defined how the additional tender rounds are financed. Two possibilities are investigated: EU Budget or a certain mandatory participation from MS. The Multiannual Financial Framework being closed, it could require a revision of the latter. If MS are to finance the Mechanism, the mandatory level of funding should be defined;
- The Commission should also precise if all MS are considered as potential host countries, as it may infringe on their right to decide what their supply mix should be;
- For each of them, the rule for sharing the contribution over MS should be clearly stated (e.g., if it depends on the type of auctions), and the rule for (possibly) sharing the benefits should be clarified (e.g., does the host MS still receives a share of the statistics, and to what extent);
- Ideally, it should be integrated in an auction planning. Besides, it would particularly make sense if these technology-specific tenders are part of the additional tender rounds. Without considering the additional tender rounds, the bottom-up functioning principle of the mechanism (calls are made if MS decide to participate) complicates the setting-up of a calendar for auctions, possibly limiting the effectiveness of technology-specific calls in bringing visibility on forthcoming investments.

Overall, the Mechanism is an efficient and powerful tool to further foster regional cooperation. It enables MS to share their renewable (and in particular offshore) resources without having to sign complex multi-lateral cooperation agreements, as the fund is managed by the Commission, both for tendering and statistics allocation[292].

Such mechanism extends and complements the current cooperation tools, without replacing them: if two Member States decide to share resources or to join forces on the development of a given project, they can still open their support schemes, launch a joint project or reallocate statistics. Then, when cooperation involves more than two MS, the pool approach of the Mechanism is a simplified way of enabling cooperation, assuming that enough MS express interest in it.

With respect to offshore technologies, the Mechanism is an efficient way of opening offshore resources to land-locked countries, with limited transaction cost as they can contribute to projects in any country with access to a sea basin involved as a host country in the Mechanism, without setting any cooperation agreement.

The Mechanism exacerbates the distributional effects described above. Indeed, it possibly involves a large number of countries, which may only slightly change between the tender rounds (yet to be confirmed based on the first tender rounds). As the auctions reveal the cheapest project across host countries anyway, countries with more favourable conditions in terms of renewable resources or economic conditions will attract most of the investments.

This process will gather renewable electricity generation in host countries where it is cheap to develop, while countries with lower potential will see less RES projects materialise. While the latter will need to invest in additional electricity generation needs to meet their needs, the host country may face increased grid reinforcement or balancing needs[105].

In particular for tenders targeting offshore technologies: a high demand from landlocked countries will be directed to the few host countries featuring a coastline with high potentials (e.g. North Sea basin), which may significantly increase grid reinforcement needs in the host countries (both onshore and offshore). It may refrain countries with large offshore potential but facing high grid reinforcement needs from participating in the Mechanism.

Eventually, it should be noted that every MS may pursue both goals of achieving their RE target and having a greener electricity supply mix. While they all have better chances of reaching their RE targets thanks to the Mechanism, the latter increases discrepancies between MSs in terms of actual renewable generation.

Effectiveness

Option 1

The issuance of guidance is fully in line with the objectives of increasing the use of regional cooperation mechanism targeted at RES deployment. However, given the non-regulatory character of this option, it may turn out that major barriers persist.

Option 2

[292] AURES II. (2020). The new renewable energy financing mechanism of the EU in practice.

Obliging MSs to set up a pilot cross-project will enable them to gain initial experiences in such an undertaking, screen and identify potential cooperation options and go through the entire process of establishing a cooperation for one type of regional cooperation action indicated in Articles 5, 8-13 of RED II (if not demonstrating why it is not possible to set up pilot project). The learning effective is guaranteed but risks to be limited.

If MSs are not “intrinsically motivated” of the benefits of regional cooperation, there is a significant risk that MSs choose to go for the implementation of a least-effort solution in order to comply with the regulation (e.g. merely a statistical transfer of a minor amount of renewable energy), which will have marginal impacts and limited gain in experience, knowledge, administrative capacity building.

Lacking minimum requirements on the pilot cross-border project (as they are suggested for the option on the mandatory partial opening of support schemes) represent the risk of pseudo projects being implemented, if there is no “intrinsic motivation” among MSs to go for such a solution and no obligation to implement a project of a tangible size, neither.

The obligation for MSs to demonstrate why they do not intend to comply with the given option might represent a useful means to incentivise MSs to deal with the topic of regional cooperation; nonetheless, the requirement for MSs to carry out an assessment regarding the potential benefits of regional cooperation might represent a more appropriate option.

Option 3

The mandatory partial opening of support schemes can be considered effective, in particular provided the fact that the option indicates a clear share that must be met, which allows to monitor and verify compliance with the option.

Option 4

Additional tender rounds de facto increase regional cooperation by setting EU-wide tenders financed by all MS. The option effectiveness directly depends on the number of additional tenders.

Efficiency

Option 1

This is a rather quick and low-cost solution to be implemented by the European Commission, which may have an impact on the development of renewable energies. As indicated above, the benefits are uncertain. However, given the low costs for implementation, the option can be considered as no-regret.

Option 2

If a MS goes for the least-effort solution, little benefits (in terms of effective cost-reduction, further integration of the EU internal market, cross-border alignment of support schemes, realisation of joint projects etc.) may be achieved at comparatively high administrative costs, as MSs do not benefit from economies of scale and the realised solution is unlikely to be repeated in the future, thus not providing long-term benefits.

Option 3

The high costs related to the partial opening of support schemes (notably in terms of implementation and transaction costs) are considered proportionate in comparison to the related benefits, notably because they may be understood as upfront costs that will decrease over time when additional cooperation projects will be set up.

The option is considered effective and efficient as MSs were reluctant to such undertakings of regional cooperation in the past despite relatively robust scientific evidence about their benefits, meaning that a mandatory character of the option may be considered proportionate.

Option 4

By setting-up EU-wide tenders, without requiring additional cooperation agreements between MS, the measure provides high benefits (cheapest project across host countries) for a limited cost, borne by the Commission centralising the procedures.

Coherence

Option 1

No specific impacts on coherence.

Option 2

The option is coherent with other EU policies, however, given the marginal effect of such an option (apart from a gain in experience), it is unlikely that the option will substantially contribute to the achievement of overarching objectives of EU policies.

Option 3

The option can be considered fully coherent with other EU policies, notably with the objective of the EU Green Deal and several dimensions of the EU Energy Union (notably a fully integrated internal EU energy market, decarbonising the economy, supporting clean energy technologies and ensuring energy security through solidarity and cooperation between EU countries).

Option 4

This option is coherent with the single market, as it removes national barriers to regional cooperation.

Synthesis

Comparative summary

The analysis of policy options to promote **power purchase agreements** has revealed, that all options tend to have positive economic, environmental and social impacts. This is notably linked to the fact that PPAs may be considered as an effective alternative in the medium to long-term perspective to provide investor security (facilitating the continuous phase-out of public support schemes), represent a follow-up financing option for existing RES installations that reach the end of term of public support and provide power consumers the option to purchase green electricity and hedge against price risks (amongst other).

Option 1 (featuring non-regulatory measures, notably guidance) may be considered as no-regret option as it comes with very low implementation costs while reducing the barrier for specific stakeholders (such as SMEs or international entities interested in cross-border PPAs) to sign a PPA. Yet, these effects may not be taken for granted given the non-binding character of the option.

Option 2 (credit guarantees) is more likely to trigger specific effects, compared to Option 1, as risks are mutualised and thus market entry barriers are lowered. However, these benefits require some dedicated efforts in establishing the respective body and products to issue the credit guarantees.

Finally, specific provisions under Option 3 to oblige MSs to facilitate the large-scale deployment of PPAs may be an effective game changer. Yet, this requires a rigorous enforcement by the European Commission or another independent body, paired with some dedicated MRV tools in order to guarantee compliance of MSs with these provisions.

The option of hourly GOs as a means to raise revenues for renewable power generators may be considered as effective but currently still costly to establish. However, this will become a more relevant option in the mid-to long-term perspective, as RES shares in the power system are rising (requiring real-time monitoring of RES market integration and an enhanced digitalisation of the power system).

To sum up, PPAs can be considered as a meaningful tool to facilitate RES deployment, thus contributing to the strive towards carbon neutrality. Ambitious and effective policy options facilitating PPAs are thus useful and all three options outlined above should be considered as necessary to increase the pace in RES deployment to meet the objectives outlined under the Fit-for-55 Package. Yet, PPAs will not be able to solve the problem of the delivery gap on their own, and additional initiatives are needed.

In the past, Member States only made limited use of the options related to regional cooperation available under RED/RED II. Nonetheless, the present analysis reveals that **regional cooperation** features clear benefits. Yet, for the policy options fostering regional cooperation, the results of the impact assessment are less unequivocal than for PPAs.

Option 1 (guidance on the opening of support schemes and the use of cooperation mechanisms) entails clear economic and environmental benefits (in particular with respect to the efficient use of renewable resources across Europe). The specific guidance for offshore wind (relating to tender design, IGA templates, CBA/CBCAs for the development of hybrid/joint projects, Sub-option 1.1) feature in particular significant environmental benefits paired with enhanced economic gains. Yet, given the non-regulatory character of the policy option, the effects may not be taken for granted. As the potential benefits of Option 1 clearly outweigh the related (notably administrative) efforts, Option 1 should be regarded as no-regret option.

In contrast, the obligation to implement pilot cross-border projects (Option 2) may imply significant transaction costs, while the benefits in terms of enhanced or more efficient RES deployment risk tend to be limited, notably if Member States opt for fig leaf solutions which merely ensure compliance with the regulation without putting effort into the implementation of a serious pilot project.

The mandatory partial opening of support schemes under Option 3 represents a strong intervention in national legislation. However, the opening of support schemes is expected to deliver ultimately effective cost reductions and potentially incentivise additional investments. Thus, Option 3 may be considered as efficient, yet it is difficult to evaluate whether the implementation costs justify the related benefits.

Option 4 (enhancing the Renewable Energy Financing Mechanism) may enhance the effect of regional cooperation financed through EU budget and Member States. This mechanism is likely to trigger additional investments (as it gives visibility and certainty to project developers, investors and the upstream value chain) while requiring limited (centralised) efforts and costs to implement it.

In this regard, Options 1 and 4 may be considered as no-regret options, even if the effectiveness of the options is subject to uncertainty. Option 3 may be considered as certainly effective, yet the option's efficiency strongly depends on the actual implementation and the extent to which the European Commission provides guidance and streamlines the mandatory partial opening of support schemes.

The assessment of the **different policy options as a whole** reveals that the promotion of PPAs and regional cooperation may contribute to a significant extent to the closure of the remaining delivery gap towards a RES-E share of 63%/64% by 2030 (which is compliant with the Fit-for-55 Package).

Considering a delivery gap of about 150 to 190 TWh of required additional renewable power generation, the removal of barriers for PPAs could contribute with some 64 TWh, notably by mobilising PPA offtakers among SMEs. Regional cooperation represents a meaningful measure to privilege the exploitation of least-cost RES potentials and to optimise RES-E system integration, thereby driving down the costs. In addition, regional cooperation may facilitate the cost-efficient integration of renewable power generation sources. Both effects trigger savings of 0.5 bn€ annually which can be translated into 10 TWh of additional renewable power generation.

It is important to note that the present assessments rely on a large number of assumptions regarding the evolution of the European power sector until the year 2030. Hence, they are subject to significant uncertainties. In addition, not all of the options could be assessed in quantitative terms due to a lack of information or time.

Nonetheless, it becomes obvious that the measures analysed are unlikely to be successful in closing the entire delivery gap. This means, that additional measures are required. A major element in this regard could be a more important and/or stable carbon price signal (e.g. via a reduction of freely allocated emissions allowances or a carbon floor price). An enhanced carbon price signal may entail higher market prices thereby 1) increasing RES market values, 2) reducing the costs for public support, 3) reducing the pressure on a dedicated GO price and in parallel (and independent from renewables) allow for a shift from coal/lignite to gas (cf. UK/DE experience). This observation of a co-existence between dedicated RES policies and an ETS system is backed by the scenarios analysed with PRIMES for the present Impact Assessment. Further measures may include for instance the setting of specific targets for renewable electricity (also known as renewable portfolio standards), implement fast-track permitting for renewable and grid installations, renewable obligations for public procurement, suppliers and/or large consumers, full consumption/supplier disclosure for GOs.

Annexes

Annex 1: Modelling of mandatory partial opening of support schemes with the METIS model

In order to quantify the benefits regional cooperation would bring in terms of cost-efficient renewable development, a METIS-based scenario has been designed. This scenario builds on the MIX55 PRIMES scenario, from which are derived the main framework assumptions in terms of fuel prices, electricity generation mix, demand structure. On this basis, METIS performs a joint dispatch and capacity optimisation of the system. In addition to the flexibility portfolio (peak generation, storage) which is optimised to ensure supply and demand equilibrium, this scenario optimises investments in renewable capacities under different assumptions regarding the opening on support schemes.

The METIS model

The METIS model is being developed by Artelys on behalf of the European Commission. METIS is a multi-energy model covering in high granularity (in time and technological detail) the entire European energy system, representing each Member State of the EU and relevant neighbouring countries as a single node.

METIS includes its own modelling assumptions, datasets and comes with a set of pre-configured scenarios. These scenarios usually rely on the inputs and results from the European Commission's projections of the energy system, for instance with respect to the capacity mix or annual demand. Based on this information, METIS allows to perform the hourly dispatch simulation (over the duration of an entire year, i.e. 8760 consecutive time-steps per year). The result consists of the hourly utilisation of all national generation, storage, conversion and cross-border capacities as well as demand side response assets. In addition, METIS can jointly optimise the investments in a large number of technologies together with the dispatch optimisation of the hourly demand-supply equilibrium.

Integration of the MIX55 scenario in the modelling exercise

In order to assess demand-side response strategies with respect to renewables integration, the MIX55 PRIMES scenario has been integrated into METIS. Some of the main characteristics of these scenarios have been taken into account in the modelling exercise, we present below the list of assumptions that have been directly taken from the MIX55 scenario:

- Installed capacities;
- Solar fleet;
- Onshore wind fleet;
- Offshore wind fleet;
- Hydro fleet;
- Geothermal fleet;
- Other renewables fleet;
- Nuclear fleet;
- Lignite and Coal fleet;
- Oil fleet;
- OCGT, CCGT and CCGT with CCS fleets (optimised);
- Derived gasses fleet;
- Biomass and waste fleet;
- Power demand;

  - Direct power demand, with a specific distinction of electric vehicles and heat pumps consumption;
  - Indirect power demand (i.e. electricity dedicated to P2X, in order to produce synthetic hydrogen, e-gas and e-fuels; electricity dedicated to batteries and pumped storage);
- Commodity prices;
  - Fuel prices (gas, coal, oil);
  - EU-ETS carbon price.

Currently, no publicly available datasets characterise the MIX55 scenario. In order to have an appropriate level of details for the modelling, we have been granted access to confidential datasets at Member State level. However, following the terms of our confidentiality agreement, we only provide EU-wide assumptions and results in the following sections as well as illustrative examples for representative countries.

Disclaimer about the scenarios used in the modelling
As explained above, the scenario that we have built to assess the role of DR in renewables integration is partly based on the MIX55 scenario, and some structural datasets are directly taken from the MIX55 assumptions (see list above). However, the modelling of the power system behaviour and the identification of the optimal flexibility portfolio relies on additional assumptions (e.g. potential, capital costs, etc.) and applies an hourly granularity while modelling an entire year. Therefore, results can differ from those of the MIX55 scenario, especially in terms of installed capacities of the flexibility solutions that are optimised in our work (gas-fired power plants, pumped hydro storage, batteries).

In addition to the European Union, 7 neighbouring countries have also been modelled to capture their interactions with the EU member states. These 7 countries are the following:

- Bosnia-Herzegovina;
- Montenegro;
- Norway;
- North Macedonia;
- Serbia;
- Switzerland;
- United-Kingdom.

For all these countries except the UK (which was included in the MIX55 scenario), their associated power production capacities and demand is extracted from the TYNDP 2018 work of ENTSO-E. The Sustainable Transition" (ST) 2030 scenario has been selected, as it is the closest to the 2030 objectives of the European Union.

Figure 4-1: Pan-European energy model in Artelys Crystal Super Grid, derived from the MIX55 scenario.

Optimised investments

Regarding the optimisation scope, it is important to keep in mind that the model performs a joint optimisation of the operation of the whole power system, and the investments in different flexibility solutions. Investments in the following technologies are optimised:

- Back-up power plants: gas capacities (OCGT, CCGT, CCGT+CCS);
- Storage capacities (Pumped hydro and stationary batteries);
- Power-to-X technologies (electrolysers and methanation);
- vRES capacities (detailed later in this document).

Table 4-1: Technoeconomic assumptions for investments in flexible technologies

	Potential	Optimised capacity	Investment cost (€/kW)	Fixed O&M costs (% CAPEX)	Efficiency	Lifetime
OCGT	-	✓	386[293]	3%	39%	25
CCGT	-	✓	579	3,6%	62%	30
CCGT with CCS	-	✓	1625	2,4%	48%	30
Pumped Hydro	+ 15 GW	✓	1212[294]	1,20%	81%	60
Batteries	-	✓	120€/kW + 120€/kWh[295]	4,30%	90%	10

The flexibility of the power systems can be provided by these additional capacities, but also by the other flexible technologies whose capacities are directly coming from the MIX55 scenario (Nuclear, Hydro, coal/lignite, biomass) or demand-side response (smart charging of electric vehicles and heat pumps with thermal storage).

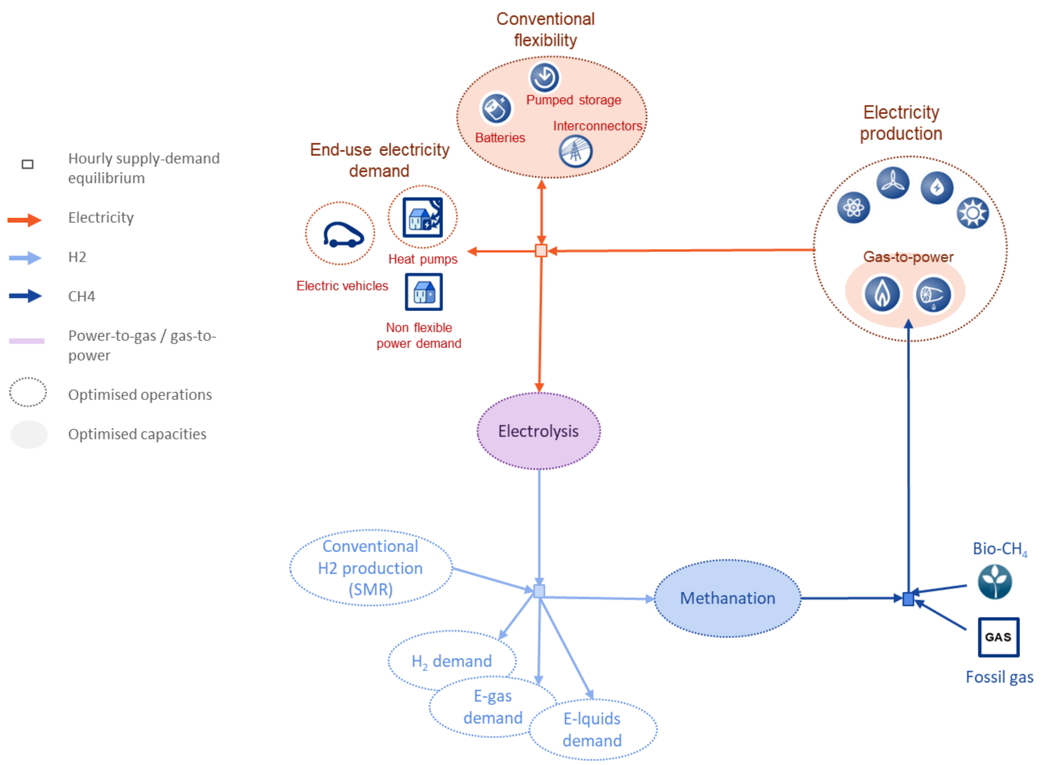
[293] CAPEX source: "Technology pathways in decarbonisation scenarios", 2018
[294] CAPEX source: ETRI and METIS S8
[295] Sources: ETRI and METIS S8

Figure 4-2 summarizes for which technologies the capacity investments are optimised and which elements of the power system are only optimised operationally. Since it is central to the analysis at hand, we emphasise the power-to-gas-to-power loop.

It should be noted that, in our scenario, the whole P2X demand (hydrogen, e-gas and e-liquids) is represented by an aggregated hydrogen demand. Since the possible flexibility on the end-user side is difficult to predict (possible storage of hydrogen, refurbishment of existing network and storage for e-gas, flexibility of the fuel supply for vehicles, etc.), a common hypothesis on the flexibility of the hydrogen demand has been made. In our model, we assume a large flexibility on the demand-side of hydrogen, e-gas and e-fuels with only a limitation on the annual volume that should be provided, in line with the values of the long-term strategy pathways.

In the different scenarios, hydrogen production from electrolysis can be complemented by hydrogen produced by SMR (steam methane reforming) combined with CCS (carbon capture storage) plants when RES generation is not high enough to produce all the required hydrogen. The associated production cost is 90€/MWh.

Figure 4-2 - Description of the METIS model used in the study[296]



Investments in renewable generation

In order to assess the effects of increased regional cooperation, the tool capabilities have been extended to cover investments in renewable generation, i.e. wind (onshore and offshore) and solar generation.

Technoeconomic parameters derived from the ASSET database[297] have been considered:

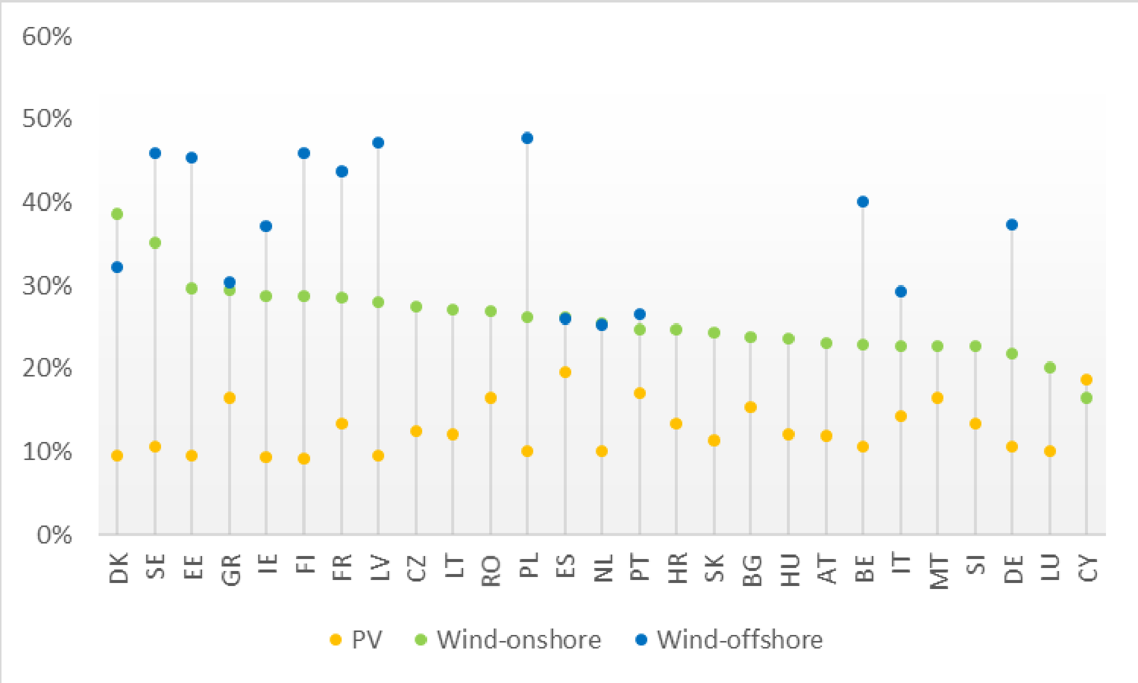
[296] Source: adapted from METIS study S1 (https://ec.europa.eu/energy/studies/optimal-flexibility-portfolios-high-res-2050-scenario_en)
[297] E3Modelling et al., (2018). ASSET - Technology pathways in decarbonisation scenarios.

Table 4-2: Technoeconomic assumptions for investments in renewable generation

	Investment cost (€/kW)[298]	Fixed O&M costs (% CAPEX)	Lifetime
Onshore wind	950	2.2%	30
Offshore wind	1874	1.7%	30
PV	387	3.2%	30

The national load factor timeseries are extracted from the METIS database and resized to match the average load factor of the PRIMES scenario:

Figure 4-3: National load factors as integrated in the METIS database, based on latest MIX55 scenario.



Regional cooperation

In order to capture the effects of regional cooperation, two model runs have been designed:

- **Baseline**: national vRES capacities are set at their values in the MIX55 scenario and are not optimised
- **Regional cooperation 10%:** 10% of the total investments in vRES technologies between 2025 and 2030 (based on PRIMES data) are subject to re-optimisation across countries. The model has to meet the same vRES capacity target as the Baseline over the EU27, ensuring that no delivery gap is created, however each country can open its support scheme up to 10% between 2025 and 2030 to other EU countries, allowing a reallocation of vRES investments.
- An additional model run has been conducted to capture the effect of a **5% opening of support schemes**, considered to be equivalent to Option 2 – mandatory cross-border project.

In the different model runs, only the capacity investment distribution across countries is optimised (if allowed), meaning that the total installed capacity of each of the three vRES technologies considered in this assessment remains unchanged, at the 2030 value from the MIX55.

[298] An 8.5% WACC has been considered for investments in renewable capacities

Table 4-3: vRES capacities opened to reallocation

	Installed capacity according to PRIMES (GW)		Capacity opened to reg.coop (10% assumption)	
	2025	**2030**	**In GW**	**In % points of the 2030 capacity**
Wind on-shore	240	338	9.8	2,89%
Wind off-shore	24	74	5.0	6,71%
Solar	212	370	15.8	4,27%

As the same cost of capital is considered for all the countries, the model mainly reallocates investments based on national load factors and integration costs. Integration costs are accounted for based on required investments in the flexibility portfolio to ensure the supply and demand equilibrium, and thermal-based generation to meet flexibility needs.

Overall, this modelling could be further extended by considering cost-potential curves for vRES technologies. Yet in this specific case, the investment window remains narrow considering the 10% limit on the opening of support schemes, ensuring that the capacity cost does not vary with the installed capacity. However, cost-potential curves would allow to refine the vRES capacity cost based on available renewable national potential.

Annex D - Increase Renewables in Heating and Cooling

Annex D to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

Acronym	Full name
BRP	Building Renovation Passport
CTP	Climate Target Plan
CSP	Concentrated Solar Power
DHC	District Heating and Cooling
DSO	Distribution System Operators
EE	Energy Efficiency
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
ETS	Emissions Trading System
ETD	Energy Taxation Directive
EPC	Energy Performance Certificate
GDP	Gross Domestic Product
GHG	Greenhouse Gas
H&C	Heating and Cooling
HPA	Heat Purchase Agreement
IRR	Internal Rate of Return
JRC	Joint Research Centre
LTRS	Long Term Renovation Strategy
MS	MS of the European Union
MEPR	Minimum Energy Performance Requirements
MEPBS	Minimum Energy Performance of the Buildings Standard
NECP	National Energy and Climate Plan
NREAP	National Renewable Energy Action Plan
PCI	Project of Common Interest
PPA	Power Purchase Agreement
PV	Photovoltaic
RED	Renewable Energy Directive
RES	Renewable Energy Sources
RFNBO	Renewable Fuels of Non Biological Origin
RD&I	Research Development and Innovation
SME	Small and Medium Enterprises
TEN-E	Trans-European Networks for Energy
TSO	Transmission System Operator
WACC	Weighted Average Cost of Capital

Background

Heating and cooling (H&C) plays a crucial role in the European Union (EU)'s ambition to transition into a clean and carbon-neutral economy by 2050, specifically as heating and cooling in buildings and industry accounts for half of the EU's energy consumption.

A recent report by the Joint Research Centre (JRC) analysed the information provided by member states (MSs) on how to decarbonise the heating and cooling sector.[299] The report finds that although significant efforts have been made to address this sector, there are also many aspects that have not been incorporated by MSs, such as, high-efficiency cogeneration or efficient district heating and cooling. In the NECPs, it was often stated that some information would be provided later, pending the respective analyses of other Directives and/or policies and plans (e.g. long-term renovation strategies).

The final NECPs of EU27 anticipate a share of renewable energy in the heating and cooling sector of 23% in 2020 and 33% in 2030. All countries show an increase in this period; however, the level of ambition varies significantly. Nine countries meet the target of 1.3%-point annual increase of renewables in the H&C sector of Article 23 of RED II. Only a few countries provided details about the constraints responsible for not meeting the objectives.

Biomass and heat pumps were the dominant renewable technologies in the H&C sector in 2018. According to all NECPs, biomass accounted for 81% and heat pumps for 11% of final energy consumption from renewables in the H&C sector. The relative contribution of biomass among the renewable H&C technologies is expected to decrease by 2030. However, with an expected share of 66% in 2030, biomass would remain the most dominant renewable source in the H&C sector in EU27. The contribution from heat pumps was 11.3 Mtoe in 2018, and it is expected to increase to 21.1 Mtoe in 2030, thereby contributing 17% of renewable H&C.

Given the broader policy goal to decarbonize the H&C sector, the main objective of this annex is to assess to which extent new renewable-specific target(s) and/or renewable-specific measures are still required on top of the overarching decarbonization goals and instruments, addressed in the frame of the Effort Sharing Regulation (ESR), the Energy Performance of the Building Directive (EPBD), the Energy Efficiency Directive (EED), the Emission Trading System (ETS)[300], and the Energy Taxation Directive (ETD), that could support, guide or re-enforce the update of NECPs in 2023. The alternative will be to consider strengthening the mainstreaming of renewables in these instruments, ensuring full integration and consideration of renewables into the decarbonization actions.

More globally, according to IEA & IRENA[301], the number of countries that have adopted regulatory and financial policies for renewable heating and cooling has changed very little in recent years, except where local governments have adopted policies, often more ambitious than their national counterparts. As of mid-2019, thousands of city governments around the globe have adopted renewable energy targets and action plans, and more than 250 cities have reported at least one sectoral target for 100% renewable energy.

[299] JRC. (2020). Assessment of heating and cooling related chapters of the National Energy and Climate Plans (NECPs)
[300] DIRECTIVE (EU) 2018/410 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
[301] IRENA. (2020). Renewable Energy Policies in a Time of Transition: Heating and Cooling. Available at: https://www.irena.org/publications/2020/Nov/Renewable-Energy-Policies-in-a-Time-of-Transition-Heating-and-Cooling

To decarbonise the energy used for heating and cooling, governments must implement comprehensive policy packages that prioritise efficiency and renewable energy while phasing out the use of fossil fuels. Urgent policy action is even more critical in the context of the COVID-19 pandemic, which has cut demand for heating and cooling services based on renewables and sapped the willingness of households and small businesses to invest in renewables-based solutions, while simultaneously worsening conditions for energy access in many developing countries.

There are several transformation pathways, driven by renewables-based electrification, renewable gases, sustainable biomass, and the direct use of solar thermal and geothermal heat – together with the enabling infrastructure required. Pathways and related policy instruments that can be used to overcome all barriers and reap the potential benefits of the move to renewable H&C are strongly dependent on national and local conditions (climatic conditions, existing infrastructures, local resources, end-use applications, …). There is not one single combination of policy instruments, options and technologies that works best in all contexts.

According to the IRENA/IEA report[302], just as for overall energy use, a well-balanced policy package will allow countries to overcome barriers and maximise the socioeconomic footprint of the transition:

- Renewable heating and cooling requires proactive policies – both to level the playing field and keep costs competitive, as well as to maximise the social, economic, environmental and other benefits.
- Measures to scale up renewable heating and cooling can and should be aligned with broader socio-economic policies and objectives. These can include improving conditions for vulnerable segments of the population, developing key economic sectors, setting long-term energy plans, and pursuing international climate and sustainability goals.
- Long-standing networks for district heating and cooling can be adapted to accommodate growing shares of renewable energy.

Solutions are ready for the taking, as are the promised rewards. What has been lacking, however, are the broad and strong political will and comprehensive planning for the long-term, requiring urgent and clear action from governments, civil society, consumers, research institutions and the private sector.

[302] Ibid.

Design

Problem Definition

The main specific problems identified are:

- The slow uptake of renewables due to an insufficient renewables target in the H&C sector, a lack of investment security and a high risk associated with the deployment of renewables in the H&C sector. Most of the technologies available to decarbonise the sector are mature, but lack a level playing field and mass market to be deployed at a competitive cost;
- The lack of a coherent approach regarding the future of energy infrastructures (transport, distribution, storage and delivery of gas, liquids, electricity, and heat), and the decarbonisation of all H&C carriers, ensuring appropriate energy system integration;
- The lack of a combined and integrated strategy at EU, national, regional and local levels to decarbonise the heating and cooling sector addressing at the same time the deployment of renewable technologies and energy efficiency.

Problem 1: Slow uptake of renewables in the H&C sector

To deliver on the increased greenhouse gas (GHG) reduction target for 2030 as set out in the Climate Target Plan (CTP), the share of RES-H&C would need to increase to around 39-40% of the final energy consumption.[303] As a result, both the current target of 1.3%-point annual increase of renewables in the H&C sector under Article 23 of RED II (adding ~11-13% over a period of 10 years) and the aggregate ambition of the MSs' NECPs (a total share of renewable energy in the H&C sector of 33% in 2030, according to the JRC's assessment of NECPs) are no longer ambitious enough. This is problematic as without sufficiently high ambition levels, it is unlikely that the share of renewable energy will increase at the rate required for reaching the GHG reduction target in a cost-effective manner.

The problem of an insufficiently high renewables target in the H&C sector can be discussed at two levels. At the more fundamental level, the lack of insufficiently high RES-H&C targets results in a higher reliance on other policy measures to reach the climate targets. They may also be suboptimal, as they do not further contribute to other policy objectives other than reaching the climate targets. In the absence of a (sufficiently high) RES target, climate policy would rely more on stricter regulation around building renovation and/or carbon pricing (e.g. through the Emissions Trading System (ETS) for H&C in industry, or Energy Taxation Directive (ETD) for non-ETS industry). While partly effective for reaching the climate objectives, such instruments do not create the appropriate investor incentives for H&C renewables and will not translate into a sufficiently high rate of renewable energy deployment in H&C, also given the large complexity to decarbonise the H&C sector globally. As a result, the opportunities for the EU industry, the construction sector and Research, Development & Innovation (RD&I) to develop, innovate and attain a position of global leadership in the renewables H&C sector are not optimally supported. Furthermore, there may be less support to upscale less mature renewable energy technologies that are not competitive enough to rely on existing carbon pricing alone, increasing investors' risks and decreasing their confidence. Finally, a greater reliance on carbon pricing in particular through the ETD targeting the space heating sector with vulnerable households sensitive to fuel price variation (given the poor insulation levels), may have sub-optimal distributional impacts. It would possibly place a disproportionately large part of the burden on less affluent consumers and countries that rely on cheap fossil fuels and lack the capital to invest in energy efficiency measures and local renewable energy production and supply, also considering the low

[303] COM(2020)562 final. (2020). Stepping up Europe's 2030 climate ambition – Investing in a climate neutral future for the benefit of our people.

competitiveness of these solutions compared to the very low fossil fuel prices. However, mitigation measures are essential and instruments to support vulnerable households facing the consequences of the transition need to be designed. Distributional impacts could be addressed by prioritising the least affluent segment when deploying energy efficiency and renewable solutions. As recalled by the CTP impact assessment[304], carbon pricing increases energy costs to the consumer, but at the same time raises revenues which can be recycled, provide possibilities for reinvestments, stimulating climate action and providing resources to address social or distributional concerns.

Hence, a sufficiently ambitious RES-H&C target could be deemed important to enforce or motivate MSs to set up various instruments for reaching the climate expectations in the building sector (almost fossil-free, or nearly-zero carbon emission building) and in the industry sector (shifting massively to renewable-based fuels and low carbon fuels, as well as technology breakthrough and process electrification), in a way that is beneficial for a wider range of policy objectives.

At the more practical level, the problem of the RES target in H&C can be broken down into three components:

1) First, the lack of an ambitious EU target creates a lack of incentives and political pressure for MSs to be more ambitious on the national H&C RES target, and to address it extensively (with the appropriate measures). Hence, an additional EU target could be an important starting point to stimulate higher ambition at MS level for the H&C sector which specifically requires some additional attention;
2) Secondly, the current target under Article 23(1) is indicative and the same for all MS, considering the current share of renewable in the H&C to a very limited extent[305], and failing to integrate the national key factors such as the resource potential, the approach to deal with energy sector integration and the existing infrastructure;
3) Thirdly, there is no revision of the national ambition levels foreseen before 2024 in the current governance process set out by the Governance Regulation. Hence, even with an increased EU target, there is no collective requirement for MSs to increase the ambition level in the short term, nor to report on it, leaving any increased ambition level up to national initiatives. The Comprehensive Assessments on the potential for the application of high-efficiency cogeneration and efficient district heating and cooling [306] and the potential of energy from renewable sources in H&C assessment [307] could possibly support national initiatives. However in practice, there may be a certain degree of political inertia that discourages a country from increasing its RES share as rapidly as would be optimal.

Without EU intervention, it is highly likely that possible upwards revisions of national contributions for H&C do not add up to the increase that is necessary to reach the level of RES consistent with the EU CTP by

[304] SWD(2020) 176. (2020). Stepping up Europe's 2030 climate ambition – Investing in a climate neutral future for the benefit of our people.
[305] Those MS with a share above 50%, but without distinction between MS with a share of, e.g., 8% or 40%
[306] As foreseen under EED article 14(1), MSs shall carry out and notify to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling, containing the information set out in Annex VIII.
[307] As foreseen under RED article 15(7), MSs shall carry out an assessment of their potential of energy from renewable sources and of the use of waste heat and cold in the heating and cooling sector. That assessment shall be included in the second comprehensive assessment required pursuant to Article 14(1) of Directive 2012/27/EU for the first time by 31 December 2020 and in the subsequent updates of the comprehensive assessments.

2030, unless article 14(1) EED and article 15(7) RED Assessments lead to an anticipated revision, before the 2024 NECP revision.

The attainment of targets, whether those stipulated in the current RED II or more ambitious ones, requires a robust set of measures and instruments to support MSs and sub-national actors in the challenging task of decarbonising the sector. Presently, RED II contains a list of indicative measures under Article 23 that may contribute to mainstreaming renewable energy sources in the H&C sectors.[308] Article 15 provides guidance on administrative procedures, regulations and codes. However, the analysis of the NECPs shows that only nine countries meet the target of 1.3%-point annual increase of renewables in the H&C sector.[309] Furthermore, the measures supporting the achievement of renewables uptake and of energy savings in the H&C sector are not adequately described,[310] suggesting that MSs may have limited know-how on measure design and implementation. In addition, the fact that only nine MSs will meet the stipulated target is a clear indication that the current measures are insufficient to adequately support the needed uptake of renewables in the sector to the extent needed to meet the targets.

Renewable H&C and energy efficiency in the H&C sector face multiple barriers: policy, market, financial, capacity, technical, administrative, and regulatory, to compete with established H&C technologies and practices, which are not necessarily open to competition. Based on the analysis of data provided in the NECPs, several barriers responsible for the slow increase in RES in the H&C sectors were identified. Untapped potential (e.g. to developed geothermal-based heating in e.g. Bulgaria), lack of statistics (on biomass consumption), lack of appropriate infrastructure, housing dispersion and fuel-switching from coal to gas are barriers listed which could be addressed by an appropriate design of measures.

The uncertainty about the best approach to phase out fossil fuels, in an affordable and cost-effective way requires adequate planning and coordination as a precondition for effectively decarbonising the H&C sector.[311] However, systematic, multi-level planning approaches for the decarbonisation of municipalities, cities and towns are often missing. Lack of such planning propagates inertia and prevents citizens from adequately preparing for needed renovations and replacements of their heating and cooling appliances. In addition, without appropriate planning, investors miss the necessary certainty to invest in the much needed renewable H&C projects.

As identified in the analysis of the NECPs, several MSs are not currently benefiting from the largely untapped potential in relation to resources such as geothermal heat which are often hindered by high capital investment costs, lack of access to financing and risks associated with high project uncertainty (e.g. in relation to drilling). Mechanisms which could support the investment in RES H&C projects and renewables uptake such as heat purchase agreements are virtually unutilised and regulatory incentives and guides are missing.
More globally, there is still a lack of investment security, with a limited long-term vision, and with sometimes a lack of stability (e.g. changing rules due to uncertainty regarding the RES-H&C options). The

[308] The measures listed under the article focus on the physical incorporation of renewables and/or waste H&C in energy and energy fuel supply for H&C, direct mitigation measures (e.g. installation of highly efficient RES &&C in buildings), indirect mitigation measures covered by tradable certificates (e.g. from an independent renewable technology installer) and d) other policy measures with an equivalent effect including fiscal and financial incentives.
[309] JRC. (2020). Assessment of heating and cooling related chapters of the National Energy and Climate Plans (NECPs)
[310] Ibid.
[311] E.g. ProgRES Heat. (2017). Policy recommendations to decarbonize the European heating and cooling system. Available at: http://www.progressheat.eu/IMG/pdf/progressheat_d5.5_inclannex_forupload_2017-12-06.pdf

high risk regarding the deployment of RES in H&C, especially for capital intensive investments (e.g. geothermal drilling, district heating and cooling networks, …), remains an important barrier.

Without appropriate measures to deploy renewables in the H&C sector, its decarbonisation risks a slow uptake and additional costs to achieving the targets specified in the RED II, let alone more ambitious targets. Thus, considerations related to RES-H&C targets should be accompanied by coherent sets of measures.

Problem 2: Lack of a coherent approach regarding the future of energy infrastructures and the decarbonisation of all H&C carriers

The deployment of renewables in the H&C sector relies on all energy infrastructures: electricity networks to supply electricity consumed by heat pumps, to connect CHP plants and to produce renewable hydrogen; district heating and cooling to supply H&C from large-scale, cost-effective RES-H&C plants (geothermal, solar heat, heat pumps, bio-energies, renewable fuels of non-biological origin (RFNBOs)); gas infrastructure, converted from fossil gases to biomethane and/or hydrogen; and even infrastructure to transport and store liquid fuels (storage and transportation, via barges, rail, road and pipelines). The evolution of infrastructure, and the options and speed of decarbonising all energy carriers are the centre pieces for the complete decarbonisation of the H&C sector. These considerations are crucial for properly phasing out fossil fuels, and avoiding stranded assets, or even lock-in effects.

This underlies the importance for H&C decarbonisation planning (cf. previous problem), building on the deployment of renewable technologies and fuels, not only at national, but also at more decentralised levels, such as regional, city or municipal levels. The planning needs to encompass phasing out fossil fuel-based heating systems, increasing the energy efficiency of H&C appliances, planning for infrastructures (see previous paragraph) and energy savings.

District heating and cooling (DHC) have an important role to play, although they currently only deliver around 12% of the total final energy demand for space heating and hot water, with around 14% of the heat being supplied by RES-H&C.[312] The decarbonisation of the existing DHC remains too slow, with an important competitive disadvantage for renewable sources compared to the incumbent and cheap fossil-based systems.

According to article 24(4a) of RED II, MSs should increase the annual share of energy from RES and from waste heat and cold in district heating and cooling by at least 1%-point per year for the periods 2021 to 2025, and 2026 to 2030, respectively, using the share in 2020 as the baseline. If that share in 2020 is above 60%, the MS may count any such share as fulfilling the average annual increase, and MSs may decide not to apply Article 24(4a) if they fulfil the criteria defined in Article 24(10) of RED II.

According to the JRC assessment[313], projections for heat and cold supply from district heating and cooling were often not provided in the NECPs. An increased use is foreseen in three countries (LT, NL, BE) and declining trends are expected in six countries (CZ, DK, EE, FI, PL, SE), which is mainly explained by efficiency improvements of the building stock and of district heating networks.

[312] Euroheat & Power, DHC+ Technology Platform, UpgradeDH project. (2020). District Heating and Cooling a Modern Solution to Traditional Challenges. Available at: https://dhcitizen.eu/wp-content/uploads/2020/05/brochure_EuroHeat_2020_1.5.pdf
[313] JRC. (2020). Assessment of heating and cooling related chapters of the National Energy and Climate Plans (NECPs)

There is clearly a lack of incentives to accelerate the deployment of renewables in district heating and cooling, and to improve their efficiency. Policy instruments aiming to accelerate the decarbonisation of existing DHC should also take care of the risk faced by highly competitive individual solutions (usually fossil-based), leading to increased rates of disconnection. Energy system integration, building on the complementarities of the different infrastructures and energy carriers, is also currently weakly addressed. Energy system integration has the potential to support the deployment of different renewable options and reinforce the resilience of the entire energy system.

Problem 3: Lack of a combined and integrated strategy to decarbonise the heating and cooling sector addressing at the same time the deployment of renewable technologies and energy efficiency

There has been growing recognition that the deployment of renewables in H&C and the increase of energy efficiency or performance should go hand in hand. However, this is not the case in practice. Very few examples demonstrate a real integration of both efficiency and renewable energy in a coherent set of policy instruments, and planning.

This problem is partially addressed by looking at the coherence between the concerned Directives (namely EED & EPBD & RED II), while this main problem would have required a drastic change by integrating all these aspects in one legislative framework. Planning the deployment of renewable infrastructure separately from planning the renovation of the building stock no longer makes sense.

Options description

For each policy option, a table is presented with an overview of the options and sub-options to be analysed, organised by their order of departure from the current approach (e.g. option 0 is the baseline, option 1 are non-regulatory measures, etc.). After each table, a full description of the option is presented.

D1 - Nature of the RES H&C target (binding/indicative)

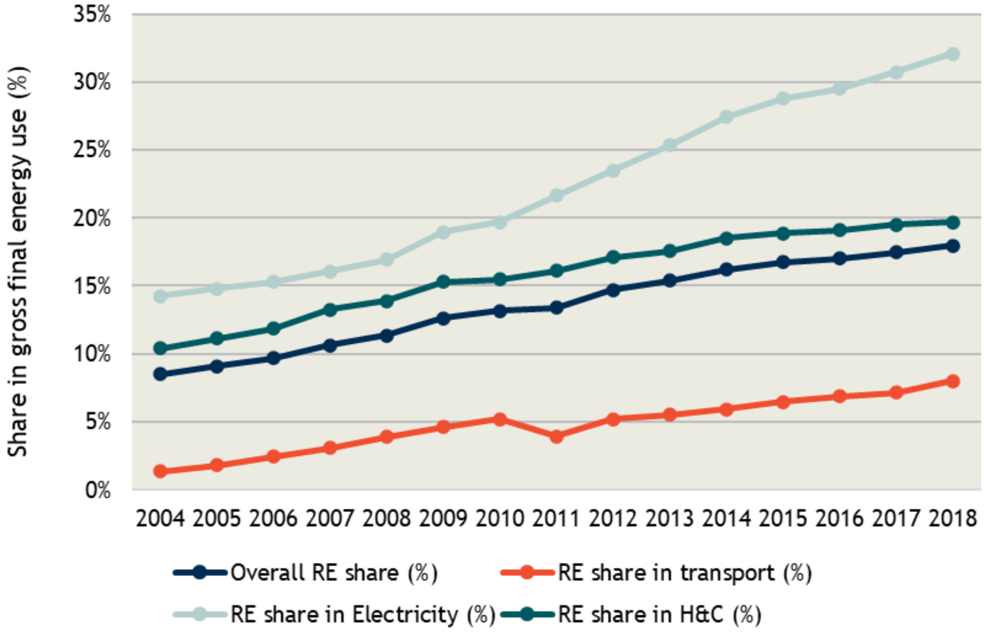
The objective of assessing the nature of RES H&C targets is to propose the most appropriate sectoral target for the H&C sector and its nature (binding/indicative) to ensure attainment of the overall 55% GHG emission reduction target as stipulated in the CTP. It also aims to identify the most appropriate measures to support MSs in achieving the RES H&C targets in the most cost-effective, socially-just and environmentally conscious way possible.

Table 2-1 Summary of options assessed

Options	Description
Option 0 (baseline)	No changes, maintain current policies under RED II
Option 1	Increase the ambition for the annual average increase (indicative uniform baseline & MS-specific additional increase)
Option 2	Increase the ambition for the annual average increase (binding uniform baseline & indicative MS-specific additional increase)
Option 3	Increase the ambition for the annual average increase (binding uniform baseline & MS-specific additional increase)
Option 4	The measures above could be flanked with an indicative 39% EU H&C target to guide and monitor efforts
Variants of measures	• Planned replacement schemes of heating appliances to facilitate fossil phase-out; • Consumer RES heat purchase agreements; • Risk mitigation framework for RES heat supply (heat production and related infrastructure) with large upfront investment; • Planning and implementation of renewable and waste heat & cold deployment projects and infrastructure in heating and cooling, specifically Article 15 (3).

The discussion about a H&C RES target should be framed in the context of the overall RES target. The EU has set out a target of at least 32% renewable energy in gross final energy consumption by 2030 under RED II. Figure 2-1 shows the progress in increasing the share of renewable energy in the electricity, heating and transport sectors. In 2019, the share of renewable energy consumption in the EU27 was at 19.7%.[314] Regarding the H&C sector, it accounted for the largest share of absolute consumption of renewable energy in 2018 with 102.9 Mtoe. The largest renewable energy source used in the H&C sector based on final energy consumption was biomass. Overall, the renewable energy share in the heating and cooling sector in 2019 was estimated to be 22.1%. The renewable energy share in H&C has been systematically above the level defined in MSs' NREAPs. [315]

Figure 2-1 Share of RES in final energy consumption per sector in the period 2005-2018. Source: Eurostat[316]



D.1 – Option 0: No changes, maintain current policies under RED II

This option is the baseline scenario in which the MS H&C RES target is not updated to reflect the increased climate ambition, relying on the existing framework, with an average indicative target for the H&C sector as a whole during the 2021-2025 and 2026-2030 periods. As variant, MSs could be encouraged by the Commission to revise their national contributions upwards, building on their new EED & RED Assessments. It is important to note that this variant constitutes a non-legislative proposal. So, while MSs would be asked to increase their contributions, there would be no requirements for them to adhere to this request. Still, MSs may revise their ambitions upwards voluntarily in the context of national policy updates and/or for the NECP update scheduled for 2024. Further, in the absence of an increased H&C RES target, other energy legislation (EED, EPBD, ETD for example) or market based instruments such as higher carbon prices through the EU ETS may be increased to compensate for not increasing the H&C RES target.

D.1 – Option 1: Increase the ambition for the annual average increase (indicative uniform baseline & MS-specific additional increase)

Under this option the indicative targets under article 23 of the RED II would be revised in order to be in line with the more ambitious target of 40% RES share by 2030, by including an additional indicative average

314 Eurostat SHARES summary results 2019.
315 EC (2019) COM(2019) 225 final
316 Eurostat – SHARES Tool. Available at: https://ec.europa.eu/eurostat/web/energy/data/shares

share increase per MS to cover the increased GHG emissions reduction ambition. The additional share calculation should be based on cost-effectiveness and Gross Domestic Product (GDP) per MS.

This option builds on Article 23 (1) of RED II, maintaining the current framework under the recast Renewable Energy Directive, and aligning with the new CTP ambition:

- The article 23(1), with an 1.1% (or 1.3% by considering waste heat recovery) point annual average increase, remaining uniform for all MSs;
- An additional xx% point annual average increase specific per MS, to be set up under article 23, and precising MSs' share in an Annex, to be calculated based on cost-effectiveness and GDP per MS.

This option would require a method to calculate the gap to reach the EU target aligned with the CTP ambition (39% RES in H&C by 2030). This method should at least take into account the cost-effectiveness and the GDP of each MS, but could also possibly mirror the gap filler for the overall RES target from the Governance Regulation, as detailed in Annex II, determining MS specific RES target for the heating and cooling sector by 2030. This would probably require to take into account other objective criteria tailored to the H&C sector.

D.1 – Option 2: Increase the ambition for the annual average increase (binding uniform baseline & indicative MS-specific additional increase)

Under this option, the indicative targets under article 23 of the RED II would be revised in order to be in line with the more ambitious target of 40% RES share by 2030, by making the minimum uniform average share increase target binding for each MS and by including an additional indicative average share increase per MS to cover the increased GHG reduction ambition. The additional share calculation should be based on cost-effectiveness and GDP per MS.

This option builds on article 23 (1) of RED II, maintaining the current framework under the recast Renewable Energy Directive, and aligning with the new CTP ambition:

- The Article 23(1) would remain unchanged, but would become binding, imposing on each MS to reach the uniform average increase target of 1.1% and 1.3% for the periods 2021-2025 and 2026-2030 respectively;
- An indicative additional annual xx% point annual average increase specific per MS, would be set up under Article 23, and precising MSs share in an Annex, to be calculated based on cost-effectiveness and GDP per MS.

The calculation method to determine the additional share per MS would be the same as under option 1.

D.1 – Option 3: Increase the ambition for the annual average increase (binding uniform baseline & MS-specific additional increase)

Under this option, binding RES share average increase targets at MS level are introduced, by revising article 23(1) of the RED II in order to be in line with the more ambitious 39% EU H&C share (aligned with the 40% RES share). National binding average increase targets for the RES share in the H&C sector would be a specific numerical share for each MS, and replacing the article 23(1) indicative target. The target would be based on cost-effectiveness and GDP per MS.

This option builds on article 23 (1) of RED II, maintaining the current framework under the recast Renewable Energy Directive, and aligning with the new CTP ambition:

- A binding annual xx% point annual average increase specific per MS, referred to under the amended article 23(1), and precising MSs share in an Annex, to be calculated based on cost-effectiveness and GDP per MS.

The calculation method to determine the additional share per MS would be the same as under option 1.

D.1 – Option 4: indicative 39% EU H&C target

The previous measures above could be flanked with an indicative 39% EU H&C target to guide and monitor efforts.

D.1 – Measures variants

Variant 1 - Planned replacement schemes of heating appliances to facilitate fossil phase-out

Planned replacement programmes aim to anticipate the replacement of old appliances risking to collapse, or even to replace less efficient systems, and at the same time, to progressively phase out fossil-based systems. Planned replacement would target very old heating systems just before they break, while scrappage would focus on replacing inefficient heating systems, arguing each replacement could significantly increase the efficiency of the heating system.

This variant would imply updating the illustrative list of measures re-enforcing article 23(4), on top of the provisions addressing fossil phase out schemes:

- Suggesting MS to establish “renewable” planned replacement programmes, aiming at replacing old boilers (>25 years) by new efficient H&C systems based on renewables. These programmes could focus on different market segments according to the national priorities: fuel types; building locations; income level of households; ownership; level of energy performance; building age. These programmes should ideally be based on the comprehensive assessment of article 15(7), building on the knowledge of the H&C renewable potential;
- Recommending MS to plan the phasing out of fossil fuels systems by different market segments (e.g. via fuel types or building locations, types, ownerships, performance, renovation vs new builds, …);
- Recommending MS to promote the replacement of old and inefficient boilers when buildings are undergoing heavy renovation;
- Recommending that MS conduct comprehensive national heat plans, in close collaboration with the major (or all) municipalities to find optimal solutions on a local level, to integrate the planning of the replacement of fossil demand in a cost-effective way, comparing optimal new local systems;
- Establishing a plan to phase out fossil supply in all district heating and cooling, while increasing the energy efficiency (EE) of DHC.

Figure 2-2 illustrates which characteristics can be taken into account when designing such schemes, and that could be tackled in the RED provision(s).

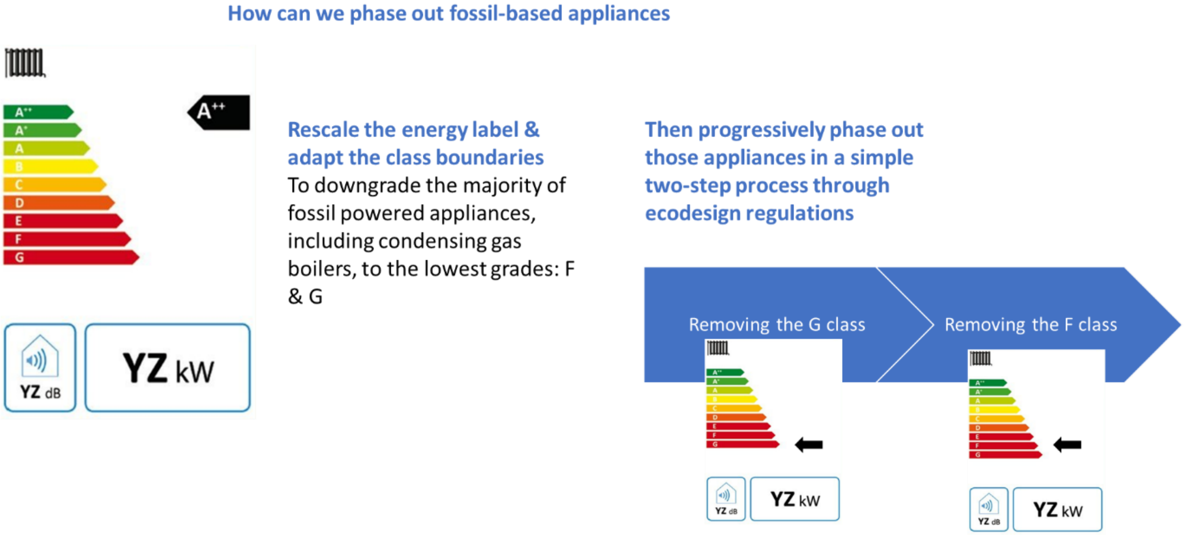
Figure 2-2 Design options for replacement schemes[317]

Design aspect	Options			
Differentiation by renewable technology	Single tariff across all technologies	Different tariff for certain groups of technologies	Separate tariff for each technology	
Differentiation by installation size	No tariff banding by installation size	Tariff banding by installation size, no tiering	Tariff branding by installation size, with tiering based on percentage output	No tariff banding, tiering based on absolute kWh output
Minimum energy efficiency criteria for participant eligibility	No tariff banding by installation size	Include min energy efficiency eligibility criteria		
		Linked to an existing EE accreditation system	Linked to new EE accreditation system	
Minimum criteria and/or tariff differentiation on biomass sustainability	No sustainability criteria beyond the min EU standards	Inclusion of sustainability criteria beyond min EU standards	Differentiation of tariffs for biomass tech based in the emissions	
Minimum criteria and/or tariff differentiation on particulate matter and nitrogen oxides emissions from biomass	No emissions criteria beyond the min EU standards	Inclusion of emissions criteria beyond the min EU standards	Differentiation of tariffs for biomass tech based on the emissions	
Eligibility criteria for biomass by location	No eligibility criteria based on the location of the installation for biomass tech	Inclusion of eligibility criteria based on the location of the installation for biomass tech		
Duration of support and profile of payments to scheme participants	Duration of support: i) 20 years (same as UK non-domestic RHI), ii) 15 years, iii) 7 years (same as UK Domestic RHI)			
	Profile of payments: i) on-going payments only – flat rate (same tariffs over duration of support), ii) on-going payments only – front loading (higher tariffs in the earlier years of support), iii)on-going payments and upfront grant			
Payment based on mattered or deemed heat use	Payment based on metered heat use for all installations	Payment based on deemed heat use for all installations	Payment based on metered heat use for large installations and on deemed heat use for small installations	
Systemic adjustment to tariff	No systemic adjustment of tariffs	Systematic adjustments of tariffs to reflect evaluation of key input costs over time	1 or 2 with no inclusion of budget management mechanisms	
			1 or 2 with the inclusion of budget management mechanisms – degression and/or budget cap	
Allowed rate of return	1.6% IRR	8% IRR	12% IRR	
Age of technologies being targeted for replacement	Target replacement of technologies at the end of lie only	Target replacement of technologies at the end of life or near the end of life	Target replacement of technologies not only at the end of life or near the end of life	
Implementation options (online/paper-based)	Online system with a paper option in exceptional circumstances	Online or paper options	1 or 2 , administered by CER	
			1 or 2 , administered by another third party	
Counterfactual heating systems targeted for replacement	Target replacement of all counterfactual technologies	Target replacement only certain counterfactual technologies		
Inclusion of the ETS sector	Exclude the ETS sector from the RHI scheme	Include the ETS sector in the RHI scheme		

A possible way to support the phase out of fossil-based heating appliances could be based on the rescaling of energy labels and the progressive phase out of class G and F appliances as illustrated in Figure 2-3.

[317] Own elaboration based on ElementEnergy and Frontier Economics (2017) Economic analysis for the Renewable Heat Incentive for Ireland.

Figure 2-3 Phasing out fossil-based appliances based on a strategy of recalling energy labels[318]



Textbox 2-1 Example of fossil based system phase out in new buildings [319]

> **The German government in its new Climate Action Programme 2030 has decided to ban the installation of oil-fired heating systems from the year 2026 in buildings where more climate friendly alternatives are available - opting out of an outright ban. To make this economically easier on consumers, a "swap-premium" for replacing old oil-fired heating systems will be introduced which repays up to 40% of the costs for a new and more efficient system.**

Banning fossil-fuel based systems

In addition to scrappage and planned replacement schemes covered above, fossil phase-out facilitation schemes could include banning the installation of fossil-fuel systems in specific situations, such as in the case of new buildings.

Allowing MSs to establish conditions under which the ban should apply is key to leave room to address particular situations (e.g. in rural areas, it may be very difficult to increase significantly the level of performance of some houses, and heat pumps may not be sufficient to supply the required level of comfort. Hybrids may then remain the only efficient option). However, leaving this door open to all MSs would require additional constraint to be applied, in order to avoid having 100% of the heating systems remaining fossil-based, even for very relevant reasons (e.g. ensuring the gas supplied to hybrid systems become renewable-based).

Given the many conditions linked to national/local parameters, banning instruments should remain the choice of MSs and not become mandatory. Such banning scheme would also be possibly contrary to the right for MSs to choose their H&C energy mix.

This whole variant would imply updating the illustrative list of measures re-enforcing article 23(4):

[318] Own elaboration based on CoolProducts for a cool planet. (2020). Five Years Left: How ecodesign and energy labelling can decarbonise heat. Available at: https://www.coolproducts.eu/wp-content/uploads/2020/12/Five-Years-Left-How-ecodesign-and-energy-labelling-Coolproducts-report.pdf

[319] Clean Energy Wire. (2020). Heating 40 million homes – the hurdles to phasing out fossil fuels in German basements. Available at: https://www.cleanenergywire.org/factsheets/heating-40-million-homes-hurdles-phasing-out-fossil-fuels-german-basements

- Requiring MSs to plan the phasing out of fossil fuels subsidies and support;
- Requiring MSs to plan the phasing out of heating and cooling appliances fuelled by fossil liquids, gases or solids. These planning could focus on market segments according to the national priorities: fuel types; building locations; income level for households; ownership; level of energy performance; building age. These planning should ideally be based on the comprehensive assessment of article 15(7) building on the knowledge of renewable potential. These planning should ideally be conducted in close collaboration with the major (or all) municipalities to find optimal solutions on a local level;
- Recommending that MSs introduce mandatory minimum shares of renewables for owners of heating system when the heating systems are replaced;
- Recommending that MSs establish plans to phase out fossil fuel supply in DHC, by increasing EE and RES in DHC.

Variant 2 - Consumer RES heat purchase agreements

This variant concerns supporting consumers to set up RES heat purchase agreements. In EU, as MSs are reducing or withdrawing subsidies for renewable energy, Corporate Power Purchase Agreements (PPAs) with a financially strong counterpart are an essential component for "banking" projects. In the heating sector, such corporate heat purchase agreements could apply in the following cases:

- Within a district heating network, where a renewable heat producer may be willing to sell its heat to a business. This could be closely linked to third party access to DHC networks;
- Renewable heat from renewable heat producers to be purchased by industry. Usually, third party financing or bilateral contracts are agreed between the producer and the customer;
- Renewable heat produced by a renewable heat producer to be purchase by a cooperative/ aggregation of heat demand from medium and small consumers (similar to the example of Test-Achat, Belgium, with the collective purchase of pellets[320]).

The variant considers adding renewable heat purchase agreements to the following articles (more or less mirroring the provisions addressing PPAs):

- Including a definition of ‘renewables heat purchase agreement’ under article 2 of RED II, mirroring article 2(17) defining ‘renewables power purchase agreement’ as “a contract under which a natural or legal person agrees to purchase renewable electricity directly from an electricity producer”;
- Article 15(8) of RED II to ensure MSs assess the regulatory and administrative barriers to long-term renewables heat purchase agreement and remove unjustified barriers to, and facilitate the uptake of such agreements. Ensuring MSs describe policies and measures facilitating the uptake of renewables heat purchase agreements in the revision of their integrated national energy and climate plans and progress reports pursuant to Regulation (EU) 2018/1999;
- Update the illustrative list of measures re-enforcing article 23(4):
    - setting up favourable frameworks to supply individual (and small scale) consumers via renewables heat purchase agreements, possibly through grouped (or bulk) purchase, to ensure price stability for heat consumers;
    - mirroring article 18(1) of the EED on energy services, promoting heat energy services market and facilitating its access for small and medium enterprises (SMEs) and households (grouped).

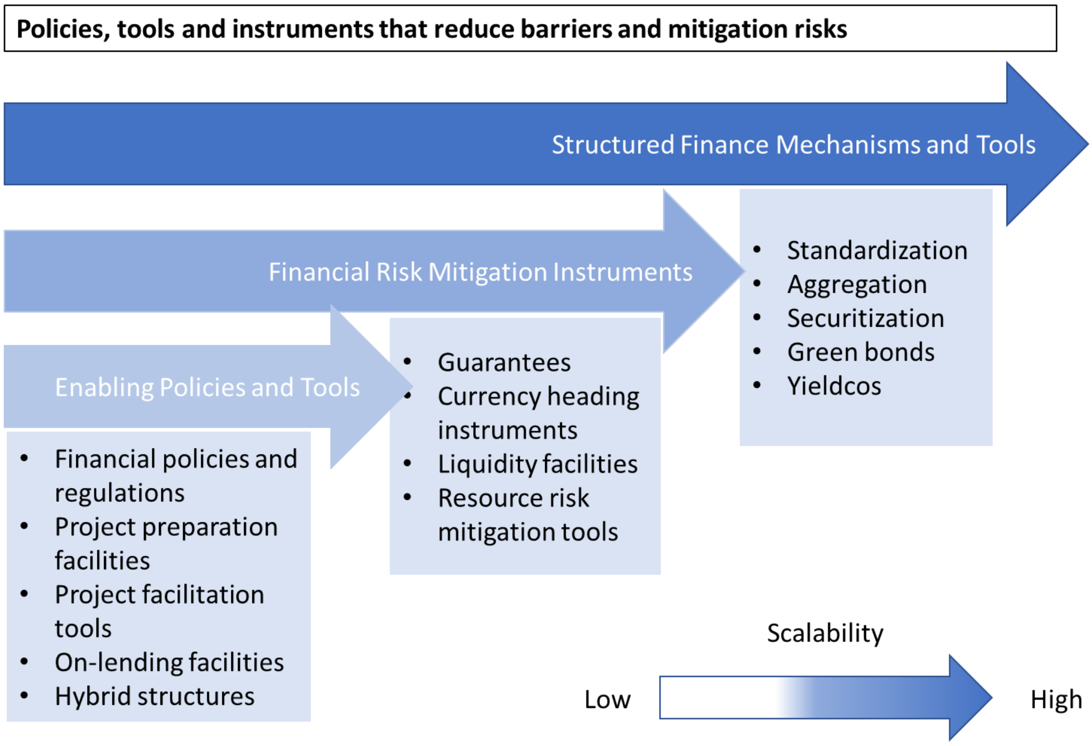
[320] Test-achats. (Accessed on 07/05/2021). Available at: https://www.test-achats.be/maison-energie/gaz-electricite-mazout-pellets

Variant 3 - Risk mitigation framework for RES heat supply projects (heat production and related infrastructure) with large upfront investment

Renewable H&C investment risks depend on various factors, linked to market forces (e.g. energy carrier supply price, amount of consumers in the case of a DHC), technology performance and efficiency (robustness, operations and maintenance, fuel and other consumable quality), less mature technology (higher risk, demonstration), financing, and environment (e.g. risk of not extracting the expected heat from a drilling). Adequate risk management insurance or risk mitigation instruments may support risk management and reduction of risks, in order to ease the access to lower cost of capital and unlock investments that may not occur otherwise (such as in the case of low income households). Some of these risks are also directly addressed through traditional financing instruments, which are able to cover them by providing additional insurance.

Figure 2-4 below provides an overview of key policy and financing mechanisms to address barriers and risk mitigation for renewable energy projects.

Figure 2-4 List of policies, tools and instruments to reduce barriers and mitigate risks for renewable energy projects. Source: IRENA(2016).[321]



A **coherent risk mitigation and financing strategy** should be established in line with a long-term H&C decarbonisation strategy (based on an assessment of the needs and existing framework) and should consider:

- Establishing an institutional framework that provides trusted knowledge on the viability of renewable-based projects;

[321] Own elaboration based on Henning Wuester, Joanne Jungmin Lee and Aleksi Lumijarvi. (2016). Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance, IRENA. Available at: https://www.irena.org/publications/2016/Jun/Unlocking-Renewable-Energy-Investment-The-role-of-risk-mitigation-and-structured-finance

- Setting up national financing instruments such as fiscal advantages, loan guarantees for private capital, loan guarantees to foster energy performance contracting, grants, subsidised loans and dedicated credit lines, third party financing systems;
- Strengthening the enabling framework comprising the enhanced use of Union funds, including additional funds to facilitate a Just Transition of carbon intensive regions towards increased shares of renewable energy;
- A framework for risk management insurance, covering investment risks;
- A risk mitigation framework. Risk Insurance Funds against the risks associated with geological energy already exist in some European countries (France, Germany, Iceland, The Netherlands, and Switzerland) and could be further considered.[322] Similar schemes could be considered for other purpose (like the construction of DHC).

Financial instruments can help mobilise upfront investment and reduce financing risk associated with long-pay-back time, lower the Weighted Average Cost of Capital (WACC) of investment in renewable energy projects and infrastructures. Similarly to the approach of energy renovation[323], providing dedicated financial solutions would decrease the overall investment cost required to meet the 2030 target, and could help renewable heating technologies to attain a level playing field, given that currently fossil solutions still largely dominate the heat market. Such financial instruments should support heating and cooling supply projects, such as, for example, developing geothermal energy and renewable district heating.

[322] EGEC (2017) “Funding schemes for Geothermal in Europe”, EGEC (2018) “EGEC Geothermal Market Report: Key Findings”
[323] According to consumers, architects and contractors/installers, in the frame of the Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU, Ipsos 2019

Textbox 2-2 Renewable heat support scheme in Ireland [324]

The scheme is designed to increase the energy generated from renewable sources in the heat sector by circa three percentage points. However, the scheme will be scaled in accordance with the funding available. It is designed to financially support the adoption of renewable heating systems by commercial, industrial, agricultural, district heating and other non-domestic heat users not covered by the ETS. It aims to bridge the gap between the installation and operating costs of renewable heating systems and the conventional fossil fuel alternatives.

Based on the economic analysis carried out, the scheme will support projects through one the following support mechanisms:

- An operational support based on useable heat output in renewable heating systems in new installations or installations that currently use a fossil fuel heating system and convert to using the following technologies:
  - biomass heating systems;
  - anaerobic digestion heating systems.
- An installation grant to support investment in renewable heating systems that use the following technologies:
  - air source heat pumps;
  - ground source heat pumps; and
  - water source heat pumps

Other technologies and methods of support continue to be under consideration for subsequent phases of the scheme.

The design of the variant could take the form of:

- Adding a provision to Article 18 of RED on information and training inspired by but expanding on article 17(1, para 2) of EED on information and training, mandating MS to encourage setting up risk mitigation instruments for the financing of heating and cooling renewable investments. These risk mitigation instruments should especially tackle specific risks not under the control of the investor/operator such as natural risks to cover highly capital intensive investments (e.g. geothermal deep wells exploration to cover the risk of not finding the resource; district heating and cooling where a long term risk exist regarding resource availability or even heat demand);
- Such provision could also be added in Article 23(4), to address only heating and cooling purpose;
- Creating the basics for a financial instruments framework, requiring adding provisions under Article 23 of RED II on heating and cooling:
  - Ensuring the provision of information to banks and other financial institutions in the financing of heating and cooling renewable investments, tackling all specific risks (similar to Article 17(1.2) of EED on information and training). This could also come under Article 18 of RED on information and training;
  - Disseminating clear and easily accessible information on financial instruments, incentives, grants, loans to support the uptake of renewable heat/cold fuels;
  - Facilitating the establishment of financing facilities, or use of existing ones, for renewable heating and cooling systems to maximise the benefits of multiple streams of financing;
  - Developing innovative financing mechanisms to facilitate access to reliable financing means to renewable H&C systems investors.

[324] Irish Department of the environment, Climate and Communications. (2019). Support Scheme for Renewable Heat (SSRH). Available at: https://www.gov.ie/en/publication/8b810d-support-scheme-for-renewable-heat/

Variant 4 – Planning and implementation of renewable and waste heat & cold deployment projects and infrastructure in heating and cooling, specifically Articles 15(3)

This option would comprise the revision of article 15(3) to plan and implement renewable deployment projects and infrastructure in heating and cooling. Article 15(3) currently requires competent authorities at national, regional and local level to include provisions for the integration and deployment of renewable energy, and the use of unavoidable waste heat and cold when planning. This includes spatial planning, designing, building and renovating:

- urban infrastructure;
- industrial, commercial or residential areas;
- energy infrastructure (electricity, DHC, gas and alternative fuel networks).

Local and regional administrative bodies would be encouraged to include heating and cooling from renewable sources in the planning of city infrastructure, and to consult the network operators on their infrastructure development plans (to address demand response programs, renewables self-consumption and renewable energy communities). Further, guidance may target local authorities, supporting them to prepare strategies for heating and cooling, and to provide tools to guide their population to the uptake of the new systems (e.g. cost comparison websites).

Article 15(3) would be expanded to provide more detail on how to involve regional and municipal authorities in the coordinated infrastructure planning to address:

- Establishment of comprehensive national heat planning in close collaboration with the major (or all) municipalities to find optimal solutions on a local level, which are consistent with overall national and European goals, comparing optimal new local systems and planning the replacement of fossil demand in a cost-effective way. This would reflect article 14 of EED (see below) on the comprehensive assessment [and is addressed under option 2];
- Establishment of local (regional, municipal) plans for the decarbonization of H&C, starting by assessing the local potential (incl. renewable sources, DHC), enabling coordination with the national level, and setting up actions. This would reflect article 2.a of the EPBD [and is addressed under option 2];
- Recommending that local authorities be responsible for their H&C decarbonisation planning and providing those authorities the required resource capacity;
- Supporting the in-depth design and comparison of optimal new local systems, through a holistic assessment of energy supply options, to be decided by local authorities and disclosed for enhanced transparency.

This variant could also be expanded by setting up a framework for planning capacity to increase RES share in DHC, which would reinforce the capacity of local and national actors through instruments such as:

- Obliging municipalities and local authorities to provide information on urban planning related issues to project developers;
- Obliging municipalities and local authorities to assess the opportunity to develop a DHC when they carry out heavy works and open the roads. Publication should be required;
- Obliging municipalities, local authorities and other infrastructure operators to support DHC operators integrating RES in their DHC, starting by assessing local RES potential (e.g. providing information on geothermal resources, providing electricity grid information and guidance to develop large heat pumps, assessing the biomass potential, …).

These instruments would require an additional provision or paragraph to article 24, with a set of policy measures that MSs may implement to support building capacity for national and local actors for heat mapping, energy planning and project development.

D2 - Accelerate the share of renewables in District H&C

The objective of assessing the nature of RES H&C targets in DHC is to propose the most appropriate DHC target and its nature (binding/indicative) to ensure attainment of the overall 55% GHG emission target as stipulated in the CTP. It also aims to identify the most appropriate measures to support MSs in achieving the RES DHC targets in the most cost-effective, socially-just and environmentally conscious way possible.

Table 2-2 Summary of options assessed

Options	Description
Option 0	No changes, maintain current policies under RED II
Option 1	Indicative EU renewable target for RES in DHC and increase the indicative 1%-point increase target
Option 2	Indicative MS renewable target for RES in DHC and increase the indicative 1%-point increase target
Option 3	Increase the 1%-point target in DHC variant 1 : **Eliminate exceptions** and make access to networks mandatory for renewables and other carbon-neutral sources (waste heat), including from prosumers, in large DHC networks
Measures variants	Enhanced coordination and common market operation of DHC systems with electricity distribution (DSO) and transmission system operators (TSO) for flexibility services, demand response and related investment in infrastructure and generation assets; Enhanced coordination and common market operation of DHC systems with gas distribution system operators, hydrogen and other energy networks - in addition to with electricity operators. Requirement to include specific RES share and a numerical energy performance number (PEF) in the information district heating/cooling systems provide to consumer (e.g. on bills, suppliers/regulators' websites) Energy label (voluntary or mandatory) for DHC systems

The requirements on promotion of renewables integration in the district heating and infrastructure (article 24) would be strengthened by increasing the performance and other requirements, also supporting EPBD & RES Directives implementation.

Modern, renewable-based, efficient district heating can operate on multiple energy sources and heat generation technologies, thus being capable of collecting and distributing renewables and other carbon-neutral sources (such as waste heat) from a wider area. By combining these sources and technologies, if needed, they can satisfy the full demand of buildings even in large cities. Modern low-temperature systems can use all types of renewables and waste heat effectively, while also reducing distribution losses and increasing generation efficiency. These systems are fully compatible and require low-temperature, i.e. efficient, buildings, and the sufficient expansion of efficient, low-temperature building stocks is a key driver for such systems to develop. Investment in the decarbonisation of heat supply must be closely coordinated with refurbishment programs. This is addressed under the planning options.

As district heating and cooling systems offer the main viable instruments to decarbonise heating and cooling and integrate renewables at large scale to heating systems, it is essential to promote their development.

The energy performance of DHC and the share of renewable energy in DHC are at the core of article 24, requiring:

- information to final consumers (art 24(1));
- allowing disconnection when efficiency[325] is not met (art 24(2)) under specific conditions concerning planned performance (art 24(3));
- increasing the share of RES (incl. waste H&C) in DHC by at least 1% by implementing measures or ensuring DHC operators are obliged to connect to suppliers of RES (incl. waste H&C) and purchase their H&C (art 24(4));
- the possibility to refuse a connection under conditions (art 24(5));
- the possibility to exempt DHC operators of the obligation to connect for efficient systems (art 24(6));
- giving the right to disconnect to customers (art 24(7));
- electricity DSO to assess in cooperation with DHC operators the potential to provide balancing and system services (art 24(8));
- clear definition and enforcements on the rights of consumers and the rules for operating DHC (art 24(9));
- the possibility to not apply all previous provisions when DHC represents less than 2% of overall H&C consumption (art 24(10)).

D2 - Option 0: Baseline

The RED II requirements for RES in DHC would remain the same. This option supports the alignment of the definition of 'efficient heating and cooling' under EED, which is also used within RED II. A new definition (ongoing) should ensure alignment with the Green Deal carbon neutrality goal and CTP 55%.

The revision of the definition of efficient DHC (art 2(41)[326] of EED) is expected under EED assessment. A new definition would be more aligned with the notion of efficiency and the EU carbon-neutrality rules. The share of renewables is an important pillar of DHC decarbonisation and needs to be strengthened. Under the current definition, DHC could still be considered efficient, if there is at least 50% CHP, even if they run on 100% fossil fuels (coal, oil, gas).

In accordance with article 24(4a) RED II, MSs should increase the annual share of energy from renewable sources and from waste heat and cold in district heating and cooling by at least 1% point counting for the periods 2021 to 2025 and 2026 to 2030, starting from the share in 2020. If the share in 2020 is above 60%, the MS may count any such share as fulfilling the average annual increase.

MSs may decide not to apply article 24(4a) if they fulfil the criteria defined in article 24(10) (point a, b or c) of RED II.

[325] Article 2(41) EED defines an 'efficient district heating and cooling' as a district heating or cooling system using at least 50% renewable energy, 50% waste heat, 75% cogenerated heat or 50% of a combination of such energy and heat
[326] Ibid.

D2 - Option 1: Indicative EU renewable target for RES in DHC

This option includes an indicative EU renewable target for renewables' share in DHC, and the increase of the indicative 1%-point increase target:

- a new indicative EU RES share target in DHC should be included under article 24, should be established in order to align with the CTP ambition, and on the expectations of DHC to increase the global share of RES in the H&C by up to 39% by 2030;
- MSs should take the necessary measures to ensure that district heating and cooling systems endeavour to increase the share of energy from renewable sources and from waste heat and cold by a percentage as an annual average which allows the global EU RES share in DHC to reach the target as set out above (amend RED II article 24(4)).

D2 - Option 2: Indicative MS renewable target for RES in DHC

This option includes an indicative MSs renewable target for renewables' share in DHC, and the increase of the indicative 1%-point increase target:

- a new indicative MS RES share target in DHC should be included under article 24, and MS-specific share should be determined under an annex. A formula to calculate these MS-specific target share will probably be necessary, ensuring alignment with the CTP ambition, and on the expectations of DHC to increase globally the share of RES in the H&C up to 39% by 2030. Such formula should ideally take into account cost-effectiveness, MSs' GDP, but also the state of DHC, and the resource to switch to renewable supply;
- MSs should take the necessary measures to ensure that district heating and cooling systems endeavour to increase the share of energy from renewable sources and from waste heat and cold in DHC by a percentage as an annual average increase deduced from each MS-specific RES share in DHC as set out above (amend RED II article 24(4)).

D2 - Option 3: Increase the 1%-point target in DHC

With this option, MSs should take the necessary measures to ensure that district heating and cooling systems endeavour to increase the share of energy from renewable sources and from waste heat and cold in district heating and cooling by an annual average to align with the CTP ambition, and on the expectations of DHC to increase globally the share of RES in the H&C up to 39% by 2030.

Variant 1 - Eliminate exceptions and make access to networks mandatory for renewables and other carbon-neutral heat (wate heat), including from prosumers

In this variant, RES integration in DHC would be strengthened, by:

- Making the provision obliging operators of DHC to connect suppliers of RES (article 24(4.b)) mandatory, and in a separate article (not as an alternative to the target under 24(4.a), but as a complementary requirement);
- Mandating DHC operators to act as single buyer, and to purchase H&C from RES from third parties (same article 24(4.b));
- **Enhancing RES access for large and small scale systems**, by excluding large district heating and cooling systems from the condition to allow DHC operators to refuse to connect and to purchase heat or cold from a third party supplier under article 24(5).

D2 – Measures variants

Variant 1 - Enhanced coordination and common market operation of DHC systems with electricity distribution (DSO) and transmission system operators (TSO) for flexibility services, demand response and related investment in infrastructure and generation assets

Coordination and common market operation of DHC systems with electricity network operators for flexibility services and related investment would be enhanced, by strengthening Article 24(8) of RED II for system integration. In addition to requiring electricity DSO to assess at least every four years the potential for district heating or cooling systems (current article 24(8) of RED II), MS would require:

- electricity DSO to collaborate upon request with any DHC system developer or operator where gas and electricity infrastructure are essential for energy system integration;
- electricity DSO to make the assessment of its flexibility or local storage and grid reinforcement needs available upon request by DHC operators.

Variant 2 - Enhanced coordination and common market operation of DHC systems with gas distribution system operators, hydrogen and other energy networks

This variant would enhance coordination and common market operation of DHC systems with gas & electricity DSO (of methane and hydrogen networks) for coordinated and integrated planning while considering concrete uptake of renewables in all infrastructure investments (in order to avoid lock-in effect when those can be easily avoided, or to plan grid reinforcement where required, to connect a large scale heat pump as example). It would add a provision to article 24 of RED II.

In addition to requiring electricity DSO to assess at least every four years the potential for district heating or cooling systems (current article 24(8) of RED II), MS would require:
electricity and gas network DSOs to consult local authorities and energy planners on their heating and cooling decarbonisation planning, before they prepare their own infrastructure planning, in order to adapt and comply with decarbonisation targets;
electricity and gas DSO to collaborate upon request with any DHC system developer or operator where gas and electricity infrastructure are essential for energy system integration.

Variant 3 - Requirement to include specific RES share and a numerical energy performance number (PEF) in the information district heating/cooling systems provide to consumer (e.g. on bills, suppliers/regulators' websites)

According to article 24(1) of RED II, MSs should ensure that information on the energy performance and the share of renewable energy in their district heating and cooling systems is provided to final consumers in an easily accessible manner, such as on the suppliers' websites, on annual bills or upon request. MSs should ensure that both the information about the renewable share of district heating supply and the efficiency of the systems are communicated to customers.[327]

Article 24(3) of RED II clarifies that the energy performance assessment of the alternative supply solution may be based on the energy performance certificate, where a significantly better energy performance of a planned alternative supply solution compared to the DHC has to be demonstrated, in order to be granted the right to disconnect. This is the only reference of the energy performance certificate, although it should be used more broadly, and ideally becoming mandatory.

[327] Aalborg University. (2019). Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy. Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

The review of the definition of efficient heating and cooling under the EED is an important complement to the review of the district heating and cooling provisions in article 24, as it specifies the conditions for exemptions on disconnection, network access and the indicative annual average RES increase requirement. To consider the energy efficiency value chain or the energy losses in the system, the distinction between supply and efficiency should be maintained.

This option would extend the existing provision under article 24(1) regarding information to final consumers by:

- elaborating on the information that would need to be disclosed in a clearer way such as requiring to establish and publish the RES share in the DHC system and the energy performance, which will cover both energy efficiency and renewable share, and the level of losses while ensuring coherence and alignment with the relevant billing and metering articles in EED;
- elaborating on the information to be disclosed regarding the type and quantity of renewable sources, including waste heat recovered, and possibly the global level of performance (and temperature level);
- using the voluntary energy label for DHC systems to disclose these information.

Variant 4 - Energy label (voluntary or mandatory) for DHC systems

This variant would establish provisions for a voluntary or mandatory **labelling scheme** for the performance of district heating and cooling systems based on three criteria: energy efficiency, renewable energy use and CO_2 emissions.[328]

This variant would imply completing with the provision under article 24(1):

- requiring MS to ensure that a labelling scheme is made available for district heating and cooling operators, providing detailed information regarding the energy efficiency of the DHC system, the use and share of renewable energy sources (including the concerned technologies, efficiencies and carbon emissions), the total emissions of the energy supplied. Such labelling should be used to disclose the energy and carbon performance of the overall DHC system, especially for the purpose of customers willing to disconnect, but not only. The label should be made available in a transparent way, at any time, also allowing to compare with other DHC systems;
- as sub-variant, this label should be made mandatory, requiring every DHC system to state its label's information.

Discarded options

Accompanying measures for renewable heating and cooling that have been discarded are:

- Financial and support;
- Scrappage;
- Obligation schemes;
- Building and industry targets, which are addressed in annexes F and G respectively.

Accompanying measures for RES in DHC that have been discarded are:

- Reinforced role of national authorities;
- Capacity building;
- Customer's right;

[328] Ecoheat4cities developed a voluntary labelling tool for district heating and cooling (DHC) schemes to encourage communities to make green choices, available at https://www.euroheat.org/our-projects/ecoheat4cities/

- Mandatory target.

Mapping of potential impacts

Target related impacts

For the identification of impacts of the options for a H&C RES target, it is important to clarify that not setting a H&C RES target would not entail a reduced burden on the EU and its MSs to reach the GHG target and overall RES target. Hence, if no H&C RES ambition would be defined and agreed on, other policies and instruments would have to take over and fill the gaps. So for the analysis of impacts we look at the absolute impact of increasing RES deployment in H&C via a binding/indicative target, also for DHC, link the impacts to those of policies and instruments, compare to the impacts of other instruments such as carbon pricing, and assess the coherence with other legislations such as EPBD, or the EED. With that in mind, the following impacts are considered most relevant for the assessment:

11. Cost-effectiveness: What is the cost-effectiveness of a H&C RES target, of a RES DHC target versus other policy instruments to reduce GHG emissions or deploy renewable (including an overarching target for renewable)? With a higher ambition, in line with the CTP? What is the cost-effectiveness of the proposed instruments, for the H&C or for DHC?
12. Investor certainty: What is the effect on investor certainty of a H&C RES target, of a RES DHC target? How does that compare to other instruments? How are the proposed instruments addressing investor certainty? To what extent does the market already provide sufficient investor certainty for H&C renewables, including in DHC?
13. Macroeconomic impacts: What are the macroeconomic impacts of increased H&C RES deployment, via a target or dedicated instruments? How are investment and jobs affected?
14. Security of supply: What are the impacts of increased H&C RES deployment on import dependency?
15. Innovation: What is the impact of increased H&C RES deployment on innovation in the EU? How are the proposed instruments supporting innovation?
16. Distributional impacts: Who takes most of the burden for enhanced RES in H&C? How do the impacts differ across countries and income classes? What are the possible mitigation measures?
17. GHG emission reductions: How effective will the option and the instruments (variants) be in realising increased H&C RES deployment?
18. Administrative burden: What are the implications for the burden on EU and policy makers of MSs? Are additional NECP updates required?
19. Compliance cost: What are the implications for the concerned market actors?
20. Political feasibility: To what extent is it expected that the options would reach a political agreement? Should any option be discarded a priori due to lack of political feasibility?
21. Coherence: How effective are the measures in addressing an ambition gap between EU and MS targets and policies? How are the proposed targets and instruments coherent and linked to other legislative frameworks, such as the EPBD, EED?

Measures related impacts

This section presents an overview of the potential economic, environmental and social impacts identified for the different policy options to be assessed, summarising the following criteria as follows:

- **Direction:** Positive or negative;
- **Magnitude:** limited or significant;

- **Horizon:** Short to long term;
- **Affected parties:** following categorization indicated below.

Option D1 - Nature & level of the RES H&C target(s) & accompanying measures (variants)

Table 2-3 Impacts mapping for option D1 - Nature of the RES H&C target (binding/indicative)

Option D1	Economic	Environmental	Social
Option 0 (baseline)	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A
Option 1 (Increase the ambition for the annual average increase (indicative uniform baseline & MS-specific additional increase))	D: neutral M: medium H: short term A: national & local authorities, DHC operators, planners, heat suppliers	D: positive M: medium H: short term A: national & local authorities	D: positive M: medium H: short term A: national & local authorities, consumers (with focus on vulnerable)
Option 2 (Increase the ambition for the annual average increase (binding uniform baseline & indicative MS-specific additional increase))	D: negative M: limited H: medium term A: MSs	D: positive M: limited H: medium term A: MSs	D: positive M: limited H: medium term A: national & local authorities, consumers (with focus on vulnerable)
Option 3 (Increase the ambition for the annual average increase (binding uniform baseline & MS-specific additional increase))	D: negative M: medium H: medium term A: MSs	D: positive M: significant H: medium term A: MSs	D: positive M: medium H: medium term A: consumers, DHC operators
Option 4 (The measures above could be flanked with an indicative 39% EU H&C target to guide and monitor efforts)	D: negative M: medium H: medium term A: MSs	D: positive M: significant H: medium term A: MSs	D: positive M: medium H: medium term A: consumers (indirectly)
Variant 1 (Planned replacement schemes of heating appliances to facilitate fossil phase-out)	D: positive M: significant H: long term A: building owners and occupiers, energy suppliers, local authorities, construction industry	D: positive M: significant H: long term A: building owners and occupiers, energy suppliers	D: positive M: significant H: long term A: building owners and occupiers, energy suppliers
Variant 2 (Consumer RES heat purchase agreements)	D: positive M: very limited H: short term A: building owners and occupiers, energy suppliers producers, DHC operators	D: positive M: very limited H: short term A: building owners and occupiers, energy suppliers producers, DHC operators	D: positive M: very limited H: short term A: building owners and occupiers,
Variant 3 (Risk mitigation framework for RES heat supply)	D: positive M: medium H: long term A: building owners and occupiers, energy suppliers & producers, DHC operators, local authorities, DSOs	D: positive M: medium H: long term A: building owners and occupiers, energy suppliers & producers, DHC operators, local authorities, DSOs	D: positive M: medium H: N/A A: N/A
Variant 4 (Planning and implementation of renewable and waste heat & cold deployment projects and infrastructure in heating and cooling)	D: negative M: very limited H: long term A: MSs and local authorities	D: positive M: significant H: long term A: DHC operators, consumers, heat suppliers, MSs and local authorities	D: positive M: significant H: long term A: DHC operators, consumers (incl. vulnerable), heat suppliers, MSs and local authorities

Option D2 - Accelerate the share of renewables in District H&C - DHC targets (options 1 to 3) & accompanying measures (variants)

Table 2-4 Impacts mapping for D2 - Accelerate the share of renewables in District H&C

Option D2 – impacts map	economic	environmental	social
Option 0 (baseline)	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A
Option 1 (Indicative EU renewable target for RES in DHC and increase the indicative 1%-point increase target)	D: negative M: limited H: short term A: national & local authorities, DHC operators, planners, heat suppliers	D: positive M: medium H: short term A: national & local authorities	D: positive M: medium H: short term A: national & local authorities, consumers (with focus on vulnerable), manufacturers RES techs
Option 2 (Indicative MS renewable target for RES in DHC and increase the indicative 1%-point increase target)	D: negative M: medium H: short term A: national & local authorities, heat suppliers, DHC operators,	D: positive M: significant H: short term A: DHC operators, national and local authorities	D: positive M: significant H: long term A: national & local authorities, consumers (with focus on vulnerable), manufacturers RES techs
Option 3 (Increase the 1%-point target in DHC)	D: negative M: limited H: short term A: national & local authorities, DHC operators, planners, heat suppliers	D: positive M: medium H: short term A: national and local authorities	D: positive M: medium H: short term A: national & local authorities, consumers (with focus on vulnerable), manufacturers RES techs
Option 3.variant 1 (Eliminate exceptions and make access to networks mandatory for renewables and other carbon-neutral sources (waste heat), including from prosumers, in large DHC networks)	D: negative M: medium H: long term A: heat suppliers, DHC operators	D: positive M: significant H: long term A: national and local authorities	D: positive M: medium H: long term A: national & local authorities, consumers (with focus on vulnerable)
Variant 3 (Requirement to include specific RES share and a numerical energy performance number (PEF) in the information district heating/cooling systems provide to consumer)	D: positive M: significant H: long term A: consumers, DHC operators	D: positive M: significant H: long term A: consumers, DHC operators	D: positive M: significant H: long term A: consumers, DHC operators
Variant 1 (Enhanced coordination and common market operation of DHC systems with electricity DSO & TSO)	D: positive M: significant H: long term A: DHC operators, elec DSOs, local authorities, heat producers & suppliers	D: positive M: significant H: long term A: DHC operators, elec DSOs, local authorities, heat producers & suppliers	D: positive M: medium H: long term A: consumers (indirectly), heat producers & suppliers
Variant 2 (Enhanced coordination and common market operation of DHC systems with gas distribution system operators, hydrogen and other energy networks)	D: positive M: limited H: long term A: DHC operators, gas DSOs, local authorities, heat producers & suppliers	D: positive M: significant H: long term A: DHC operators, gas DSOs, local authorities, heat producers & suppliers	D: positive M: medium H: long term A: consumers (indirectly), , heat producers & suppliers
Variant 4 (Energy label (voluntary or mandatory) for DHC systems)	D: positive M: limited H: long term A: consumers, DHC operators, heat producers & suppliers	D: positive M: significant H: long term A: consumers, DHC operators, heat producers & suppliers	D: positive M: significant H: long term A: consumers, DHC operators, heat producers & suppliers

Analysis

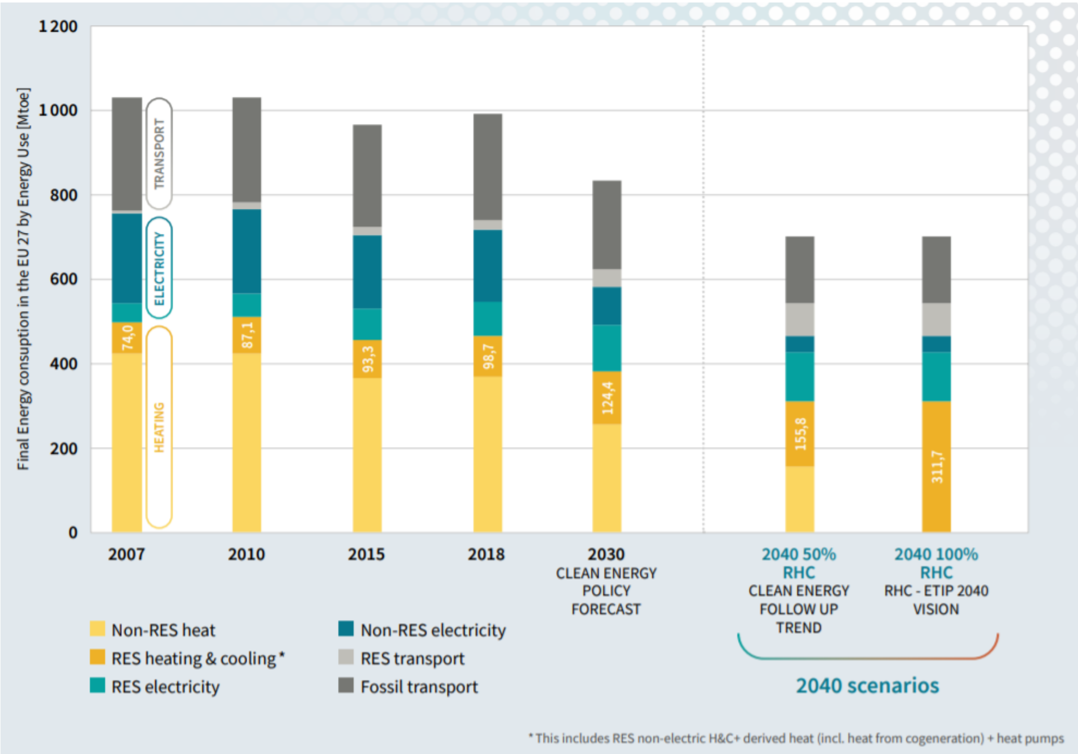
The assessment of impacts in this chapter and the next chapter will discuss each group separately.

Semi-quantitative and qualitative assessment

D1 - Nature & level of the RES H&C target(s)

The recast RED, with the EED and the EPBD, specify that renewables should cover a minimum share of 32% of total energy consumption by 2030, with 40% of the total target expected to come from the H&C sector. The Directives recognises that H&C plays a key role in accelerating the decarbonisation of the energy system. With the new GHG emission reduction target of 55%, the renewable target could become 38.5%, which would also increase the H&C target to 39% of the new, higher overall renewable target. Combined with energy efficiency, which brings an important reduction of energy use, especially in H&C, a significant increase of the share of renewables in the heating and cooling is feasible, as illustrated by Figure 3-1, under the Clean Energy Policy scenario suggested by the Renewable Heating and Cooling Platform.

Figure 3-1 Final energy consumption in the EU 27 by energy use. Source: RHC ETIP (2020)[329]



Addressing the opportunity of an increased and binding RES H&C target should be carried out based on the analysis of the NECPs, including the national commitment to increase the share of RES in H&C, the identification of the barriers, and the measures taken to achieve the target.

National Energy and Climate Plans describe policies and measures to achieve the EU's 2030 energy and climate targets, regarding GHG emissions reduction target (as established by the ESR, for the non-ETS

[329] Renewable Heating & Cooling, European Technology and Innovation Platform. (2020). Strategic Research and Innovation Agenda for Climate-Neutral Heating and Cooling in Europe. Available at: https://www.rhc-platform.org/content/uploads/2020/10/RHC-ETIP-SRIA-2020-WEB.pdf

sectors, binding at MS level), the renewable target (binding at EU level) and the energy efficiency target (binding at EU level). In their NECPs, MSs addressed the heating and cooling sector through their commitment (fixing a 2030 target, and a trajectory), the identification of barriers, and the measures taken to reach both energy efficiency and renewable energy targets. The H&C addresses energy efficiency and RES in one global and integrated framework.

In 2018, according to the NECP assessment, the final energy consumption for heating and cooling represented about 46% of the total final energy consumption in EU27[330], while the renewable energy share in the heating and cooling sector amounted to 21% in 2018 in EU27 (1% point above the overall EU RES target).[331]

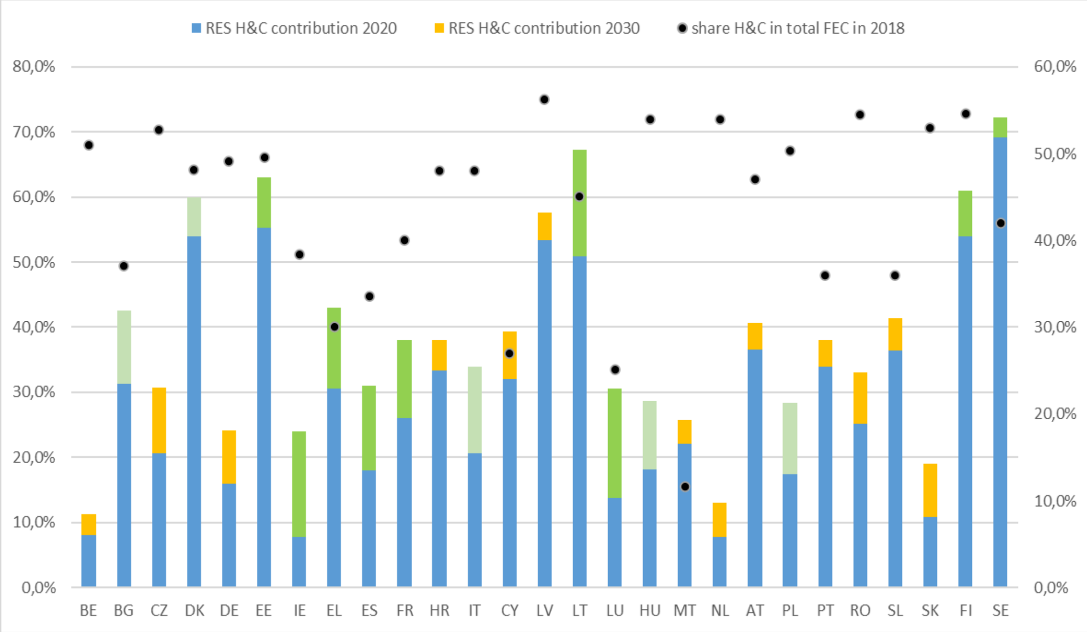
The addition of the individual targets of all MS targets, based on the NECPs' additional measures (WAM scenarios in NECPs), shows a decrease of more than 10% in the final energy consumption for H&C from 2020 to 2030 in EU27. In these scenarios, the share of RES is expected to increase in all MSs and reach 33% in 2030 (1% point above the overall EU RES target).

Although MS demonstrated significant efforts to decarbonise the H&C sector, there were still many aspects that were not properly incorporated by all MS. It was often stated that some information would be provided later, waiting for the respective analyses or plans covered under other frameworks, such as the long-term strategy for renovations of buildings, or the potential for efficient district heating and cooling. It should also be pointed out that the elaboration of these NECPs, closely following the negotiation of the winter package (with 8 legislative texts), was the first fully integrated exercise encompassing all energy and climate related actions and sectors (except the ETS industrial processes[332]).

The current share of RES in the H&C sector, as well as the ambition to increase it over the period 2020-2030, varies considerably between the MSs, as illustrated by Figure 3-2.

[330] Calculation based on the Shares Tool (Eurostat Statistics)
[331] JRC. (2020). Assessment of heating and cooling related chapters of the National Energy and Climate Plans
[332] The power sector (also in the ETS), is addressed for the production of renewable.

Figure 3-2 Shares of RES in H&C in all MS in 2020 & in 2030 + share of H&C in final energy consumption. JRC (2020)[333]



In Figure 3-2, the blue bars show the huge variations between MSs regarding their share of renewable energy as expected for 2020. In 2020, six MSs were expected to have a share of RES in H&C above 50%, while three MSs would have a share below 10%. In 2030, only nine MSs are expected to meet the target of 1.3%-point annual increase of renewables in the H&C sector established in article 23(4) of RED II (dark green). Four additional MSs meet partially the target (light green), on either the 2021-2025 or the 2026-2030 period, and the 14 remaining MSs do not meet the target (orange bars). Only a few countries provided details about the constraints responsible for not meeting the objectives.

The black dots (Y-axis on the right side in Figure 3-2), show the differences between MSs regarding the weight of H&C in the total final energy consumption in 2018. For 21 MSs, this share is above 40% (few variance around the 46% average), emphasizing the importance of the H&C sector in the total energy system (and its impact on carbon emissions), which decarbonization should be considered as a priority.

Projections for heat supply from district heating and cooling were often not provided. An increased use is foreseen in three countries and declining trends are expected in six countries, due mainly to efficiency improvements of the building stock and of district heating networks. This missed opportunity to consider DHC as a cost-efficient way to deploy renewable at scale, can probably be partly explained by the fact that the upcoming Comprehensive Assessments in the EED (art 14(1)) and RED II (art 15(7)) are linked to one assessment and had only to be delivered by the 31st of December 2020.

Under the EED, MSs must assess the potentials for efficient district heating and cooling (including small-scale household projects), high-efficiency cogeneration and efficient individual heating technologies focusing on energy efficiency rather than the fuel mix. Under the RED II, MSs must assess the potential of renewable and waste heat/cold sources for heating and cooling.

[333] JRC. (2020). Assessment of heating and cooling related chapters of the National Energy and Climate Plans.

With these Assessments still ongoing at the time of the NECP submission, it was probably more complicated for all MS to establish their renewable target for the heating and cooling sector without a clear view on their potentials (including waste heat, but also district heating and cooling). Therefore, some iteration may be necessary to establish targets based on potential assessments.

The recovery of waste heat should also be considered in DHC, but none of the NECP detailed the contribution of waste heat for the future (article 24 of RED II). Only France, which had already set up a support scheme[334] to promote the use of renewables and waste heat, has mentioned its intention to make use of that resource. In addition, measures for greater use of waste heat were presented by seven MSs.

According to the JRC's assessment of NECPs, policies and measures in the heating and cooling sector were often incomplete and described without a clear link to the expected impacts in energy or carbon emission savings due to more energy efficiency and the deployment of renewables. Iteration to enhance the quality of the NECPs in terms of compliance with the Governance Regulation and the targets of RED II and EED, is required. Support is probably required to enhance their planning and provide clear directions and transparent integration with the long-term objectives on renewable energy and energy efficiency. Investment requirements were not exhaustively assessed in all MSs, addressing building renovation, centralized energy supply and modernisation or installation of renewable decentralised heating systems (mainly heat pumps). The sources of financing were mostly not provided.

This section evaluates the options for making the H&C RES target(s) binding by comparing them to the most relevant alternative policy instruments, by assessing the policy that would best make up for the lack of progress in H&C RES deployment:

3. The **Emission Trading System** intending to reduce emissions by putting a price on emissions in the heavy industries (and possibly extending its potential extension to buildings and transport). The ETS, as a market instrument, is expected to promote the most cost effective solutions and technologies to support industrial plants to reduce their direct emissions (scope 1 & 2);
4. The potential revision of the **Energy Taxation Directive**, which aim would be to reduce emissions by putting a price on emissions for the non-ETS sectors (buildings, transport and non-ETS industry, agriculture, waste). A carbon price is expected to re-establish the level playing field for low carbon fuels and technologies, incentivising renewable fuels;
5. **Energy efficiency instruments** that aim to reduce emissions by reducing energy consumption, including the EED and the EPBD;
6. The **EPBD**, with the aim to reduce energy consumption and carbon emissions of the building stock, through several instruments like the Long Term Renovation Strategies, the Energy Performance Certificate of buildings or the energy building passports;
7. The **EED** with the aim to globally reduce energy consumption, by promoting efficient investments and measures.

Cost-effectiveness

As a market instrument, the EU ETS results intrinsically in cost-optimal emission reductions. Hence, pushing for emission reductions through specific measures such as binding RES deployment will be less cost-effective as long as the carbon price is not high enough to enable H&C RES to become competitive in the industry. The same applies to the ETD, for the building sector.

[334] Le fonds chaleur. Available at: https://www.ademe.fr/expertises/energies-renouvelables-enr-production-reseaux-stockage/passer-a-laction/produire-chaleur/fonds-chaleur-bref

However, the currently low uptake of renewables to support the concerned industrial sectors to reduce their emissions can be linked to the low competitive advantage of renewable fuels (due to the current low carbon price level, and to the other more cost effective solutions such as fuel switch – from coal/oil to natural gas, or energy efficiency), and to the lack of knowledge and risk management compared to existing options such as energy efficiency. With an increasing carbon price, and the fact the industry has already managed to invest in many of the “low hanging fruits” investments, renewables may become more attractive and deploy without any further intervention or policy action than the ETS. But there is probably no such guarantee without additional intervention in the frame of the RED, either with additional measures, or with a specific target for H&C or for the industry (those are addressed under Annex G-Industry).

Compared to energy efficiency measures in industry (EED), many of the efficiency investments have a very short payback time without any incentives, while RES investments generally require support, given their higher GHG abatement cost.[335][336] For the main categories of H&C energy efficiency measures in industry, the global average abatement cost remains negative, indicating that such measures are profitable. For H&C renewables, abatement costs remain positive. Hence, increased H&C RES deployment appears to be less cost effective than increased energy efficiency progress. However, most of the low hanging fruits in heavy industries have already been tackled, and to further decrease their emissions, those industries would progressively require to explore the possibility to deploy alternative low carbon fuels, including renewables. At the same time, some renewable options are already more profitable than energy efficiency, but it remains challenging for those to make rapid progress, despite potential profitable business cases, and it is less clear what would be required to accelerate their uptake, and how much it would cost.

The building sector has been identified by various studies as a sector that offers considerable potential for the cost-effective reduction of greenhouse gas emissions.[337] Two independent EU-wide assessments[338][339] indicate that 75%-85% of the technical savings potential in buildings is comprised of cost-effective options, meaning that over the lifetime of clean technologies, energy savings will more than compensate for the investment costs. Here also, renewable solutions have higher abatement costs than some of the energy efficiency measures, and may face difficulties to compete. It should be highlighted that the concerned instruments (EPBD & EED) do not fully address renewables, as their main objective is to promote energy savings.

To conclude, in both industry and buildings, without specific measures to increase renewable’s competitiveness, the risk remains high that renewables would not be taken up in the H&C sector. The two options would then be either to increase carbon pricing significantly, or to enforce the uptake of renewable via specific instruments. In the first case, accompanying measures would be necessary to guide the

[335] McKinsey. (2009). Pathways to a Low-Carbon Economy. Available at: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Pathways%20to%20a%20low%20carbon%20economy/Pathways%20to%20a%20low%20carbon%20economy.pdf
[336] IEA. (2020). GHG abatement costs for selected measures of the Sustainable Recovery Plan. Available at: https://www.iea.org/data-and-statistics/charts/ghg-abatement-costs-for-selected-measures-of-the-sustainable-recovery-plan
[337] Buildings Performance Institute Europe. (2015). Cost optimality, discussing methodology and challenges within the recast EPBD. Available at: https://www.bpie.eu/wp-content/uploads/2015/10/BPIE_costoptimality_publication2010.pdf
[338] Fraunhofer-Institute for Systems and Innovation Research (Fraunhofer ISI) et al. (2009). Study on the Energy Savings Potentials in EU MSs, Candidate Countries and EEA Countries. Final Report for the European Commission Directorate-General Energy and Transport
[339] Ecofys. (2009). Sectoral Emission Reduction Potentials and Economic Costs for Climate Change (SERPEC-CC) Summary report

integration of renewable in all low carbon actions. In the second, accompanying measures will also be necessary (see sections below on these measures) in combination with specific renewable targets. For the simplification of the assessment, we will not take into account any hypothetical interventions in the ETS or ETD, while considering possible synergies, and amendments of the EED and the EPBD may still be required and deemed relevant.

Therefore, a specific target for the H&C remains important and more cost-effective than the existing instruments (from option 0 to option 4), by giving more guarantee that the overall renewable target will be met. Having in mind the full decarbonisation of the sector by 2050, such target also supports overcoming no-economic barriers, such as the basic lack of awareness (e.g. in the industry where renewable is not associated to the core business), the administrative barriers, the lack of information (to final consumers) and public perception and the high upfront investments. The past experience has demonstrated how complex it is to decarbonise or to deploy renewables in the H&C sector, while it has arguably been more straightforward (even easy) to decarbonise the electricity sector. These H&C targets will also support the complex reforms necessary to push RES in H&C.

However, an increased (options 1 to 4) and binding (partially under options 2 & 3, fully under options 3 & 4) target would raise the issue of the freedom of MSs to determine the best global approach to deploy renewables in all sectors (electricity, transport, heating & cooling), considering their national and local influencing factors and at the same time targeting a complete decarbonisation of the H&C sector by 2050.

Given the fact that the majority of the MS are well below the article 23(1) target in their NECP (cf. analysis of NECP above, based on JRC’s assessment), calculating additional contributions to reach the cost-optimum based on GDP to fulfil the CTP ambition (39% H&C RES in 2030) will be the most cost-effective approach (options 1 to 4). However, a calculation method based only on the cost-effectiveness (at macro level) and the GDP may completely miss the broad set of factors that influence the real cost of switching from fossil fuels to renewables (in building and industry), although a methodology based on cost-effectiveness and the GDP would remain the most simple and undisputable approach.

As first alternative, the calculation method should be inspired from the EU gap filler mechanism for the overall RES target from the Governance Regulation, as detailed in Annex II, which objective is to determine (in the case of a gap), what would be the most appropriate national contribution of each MS (any MS with contributions below the calculated contributions are requested to either increase the ambition level of their national contributions, or make a proportionate payment to the Union Renewable Energy Financing Mechanism [340]). The current criteria set in Annex II of the Governance Regulation (concerning the overall RES target) are:

(a) the MS's national binding target for 2020 as set out in the third column of the table Annex I to Directive (EU) 2018/2001;
(b) a flat rate contribution (CFlat);
(c) a GDP-per-capita based contribution (CGDP);
(d) a potential-based contribution (CPotential);
(e) a contribution reflecting the interconnection level of the MS (CInterco).

[340] Commission implementing regulation (EU) 2020/1294 on the Union renewable energy financing mechanism

But this may not allow to capture the heating and cooling specificities (as those criteria are more addressing the electricity sector). Therefore, a second alternative could take into account other objective criteria addressing the purpose of heating and cooling, by :

- Replacing criteria (e) by a new criteria specific to heating and cooling infrastructure & not considering interconnection, including the electricity distribution grid, district heating and cooling and gas infrastructure;
- Focusing criteria (d) on H&C potential, considering all renewable fuels and technologies;
- Adding a criteria related to the H&C demand pattern, integrating the energy performance of the building stocks (and possibly the pace of renovation) and the energy profiles of the industrial sectors (considering the large variety of options to decarbonise).

Without integrating those criteria, it would probably remain complicated to reflect MS's specific ability to deploy renewables in the H&C, and the associated costs that cannot be fully captured at macro level.

Option 1 could use the basic calculation method (or formula) based on GDP and global cost-effectiveness, to determine MS indicative additional efforts to the already agreed baseline indicative target set out in article 23. As the target would remain indicative, a simple calculation method seems to be fit for purpose.

Given the important discrepancies between MSs in the NECPs, with completely different reference/current situations, and the fact that 14 MSs do not meet this target in their NECP, the cost-effectiveness of the 1.3% annual share increase can be challenged, probably due to the fact a uniform target does not take into account the national factors. Option 2 would first require an agreement that the baseline target set in article 23 is cost-effective, before it becomes binding.

Binding a MS-specific additional RES share target, under option 3, would require the use of a very specific calculation method, the too simplistic method based on GDP and macro-cost effectiveness would not be precise enough to determine a MS contribution, especially when the target increases and reduces MS's freedom and possibility to determine the global cost-optimum based on national and local factors.

Option 1 would be the most cost-effective, providing to MS a clear direction, while allowing for freedom to select the most cross-sectoral balance and cost-effective option, and also simplifying the process to calculate the MS contribution.

Option 2 would be a little bit less optimal by binding a partial target (existing 1.3% article 23(1) target) uniform for all, without considering national/local factors. On the other hand, with a zero-carbon sector by 2050, increasing by only ~10% the share of renewable in H&C on a 10 year period would be far from enough. Therefore, making it binding would probably be needed.

The cost-effectiveness of options 1 and 2 could be even improved with the deployment of accompanying measures under RED (see variants below), with the mainstreaming of renewables in H&C in the frame of EPBD and EED, and with the reinforcement of market-based instruments (ETS & ETD).

Investor certainty

While renewables in H&C have shown slight cost reductions over the past two decades, investments generally still rely on subsidies, especially in the case of capex intensive investments (such as geothermal heat, or district heating and cooling infrastructure). As a result, the binding nature of a target is an important signal to investors, as future deployment should normally be supported by policy makers. The higher the certainty, the more attractive it is for market players, which can lead to higher competition and lower cost of H&C renewables.

The perceived risk of adverse policy changes for renewables will be smaller with a national binding H&C RES target, which will lower the cost of capital for H&C renewable energy investments.[341] [342] Overall a binding H&C RES target would be a positive sign for investors in the H&C renewables market.

However, the most effective way to enhance investor certainty is provided by stable framework for the long term, including support schemes where required. Therefore, if H&C renewables are able to compete without additional incentives (e.g. if the ETS carbon price is high enough), these instruments would be more secure for investors than the binding targets. If renewables are properly integrated into the EPBD instruments (e.g. LTRS or building passport), and become profitable, investor certainty would be increased.

A binding H&C RES target is only slightly beneficial for investor certainty in the case of option 1 (EU level), while options 2 and 3 would have a more positive impact than option 1, as these would be established at MS level.

Macro-economic impacts

Theoretically, there would be no additional macro-economic impacts (investments and jobs) than the baseline option, as the three options would not increase the H&C RES ambition, but only make them binding. The only slightly positive impact of all three options comes from the fact that the binding nature of the target increases the likelihood for MSs to reach their target. Therefore options 2 and 3 would be a little bit more secure than option 1 (with an EU target, there remains a likelihood for MSs to miss their targets). It is hard to assess these minor impacts, as we would have to assume by how much MSs would have failed to meet their targets, which is unfeasible.

Security of supply

The benefit of most renewable energy sources for the heating and cooling is that they would create value with locally produced energy, building mainly on the match between demand and supply (e.g. geothermal heat, solar heat, heat pumps using a local heat source, bio-energies, including the production/use of biomethane). It does not mean these sources are only locally based, as, e.g., massive import of pellets exist, renewable-based hydrogen would not be produced locally on a regular basis, biomethane can be transported via the gas grid, etc. But except for the case of wood-based energy sources (such as pellets) and RFNBOs, these renewables would be produced in the EU, as opposed to fossil fuels for which the EU relies heavily on imports. Therefore, renewable deployment in the heating and cooling sector reduces import dependency and thereby enhances security of supply.

All three options making the EU H&C RSS target binding would have a positive impact on security of supply by creating reduced import dependency, with possibly a slight decrease of this positive impact for MSs relying on imported bio-energies (such as pellets).

[341] Diacore. (2016). The impact of risks in renewable energy investments and the role of smart policies.
[342] Trinomics, Cambridge Econometrics and E3M (forthcoming). Study on the Macroeconomics of the Energy Union, Report on literature review and stakeholder interviews regarding the representation and implications of the financing challenge.

Innovation

The contribution to renewable heat supply is made by bioenergy (main source for heating purpose), active solar heat, geothermal, ambient and renewable electricity. In the last two decades, the increasing focus on emissions (air quality and GHG) and energy performance has driven the improvement of biomass heating technologies, including wood-burning stoves. CHP production from biomass has been developed also at all scales (up to micro), and is now suitable for installations in individual houses and larger buildings not connected to a district heating network or gas grid. The current R&D efforts are mainly focusing on further technology optimisation, emission reduction, increased energetic (thermal, or thermal-electric) performance, reduced costs, optimum integration or hybridisation with other RE sources and technologies and energy storage solutions on a building level, stable and adaptive heat delivery and improved user interaction and satisfaction. Biomass fuel is storable from season to season. However, its limited availability and its future increased use for transport and materials will certainly lead to a decrease in its relative contribution to renewable H&C. Other renewable sources will take over and be deployed massively.[343]

Direct solar energy for the heating of individual buildings has already a long experience, via the building design and positioning to harvest most of the energy delivered by the sun. More recently, solar energy is harvested in solar collectors for thermal uses and in photovoltaic (PV) cells, or even concentrated solar power (CSP) for electricity generation. Combining PV with solar thermal is becoming attractive, as well as solar heat driven cooling systems.

Geothermal energy can be extracted directly from hot springs or deep wells, but the biggest potential comes from extracting lower temperature geothermal energy from shallow ground or surface water in combination with a heat, especially for individual buildings or districts. Extracting heat from ambient air and through air to air heat pumps (HP) is less efficient compared to ground-sourced HP, but the performance is continuously improving.

The intermittent nature of electricity production from wind and solar PV, which will continue to increase, requires demand flexibility. This demand-response can be provided by the H&C sector, via HP activation/deactivation based on electricity abundance/scarcity, via dispatchable stock energies (like bioenergies) for the supply of CHP, via large scale systems in DHC and the storage capacity of the network, via storage systems (e.g. heat tanks). Replacing all fossil energy sources with renewable should be combined with effective energy efficiency measures in buildings to limit the need for active H&C. The main challenge is to provide cost-effective and easy/fast to install retrofitting solutions for old buildings, both for energy efficiency and H&C, where additional research and innovation are still required.

Binding H&C RES target(s) and the resulting secured (or guaranteed) H&C RES deployment is relevant for innovation, as those targets would create and enlarge market opportunities for all heating and cooling applications and technologies based on renewable energy sources, and the enabling technologies such as those providing flexibility to the energy system. Most of the H&C technologies are mature, however further innovation is still expected regarding cost and efficiency improvements. In the building environment, mass market will be the main driver to accelerate the learning-curve, including on the side of installers and operators where increased skills are still required to adequately ensure cost-efficient and quality delivery.

[343] Renewable H&C ETIP. (2020). Strategic Research and Innovation Agenda for Climate-Neutral Heating and Cooling in Europe. Available at: https://www.rhc-platform.org/content/uploads/2020/10/RHC-ETIP-SRIA-2020-WEB.pdf

The EU value chain actors, starting with the EU manufacturers, would get more confidence and possibly strengthen research. Several technologies, such as heat pumps manufacturing[344], are already well represented at EU level, with some of the major global players. An accelerated deployment would support learning and ease the commercialisation of new products or improved components. The EU industry can benefit from accelerated learning-by-doing and increased economies of scale, increasing the prospects of global leadership in renewables.[345]

For less mature technologies, such as in some industrial sectors, especially with high temperature levels, the positive impact of a binding target would be larger.
There is no clear difference between the three options regarding the impact on innovation.

Distributional impact

For the deployment of renewable H&C solutions, support will certainly be required. As in the case of supporting schemes for renewable electricity, the distribution of the incurred economic impacts could be better managed than simply relying on a carbon pricing, where no distinction is made between consumers. Carbon pricing would simply increase the costs of carbon intensive consumption without any consideration for income levels, while specific support schemes can be financed in a way that does account for a just distribution of costs (e.g. taxpayers to bear the cost, or consumers with exoneration for certain consumer categories). The impact assessment carried out for the CTP confirmed that the scenario relying most on carbon pricing has the highest negative impact on low income households.[346]

However, the distribution could also be managed appropriately with the ETD if the revenues are directly used to support low income consumers to decrease their energy bills, by, e.g., focusing on these target groups with deep renovation programmes, or providing subsidies for the replacement of old and inefficient heating appliances (by renewable-based technologies), or providing lump sum support (possibly linked to the use of renewables). These revenues offer an opportunity to accelerate both energy efficiency and renewables in the buildings. Such programmes should be adapted to overcome the lack of capital and other barriers that may exist.

The distribution of the costs and benefits of a binding H&C RES target across MSs will rely heavily on how the MS intends to design their framework in order to meet their target (being defined at MS level, or through a national contribution for the EU binding target). As in the NECPs, according to JRC's report, the measures related to renewables and energy savings in heating and cooling are in most cases provided with limited description, it remains hard to evaluate what will be the global impact yet. However, the countries already complying with the target under article 23(1) (only 9 MS), would be less affected as they would probably not be required to increase their ambition.
Additionally, lower income MSs have a larger share of lower income households which would intensify the distributional issue on low income classes at national level. Therefore, their contribution to the EU binding target (option 1) or their MS specific binding target (option 2), can have a positive impact on low income MS if the methodology to calculate the MS contribution/target considers these incomes. Otherwise, the

[344] The Heat Pumps Barometer. (2020). Available at https://www.eurobserv-er.org/category/all-heat-pumps-barometers/
[345] IRENA. (2015). Renewable energy technology innovation policy. Available at: https://www.irena.org/publications/2015/Jan/Renewable-Energy-Technology-Innovation-Policy-A-process-development-guide
[346] SWD(2020) 176 final. Impact assessment accompanying the document "Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people".

impact would be negative on these MS. Option 3 has a negative impact, as the target would be uniform for all MS, without any distinction regarding the income level of consumers.

Therefore, options 1 and 2 can have a better distributional impacts than relying more on carbon pricing and other energy efficiency instruments, unless the adopted programmes are set up to uniformly distribute carbon revenues, leading to an equal impact for both instruments. Option 3 has definitely a negative impact.

GHG emissions reduction & other environmental impacts

The displacement of fossil fuel consumption and thereby the reduction of GHG emissions, is directly linked to the ambition level and its binding nature. A binding target can lead to additional H&C renewables than a higher non-binding target which is not providing any guarantee. Hence, a binding H&C RES target will have a positive contribution to GHG emission reductions as it is expected the target will be met. As a result, all three options have a more favourable emission reduction impact than the baseline option 0.

A potential environmental impact due to the rapid deployment of all renewables in buildings is linked to biomass deployment, as this is probably one of the most competitive options without any incentive scheme and could possibly take the lead in deploying the various renewable technologies in buildings. Depending on the heating system used, biomass might have potential adverse impacts, such as on air quality or biodiversity, that should be considered vis-a-vis the benefits in terms of renewable energy deployment and GHG reduction. Depending on the pathways, great care should be taken when considering biomass sustainability including expanding the scope to small-scale systems.

Administrative burden

The impacts of a binding H&C EU RES target on the administrative burden will be important as trajectories and achievements for the specific sector of H&C will have to be calculated regularly, in addition to the overall target achievements.

Therefore, options 1 and 2 would have a strong negative impact, and option 3 would have an even much stronger impact compared to options 1 & 2.

Political feasibility

When fixing a target, the higher the level of granularity, the more it decreases the freedom of the responsible parties (EU & MS) to reach the overall target to deploy renewable globally, and thereafter to reduce carbon emissions and to increase security of supply at an affordable cost.
Increasing the share of renewable in the heating and cooling sector requires a systemic approach as it is at the core of energy system integration. The capacity to increase the electrification of the H&C sector (e.g. through heat pumps, or even by using RFNBOs) will depend at the same time on the capacity to produce renewable electricity, and to deploy electrical vehicles (EVs).

Textbox 3-1 National and local factors to consider

A MS with high RES-E potential could freely chose to deploy electric vehicles and heat pumps, and even produce RFNBOs (for its own consumption or for exporting), or simply increase its RES-E target to reach its overall RES target. A MS with low RES-E potential should think about importing its electricity, or using more local sustainable biomass resources if available.

Deploying heat pumps will depend on the needs to increase the energy performance of the buildings and the requirements to strengthen the electricity grid, but also the gas grid as potential alternative. Using more solar or geothermal heat depends directly and only on the available resource at local scale, and the capacity to deploy district heating and cooling infrastructure, while bio-energies could also be imported from outside the country or even the EU.

Such freedom should be left to the MS to find its own cost-optimum balance to deploy renewable in the H&C, considering all national and local parameters. It is becoming more and more clear that it is very important to plan at national or even local levels, using a bottom-up approach.

At the same time, deploying renewables in the H&C remains a complex task, touching upon energy infrastructures, building renovation (incl. skills in the construction sector), industrial decarbonisation possible pathways, local/renewable resources, local players involvement, providing flexibility services, empowering the consumers (with smart systems). Given this complexity, the risk is still high for the MS to postpone the actions to deploy renewables in this sector. Therefore, a clear signal from the EU level should pave the way for the MS to accelerate the decarbonisation of the H&C sector by using more renewables, in addition to increasing energy efficiency.

The methodology to determine the MS contribution/target and/or to monitor progress would also ideally mainstream all these interlinked parameters, and it could be expected from the MS to request so. Therefore, agreeing on a common EU methodology formula would probably become a complex task to negotiate considering all the specificities of MSs.

In addition, given the many missing elements in most of the NECPs, determining the national contributions would require the MS to further study the penetration of renewable in the H&C. A new methodology would include the interlinkages with all the sectors, based on the assessment of the RES-H potential, integrating many of these factors.

Therefore, option 2 would have a negative impact, while option 1 would require a less hard-binding formula and leave some room for simplifications and common agreement. Option 3, given all these elements to consider, and the fact only nine MSs already meet the target under article 23, would probably also have a negative impact.

To conclude, setting up a higher indicative RES-H (at EU or even MS level), to comply with the new ambition of the CTP, would give the MS a clear direction on the way forward. However, making this target a binding one at MS (options 2 & 3) would probably be complex.

Compared to an overall RES target

According to the mid-term evaluation of RED I,[347] conducted in 2015: *mandatory RES targets backed by indicative interim targets seem to be effective, especially in MS with low renewable energy sources (RES) shares and investments. They have also enhanced investor security and contributed to drive RES technology cost down. The indicative interim targets contribute to ensure that measures to achieve the national targets are introduced timely, and allow a continuing assessment whether MS are on track*. Although this conclusion applies to overall national RES targets, (leaving MSs the freedom to decline their own target for each sector and sub-sector, according to their strengths, needs and potentials), it would become more complicated to impose that MSs reach a sub-sector target, such as for the buildings.

There is a strong argument for the added value of mandatory national RES targets since former experience with indicative targets indicates that without binding targets substantial RES deployment would have remained limited to few MS and sectors. Moreover, stakeholders confirm that mandatory national targets contribute to a clear policy framework that creates investor's security, leads to greater discipline in implementing the RED and makes it much more difficult to deviate from the planned trajectory. Mandatory RES targets and adequate support schemes have contributed to driving down technology costs for RES technologies. In doing so, the RED has successfully addressed market failure in the field of innovation, which is essential in order to achieve ambitious emissions reductions in the long term

With a share of renewable in H&C above 60%, one MS (SE) is not subject to the renewable increase requirement (article 23(2)(b) of RED II), while 3 MS with a share above 50% (and below 60%) have to achieve only half of the renewable increase requirement (article 23(2)(c) of RED II). Hence, on the total nine MSs meet the target of article 23(4) of RED II, only 5 are effectively meeting the target of 1.3%-point annual increase of renewables in the H&C sector of article 23(4) of RED II, while 18 MSs are not meeting the requirement at all. Therefore, it seems unrealistic to make it binding for all MSs, which is the aim of option 2, when the gap remains so important, especially for 13 MSs. It should also be pointed out that a common target for all MS does not take into account national renewable resources, nor current market dynamics, or existing situation.

[347] CE Delft, Ecologic Institute, Ricardo-AEA, REKK, E-Bridge (2015), Mid-term evaluation of the Renewable Energy Directive: A study in the context of the REFIT programme. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/CE_Delft_3D59_Mid_term_evaluation_of_The_RED_DEF.PDF

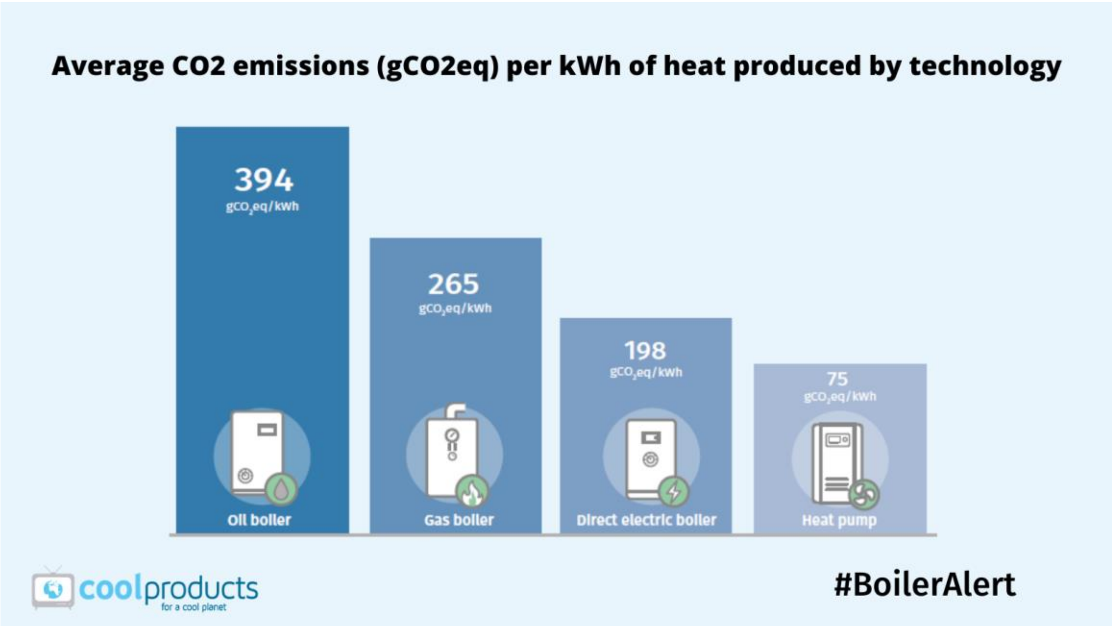
D1 - Accompanying measures (variants)

Variant 1 - Planned replacement schemes of heating appliances to facilitate fossil phase-out

Effectiveness

A phase out of gas and oil boilers could bring about 110 million tonnes of annual CO_2 savings by 2050.[348] This is two thirds of the total emissions reduction needed from residential and public buildings to achieve climate neutrality by 2050. The figure below shows the average CO_2 emissions per kWh of heat produced from different fossil and renewable technologies. The emissions from an oil boiler are more than 5 times greater compared to those from heat pumps and 3.5 times greater than those from gas boilers.

Figure 3-3 Average CO_2 Emissions per kWh of heat produced by technology [349]



Heating appliances usually last longer than 20 years so it is important to avoid the installation of old, inefficient and fossil-fuelled heating systems in buildings by 2030 at the latest, as this can lead to a carbon lock-in and stranded assets. The European Commission is currently revising the ecodesign and energy labelling regulations for heating systems. The revision should consider rescaling of the energy labels to downgrade the majority of fossil appliances (including condensing gas boilers) to the lowest grades (F and G). These appliances then need to be progressively phased out by removing the G and F classes. This should lead to the situation that by 2030 it would no longer be allowed to put inefficient, fossil-fuelled heating systems on the market under the Ecodesign Directive.[350]

Certain cities, such as Vienna, have already committed to phasing out fossil-fuelled heating in new buildings.[351] The phase-out programme is based on climate protection areas. These are geographically

[348] CoolProducts (2020), The EU must phase out new fossil fuel heaters by 2025 – or it will not reach climate neutrality on time. Available at:
[349] Ibid.
[350] Views expressed by the European Climate Foundation in a questionnaire for the project “Policy Support for Heating and Cooling Decarbonisation”. Based on ECOS, CoolProducts. (2020.) Five Years Left : How eco-design and energy labelling can decarbonize heating. Available at: https://www.coolproducts.eu/wp-content/uploads/2020/12/Five-Years-Left-How-ecodesign-and-energy-labelling-Coolproducts-report.pdf
[351] Euroheat and power. (2020). Vienna phasing out fossil fuel use in new buildings. Available at:

designated areas with district heating connections and at least, one other, heating-system option that is based on renewable energy or waste heat to ensure freedom of choice for the inhabitants of the area. As a next step, climate protection areas are to be extended to phase-out fossil fuel H&C systems in existing buildings.[352] In Germany, under the Climate Action Programme 2030, the government will ban the installation of oil-fired heating systems from the year 2026 in buildings where more climate friendly alternatives are available. To make this economically easier on consumers, a "swap-premium" for replacing old oil-fired heating systems will be introduced which repays up to 40% of the costs for a new, more efficient system.[353] The United Kingdom will ban gas connections to new developments beginning 2025. New oil-fired boilers in residential properties are banned in Denmark, Sweden and Norway.[354]

Textbox 3-2 Considerations for the phase-out of residential oil heating in the Aosta Valley region of Italy [355]

A study from the Aosta Valley Region in Italy shows that residential oil heating is still widely used in the region given that the area is not connected to the gas grid. Oil heating has important economic and environmental drawbacks: it is becoming more expensive, requires frequent tank refill operations and emits high concentrations of GHG and other air pollutants such as SOx. Moreover, another, less frequently recognised problem involves spills from oil underground storage tanks which represent a serious environmental problem associated with soil and groundwater contamination. In the Aosta Valley, 68 leakages occurred between 1999 and 2018; of these, only 10 were remediated.

This is also advocating for the additional need to implement a rapid phase-out strategy for oil heating. A techno-economic assessment shows that it is feasible to rapidly phase out oil heating systems in the Aosta Valley. For the region wood logs and chips boilers are the cheapest and least carbon-intensive alternative however, their impact on air quality is assessed as strongly negative. In addition, the need for large storage space is a limiting factor. On the other hand, heat pumps are more expensive and have longer payback times, but have several advantages: they produce no emissions on site, substantially reduce GHG and pollution emissions globally and do not require fuel storage. Payback times for replacing oil boilers have been calculated to be in the range of 6 to 16 years without considering incentives and between 3 to 8 years based on the current Italian incentives for residential buildings.

As demonstrated in the German state of Baden Württemberg, such fossil phase out schemes, even partial, can be successfully implemented, by taking all the required steps to build the way to mainstream renewables in the heating and cooling sector.

[352] City of Vienna. (Accessed on 10/05/2021). Climate protection areas: No more fossil fuels for new buildings. Available at: https://www.wien.gv.at/english/environment/energy/climate-protection-areas.html
[353] Clean Energy Wire. (2020). Heating 40 million homes – the hurdles to phasing out fossil fuels in German basements. Available at: https://www.cleanenergywire.org/factsheets/heating-40-million-homes-hurdles-phasing-out-fossil-fuels-german-basements
[354] IRENA, IEA, REN21. (2020). Renewable Energy Policies in a Time of Transition: Heating and Cooling.
[355] Casasso, A. et al. (2019). Environmental and Economic Benefits from the Phase-out of Residential Oil Heating: A study from the Aosta Valley Region (Italy).

Textbox 3-3 Baden Württemberg - replacement scheme[356] (Germany)

Germany's third largest state, Baden Württemberg, was the first to mandate the installation of renewable heating technologies in 2008. Owners of a heating systems need to employ a minimum share of renewable energy of 15% of the heat demand when the heating system is replaced. Instead of employing a renewable heating system, the building owner can also opt for efficiency measures, including insulation of the building. A part of the obligation can be fulfilled by carrying out an energy audit based on an individual building roadmap.

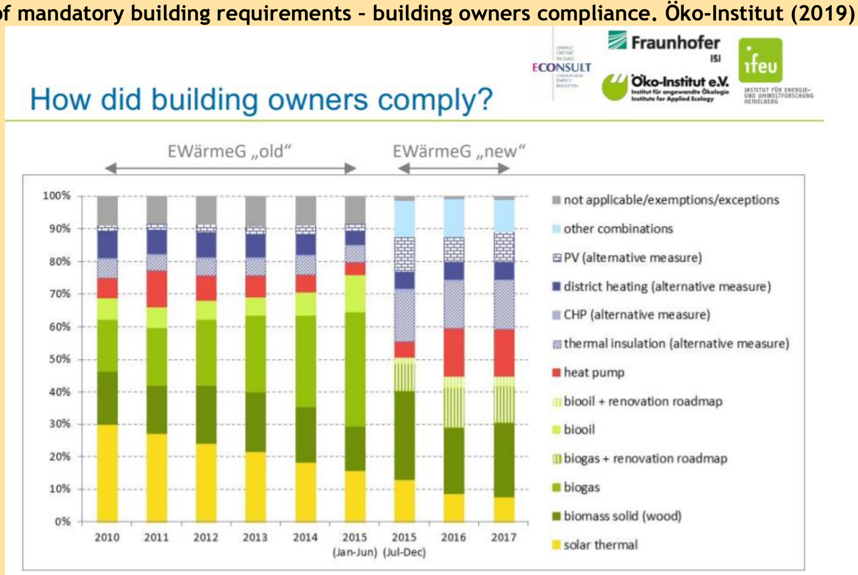
The effects of the Renewable Heating Act Baden-Württemberg have been evaluated, based on market observations and interviews (1000 clients, 450 installers and other professionals).

Overall, the act provides positive incentives for additional installations of RES H&C, also increasing energy efficiency. Thanks to the explicit requirements, the scheme provides an additional direct incentive to expand renewables and substitute measures. Indirectly, it strengthens the involvement with renewables both in the consultation process with heating engineers and planners/architects and in the purchase decision of customers. Additional energy consulting is also encouraged.

The complete scheme is summarised in the following presentation.
It is interesting to see there has been a move of technologies, meaning such tool could also be used to slightly influence the technology choice, while being designed on the technology-neutral principle.

Since 2015, with the new scheme, it can be observed that some technologies such as PV and heat pumps are taking up.

Figure 3-3-1 Evaluating the renewable heating and efficiency obligation for existing buildings – insights into the mechanisms of mandatory building requirements – building owners compliance. Öko-Institut (2019)



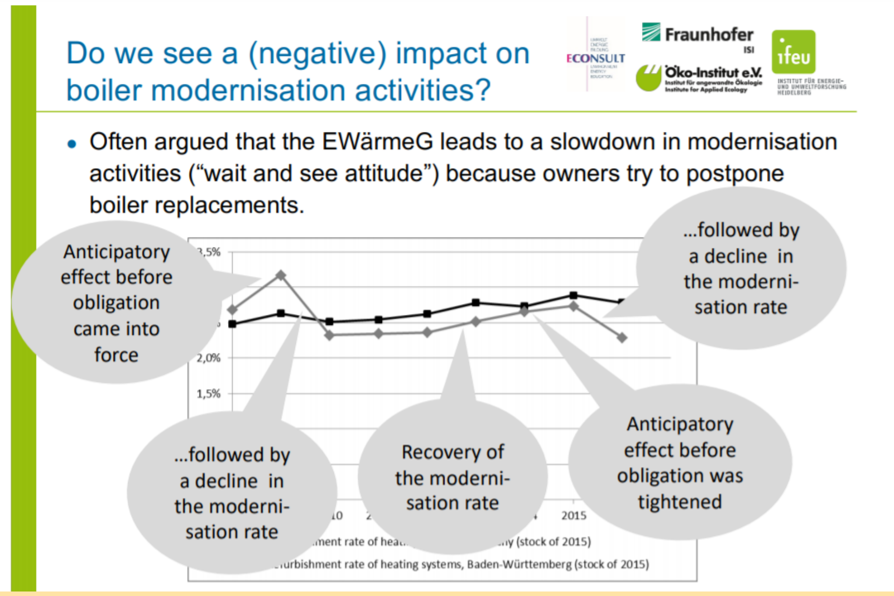
The evaluation also came to the conclusion that use obligations (or fossil phase out schemes) alone are not sufficient to achieve the climate targets in the heating sector. Additional and complementary measures are

356 Pehnt, M. et al. (2019). Evaluating the renewable heating and efficiency obligation for existing buildings – insights into the mechanisms of mandatory building requirements. Available at: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2019/7-make-buildings-policies-great-again/evaluating-the-renewable-heating-and-efficiency-obligation-for-existing-buildings-insights-into-the-mechanisms-of-mandatory-building-requirements/

required to ensure the sector transformation (e.g. CO2 tax on fossil fuels, replacement obligations for inefficient boilers, introduction of strategic heat planning, etc.).

The evaluation also assessed whether there was a (potentially negative) impact on boiler modernisation activities, which was apparently not the case.

Figure 3-3-2 Evaluating the renewable heating and efficiency obligation for existing buildings - insights into the mechanisms of mandatory building requirements - impact on boiler modernisation. Öko-Institut (2019)



The ecodesign alone would probably be the most cost-effective measure for the progressive replacement of old boilers. However, accompanying programmes such as replacement or scrappage schemes would be necessary to accelerate the phasing out, with the aim to avoid lock-in and stranded assets (avoiding replacement with fossil-fuelled technologies while alternatives already exist in the coming decade), but also to start immediately deploying all alternatives and building the required capacities and knowledge, among installers, workers, construction professionals and citizens (consumers). The risk remains that the ecodesign alone would take time to building the capacities.

Depending on the design of the replacement programmes, and the level of requirements (or ban), this variant may require additional budget, to incentivise the shift to renewables, especially for those situations where renewable alternatives still remain more expensive. The uptake of the markets would progressively ensure these renewable alternatives become affordable and competitive.
Allowing the installation of hybrid systems, under well-defined conditions with the aim to fully decarbonise the H&C system by 2050, would be an intermediate alternative to get the costs as low as possible.

Planning requirements and related cost

A recent analysis shows **that many EU MS continue to subsidise fossil-based heating technologies, e.g. to install** new gas boilers, despite evidence that this is slowing down the uptake of renewable heat.[357] Public funding will play a key role in supporting the uptake of renewable H&C solutions, but an

[357] CoolProducts. (2020). Available at: https://www.coolproducts.eu/failing-rules/mapping-europes-subsidies-for-fossil-fuel-heating-systems/

important aspect will be to clarify what investments should be considered green and worthy of support (e.g. under the EU Taxonomy).

This option would require planning the phasing out of fossil-based systems, based on the renewable potential assessment (art 15(7) RED II), in close coordination with infrastructure planning (deployment, reinforcement, dismantling or conversion of gas infrastructure to hydrogen), and hand in hand with the building renovation addressing energy efficiency, and renewable heating alternatives. Given the complex task to fully decarbonise the H&C sector, and to deploy renewables in H&C, any reform will require such integrated planning and coordination efforts. The additional cost of variant 1 will be higher compared to no action, but would remain limited if associated with other measures, notably planning.

Investor certainty

The switch from fossil fuels to renewable-based fuels in the heating and cooling sector is taking some time, given the complexity, the lack of competitiveness, and the absence of a clear signal on the long term preferred options. Phasing out fossil programmes provide a clear signal to investors, but also to all professionals in the whole chain (installers, architects, designers, engineers), on the technologies to focus on.

With a stable framework, avoiding short-term changes, these instruments have a positive impact on investor certainty, including on those having to develop completely new business models, to propose new services and products.

Macro-economic impact

The economic impact depends on the rate of old boiler replacement. With a lifetime of about 20 years, the rate should be around 5%/yr, but as illustrated by the Baden-Württemberg case, the rate seems to be around 3.5%/yr. Therefore, as average, we could consider the old boiler replacement rate at ~4%/yr.

Despite the implementation of planned replacement schemes, all fossil-based systems replacement would not fully switch to 100% renewable, depending on the specific scheme requirements (15% RES in the case of Baden-Württemberg , allowing a lot of freedom, to reach cost-effectiveness on a case by case basis). Hybrid systems may still be required, and possibly fossil fuels would cover the bulk of the energy produced, at least in the first years.

Other instruments or incentives, such as carbon pricing, would be supportive to effectively switch to 100% renewables (based on market competitiveness). The replacement scheme could give a signal to owners of heating systems to make an effort considering RES H&C options, to overcome the first barrier which is the lack of awareness, and knowledge.

Assuming a 4%/yr replacement rate, with about 120 million units[358] across EU, in ten years' time, 48 million units could be replaced by new and more efficient ones, and partially fuelled by renewables. If we assume that each replacement is switching to an average of 50% renewable fuels (well above a 15% threshold like in Baden-Württemberg, but most of the replacement will certainly fully switch to RES), in 10 years, we would add about 20% (4%/yr * 10 years * 50%) of the heat demand in the building sector supplied by renewables (on top of the existing share) thanks to such fossil phase out schemes.

[358] According to the project REPLACE, about two thirds of the heating systems installed in Europe, which accounts for a total of 80 million units, are inefficient. Project website available at http://replace-project.eu/).

Subsidiarity

According to JRC's NECP assessment, measures related to phasing out fossil fuels in the heating sector were expressed by eight MSs, meaning these are probably already considered as non-regret instruments. In addition to Austria and Germany, Ireland has also set up such a scheme.

These schemes are concrete, driven by national or regional authorities, already implemented with success and sometimes could be considered as the key pillar of decarbonising the H&C sector, depending on the MS strategy. As these schemes would depend on many national/local factors, more requirements from the EU would be counterproductive, although the EU could support the sharing of best practices, and possibly provide some guidance.

Textbox 3-4 Amsterdam - citizens driven phase out of natural gas [359]

> Amsterdam has set up the Natural Gas-Free City Deal programme to phase out natural gas. Housing corporations are responsible for initiating the phase-out in at least one of the neighbourhoods where they are active. One of the first projects of the programme is in Middenmeer. The project has been started by citizens who set up an energy cooperative called MeerEnergie. The project plans to use residual heat from a local science park centre via heat networks. It will allow 1650 households to switch from natural gas to district heat. In addition, the project has been scheduled to coincide with electricity and sewer renewal works to minimise the frequency of disruptions.
>
> The project is finances by the city of Amsterdam, the national government, and other stakeholders. The financing by the city of Amsterdam is seen as a 'tuition fee' for learning by doing in order to understand what solutions work best and how to apply the knowledge gained to other areas of the city.
>
> Dealing with the national government which still allows citizens to opt for natural gas is cited as one of the challenges of the project. This illustrates the importance of national and local authorities working on synchronized objectives.

Coherence

Planned replacement schemes of heating appliances to facilitate fossil phase-out are designed to complement other instruments such as:

- ETS, to incentivise and start deploying technologies that may become competitive, but that may still face a lack of recognition, of capacity and knowledge. This should be tackled also with incentivising the industry to adopt renewable energies, either via a sub-sector target, or via dedicated funds (demonstration and pilots);
- Renewable heat planning requirements, where the trigger should always remain the replacement of fossil fuels by either district heating and cooling with a large (or complete) share of renewables, or by individual heating systems based on renewable-based fuels paying attention to potential lock-in effect. Local planning is essential to adapt the phasing out rules to spur the most adequate alternatives. Focusing on specific market segments first (e.g. start phasing out heating oil appliances) would support finding the right priorities (easier and cost effective, limited stranded assets compared to gas, CO_2 savings, other pollutants);
- Requiring the integration of global renewable heat planning and fossil phase out within existing planning instruments:
  - the revision of the Long Term Renovation Strategy (LTRS, article 2.a of EPBD) should be based on phasing out fossil fuels (to reach long term full decarbonisation)

[359] Eurocities. (2019). Cities leading the way on climate action. Available at: https://eurocities.eu/wp-content/uploads/2020/08/EUROCITIES_cities_climate_action_2019-1.pdf

  - the next update of the comprehensive assessments of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling (art 14 EED) should be based on replacing fossil fuels by renewable fuels when considering DHC or CHP (but also paying attention to individual solutions);
- Minimum energy performance requirements (MEPR) (art 4 of EPBD, possibly reinforced by the EPBD revision) should be based on phasing out fossil fuels, ensuring their replacement by renewables fuels. As these requirements would probably be based on the Energy Performance Certificate (EPC), including the phasing out of fossil fuels should also be tackled in the framework of the EPC (possibly as one of the indicators, and at least as information to be included in the EPC). Integrating the phasing out of fossil fuels within instruments dealing with planning at building level, such as the Building Renovation Passport (BRP) (an option to be addressed in the frame of the EPBD revision). As these passports may be recognised as a useful tool to prioritise the investments in the renovation of a building, a complete alignment of the planned replacement schemes would be required.

Planned replacement schemes of heating appliances to facilitate fossil phase-out would support the clear signal of a move to a low-carbon (or even zero-carbon) energy system, which would also benefit other areas lacking such strong signal. A specific provision on planned replacement of fossil fuel systems should at least require to be integrated in the revision of the above-mentioned articles under RED II (planning), EPBD (LTRS, MEPR, EPC, BRP) and EED (Comprehensive Assessment, CA under article 14).

As a market instrument, a fit for purpose ETD (or possibly extension of the EU ETS to the building sector) would result intrinsically in cost-optimal emission reductions, pulling the most competitive solutions (with an increasing carbon price, renewables may become more attractive and deploy faster). Hence, the planned replacement of fossil systems would be reinforced, or even facilitated by an adequate carbon pricing, especially when the income generated by carbon pricing (e.g. carbon taxes) is allocated to supporting the low income households, replacing the worst performing systems. One of the key issues of a carbon pricing is to ensure that low-carbon alternatives are available in any situation, at an affordable cost, which is the first step and aim of a planned replacement scheme. The planned replacement can also be considered as one of these instruments accompanying a carbon pricing, in order to progressively diminish or suppress the negative (cost) effect of an increasing carbon price on the worst performing systems.

To conclude, the appropriate combination and phasing of these two instruments would be beneficial, although the planned replacement should be complemented by other instruments addressing the energy performance of the buildings, to be tackled in the frame of the EPBD, such as a Minimum Energy Performance of the Buildings Standard (MEPS).

Administrative burden

Planned replacement schemes of heating appliances to facilitate fossil phase-out can be implemented through several instruments such as support schemes, fiscal incentives, building requirements (e.g obligation to replace heating systems older than xx years) for new buildings and deep renovation, or via banning purchase of determined products (heating appliances). The MS, to decarbonise the building sector, have fixed energy efficiency and renewable targets by 2030, and defined a set of supporting policy instruments. To phase out fossil fuels, most of the instruments already exist, and are mainstreamed in their LTRS and NECP. A good example is Ireland, which LTRS encompasses a replacement scheme. The existing instruments, such as a support scheme (for the purchase of individual heating system fuelled by renewable, or for the connection to a district heating defined as “renewable”), could be slightly adapted and oriented to ensure the targeted systems are being replaced. The nature of the instruments would not change, only their scale, to accelerate the phasing out of fossil fuels.

The building owners (investing in a renewable system) would not be impacted compared to the current LTRS implementation, and the related compliance costs would be limited. The only impact would be the acceleration of the deployment of renewable heating technologies in the buildings (e.g. thanks to the increase of incentives). Only banning would have an important impact on building owners, and possibly increase significantly the compliance costs.
Depending on the scheme and instruments, additional audits and verifications may be required. These would certainly increase administrative costs, certainly for obligations or bans.
Replacement schemes would mainly impact building owners (landlord and occupier), while tenants would be impacted to a limited extent.

Building professionals (installers, designers, architects, …) would need to be trained and qualified. The expected qualification is already required for the implementation of LTRS, though additional expertise would be needed to allow them to recommend the most appropriate solution to replace fossil systems. Qualification and the building of skills and expertise would require to be reinforced, indirectly increasing administrative costs.

Administrative burden and associated costs will vary per MS depending on the extent of multi-level governance between different levels of government (national, regional, municipal), the choice and level of ambition of the phase-out and the existing administrative framework in place among many other variables. Minimum administrative requirements foreseeable would include:

- **Data collection**. In order to understand the extent of the necessary replacements and to monitor the implementation of any phase-out scheme reliable data is a pre-requisite. Thus, lack of reliable information is often a barrier as setting up data collecting procedures might require significant administrative costs. For example, an evaluation of the effects of the Baden-Württemberg Renewable Heating Act found that data sources were inconsistent. Data on the number of heating system exchanges reported to the Statistical Office of the State of Baden-Württemberg including that reported by chimney sweeps was different from the market statistics of boiler manufacturers. One of the reasons for this was attributed to authorities not having enough time and resources to ensure rapid data processing.[360];
- **Monitoring, reporting and enforcement costs**. To ensure that the phase-out programmes are proceeding accordingly and that the results are consistent with targets set for e.g. 2030 or 2050, monitoring and reporting procedures should be set up periodically. The time-intervals for monitoring should strive to find a balance between achieving sufficient information for assessing the programme and excessive administrative burden. For example, in the case of Baden-Württemberg the number of energy audits has increased significantly since 2015 – the year in which the Renewable Heating Act was amended introducing the renovation roadmap (see Figure 3-4);
- **Awareness raising campaigns**. Are important to adequately communicate to the citizens the programme being implemented, the reasons for it, expected outcomes etc. Benefits include

[360] Pehnt, M. et al. (2019). Evaluating the renewable heating and efficiency obligation for existing buildings – insights into the mechanisms of mandatory building requirements.

increased awareness of citizens, increased probability for public acceptance and support, stimulating capacity building, generating conditions for an efficient citizen participation process and the involvement of stakeholders. As such replacement schemes could be misunderstood by the concerned parties[361], a very clear communication is of paramount importance. Campaigning costs could be as high as 400, 000 EUR/yr.[362] Costs to consider include:

- Market research expenses
- Expenses related to the design of communication tools and brand
- Publication expenses
- Website maintenance costs
- Direct communication and meetings
- Training of staff
- Organisation of press conferences and events

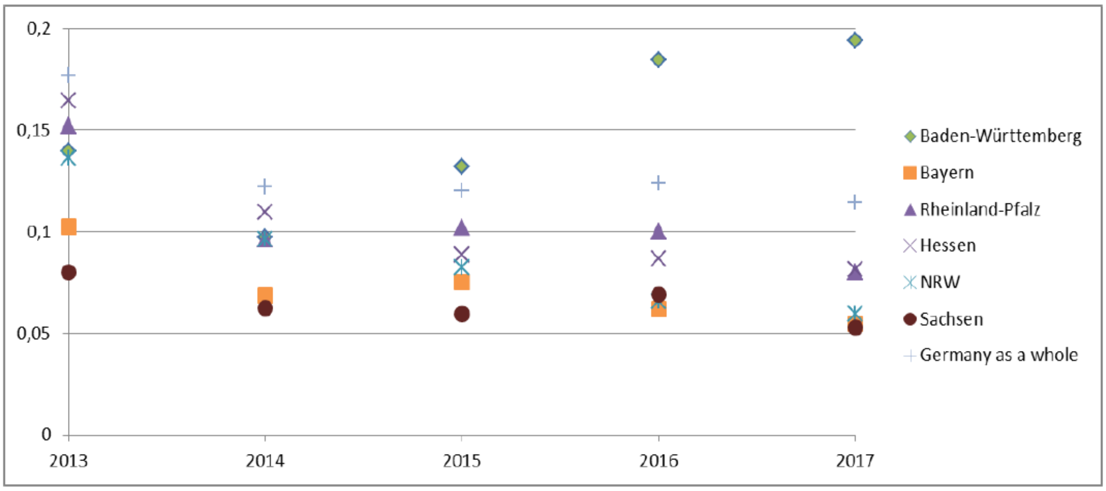
- **Multi-level coordination**. As already mentioned, these instruments would require additional planning efforts, to tackle all local/regional/national influencing factors and constraints, and therefore increasing development costs, for national involved parties (national authorities and administrations, but also building professionals, such as architects, planners, designers and construction workers, and local authorities);
- **Importance of local actors engagement**. When phasing out fossil systems, it is of paramount to have a clear vision on the long term low-carbon/renewable alternatives (to determine by what a fossil-based system should be replaced). The other case of the Aosta Valley region illustrates how important it is to consider local parameters, when assessing the demand side (consumption profiles), and mainly the supply side (the most attractive renewable alternative is wood-based fuel). This requires engaging decision bodies at regional or even local levels to plan correctly the deployment of renewable. It is hardly recommended to start at these levels (as was also the case for Baden-Württemberg).

As explained above, depending on the national situation, some of these steps are already tackled in the implementation of the LTRS, and would only require a marginal additional effort, while for others it would require deploying a new vision.

The figure below shows that the number of energy audits in Baden Württemberg has increased since 2014 and is the highest among several German federal states. The high number of audits can be linked to the updated made in 2015 to the Renewable Heating Act Baden-Württemberg. There is a correlation between the success of a replacement-schemes and associated monitoring and energy audits. The administrative burden could be limited to a simple scheme driven from the national level, and increased in complexity and involvement of local actors.

[361] As it was the case in Belgium, end of 2017, when the 2050 Energy Pact fixed the objective to stop selling heating oil appliances after 2035, there was a large confusion and strong reaction from the stakeholders, and even social actors. See https://www.chauffagistes-belgique.be/pacte-energetique-implications.htm & https://heatingexpertise.be/fr/2019/07/10/vers-la-fin-du-chauffage-au-mazout-en-belgique/
[362] Niches. (n.d.). Innovative Demand Management Strategies: City-wide Campaigns. Available at: http://www.rupprecht-consult.eu/uploads/tx_rupprecht/14_City_wide_campaigns.pdf

Figure 3-4 Evolution of the number of funded energy audits per capita in different German federal states. (ECEEE, 2019)[363]



Variant 2 - Consumer RES heat purchase agreements

Effectiveness

A power purchase agreement (PPAs) is a long-term electricity supply agreement between an installation operator (seller) and an electricity buyer (final consumer or reseller, supplier or trader). The agreements are generally signed for a period of up to 10 years, though shorter-term PPAs are also possible. Renewables heat purchase agreements (HPAs), as the name implies, mirror PPAs but focus on the selling and buying of heat. The generator of the renewable heat receives a fixed price per unit of energy (e.g. joule), meaning that it can expect fixed returns on its investment and offer the bank the certainty it requires for the loans. The high-demand customer can therefore ensure that its renewable energy supply comes either directly from a specific plant, or from a green portfolio, at a fixed price for the duration of the agreement. The proof of the green quality and origin of the energy supply is provided by the guarantees of origin (GO) of the energy/heat-generating plants. The consumer would also pay a fixed price per unit of energy, meaning it can expect fixed fuel-costs, and therefore switch to renewable fuels with more security (established in the frame of an agreement) and cost certainty (depending on the length of the agreement). This would secure high upfront investments when switching to renewable-based heating alternatives by giving some guarantee for the business case.

Heat purchase agreements can be an important tool to support the creation of heat markets. Heat purchase agreements are currently used much less frequently than power purchase agreements. Although supplies of heat (or cooling) are similar in many respects to other utility type supplies, in heat networks there is a key difference, namely that the customer's use of the energy supplied has a significant effect on the overall operational efficiency of the network. This is reflected in how heat purchase agreements and their tariffs are structured.[364] The company learning costs and associated administrative burden costs related to contract drafting, legal implementation etc. are expected to be outweighed by the financial certainty for

[363] Institute for Energy and Environmental Research Heidelberg, Öko-Institut, ECONSULT Lambrecht Jungmann Partnerschaft, IREES. (2019). Evaluating the renewable heating and efficiency obligation for existing buildings – insights into the mechanisms of mandatory building requirements. European Council for an energy efficient Europe. Available at: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2019/7-make-buildings-policies-great-again/evaluating-the-renewable-heating-and-efficiency-obligation-for-existing-buildings-insights-into-the-mechanisms-of-mandatory-building-requirements/
[364] Scottish Futures Trust. (2018). Guidance on the development of Heat Supply Agreements for District Heating schemes. Available at: https://www.districtheatingscotland.com/wp-content/uploads/2018/02/HSA-guidance-final-Feb-18.pdf

suppliers and provision certainty that such agreements bring. These in turn, are be expected to support the mainstreaming of heat markets.

The following textbox illustrates how a national scheme can combine a renewable heat purchase agreement and a "heat as a service" instrument. It also shows the success of increasing the interest of individual consumers to switch to renewables, with 58% of the consumers being supplied via heat purchase agreements (Heat Plan in the case of Bristol, UK) to be open to a low carbon alternative when replacing their gas boiler. While only 33% of the general population seems to be interested in such replacements (which would probably become lower when it comes to take the decision to invest). Combining the purchase agreement with a "Heat as a Service" is increasing the attractiveness of renewable up to 85% of the same concerned consumers being ready to switch to renewables, when the provider can guarantee the desired level of comfort for a determined price consumers are willing to pay.

Textbox 3-5 Example of Heat as a service project in Bristol[365]

Bristol Energy has become the first energy supplier in the UK to trial selling 'heat as a service', rather than kilowatt hours (kWh). Currently, energy suppliers in the UK can only sell energy to customers in strict units known as kilowatt hours (kWh). But through a government-backed trial run by Energy Systems Catapult, Bristol Energy is offering households the chance to buy a 'Heat Plan' tailored to their individual needs.

Heat Plans offers consumers a room-by-room, hour-by-hour control over their heating. Using data collected via a smart heating control system, the energy provider can calculate a fixed monthly cost that does not fluctuate with the weather. This approach is designed to give people greater control over comfort and cost. In addition, it also:

- **Provides a commercial incentive for energy providers to deliver comfort using less energy and carbon;**
- **An opportunity for energy providers to differentiate themselves in a market; and**
- **Could create a route-to-market for low carbon technologies and fuels.**

With regards to the first point, findings from a pilot study found that 58% of trial participants who bought a Heat Plan were open to a low carbon alternative when replacing their gas boiler. In comparison, only around 33% of owner-occupiers in the general population were interested in such replacements. This rose to 85% of triallists if their Heat as a Service provider could guarantee the desired level of comfort for a price they were willing to pay.

For the MS, the operating cost would be limited to the administrative costs to develop such global framework and the cost of covering (backstopping) pilot or demonstration projects (such as for the case of Bristol Energy). After such trial/demonstration period, operating costs would be tackled by market actors, such as heat/fuel suppliers, to be integrated directly into their new business models. This could also provide some commercial advantages compared to fossil fuel suppliers not adapting their business models to the needs of the transition to a low carbon heating and cooling system (driving more energy efficiency and renewables, with energy utilities and other suppliers delivering new services).

[365] Energy Systems Catapult. (2019). Bristol Energy becomes first UK supplier to trial "heat as a service". Available at: https://es.catapult.org.uk/news/bristol-energy-is-first-uk-supplier-to-trial-heat-as-a-service/

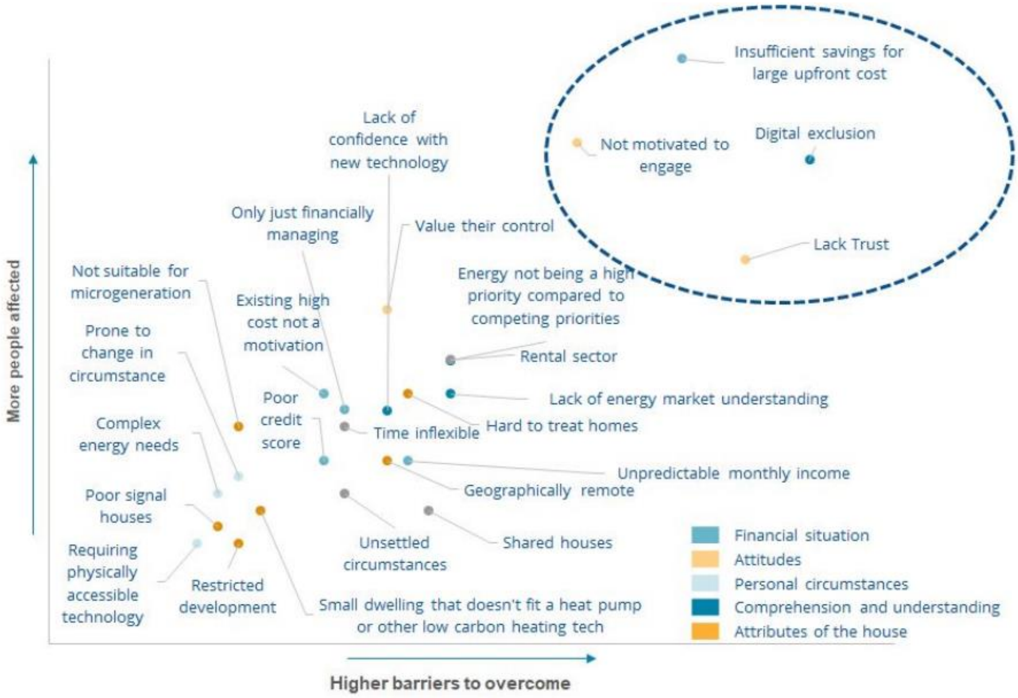
Consumer empowerment[366]

The example of Bristol Energy (textbox 3-5) highlights a very big opportunity associated with this option – consumer empowerment and increased awareness. Some of the key aspects highlighted during a workshop held on September 2019 on the topic of "heat as a service", point to consumer distrust due to lack of information and the underdeveloped stage of this concept (cf. figure 3-5). In particular, consumers would be interested in having flexible contracts of no longer than 1-2 years and to be able to "roll-over" the next year unused usage under the "Energy as a Service" contracts (similarity with mobile phone plans). Further, consumers need to be able to easily quantify the benefits and risks of taking up an offer and how the technology and service is performing in real world scenarios. During the same workshop, key barriers identified by customers to Heat as a Service (and wider Energy as a Service) were presented:

- Physical aspect of homes – service companies might not guarantee outcomes for energy inefficient homes and there can be insufficient space to install new equipment;
- Changes in circumstances – contracts are less attractive if they do not allow for change or if a changed contract might lead to a higher price;
- Trust – the concept is unfamiliar to consumers, and they need to trust a third-party to externally deliver the agreed service in order for the business model to be viable;
- Digital literacy – the service requires accessing energy use through technology and a significant minority of adult population does not have a smartphone or do not know how to use it.

Figure 3-5 provides an overview of barriers and concerns to implementation of the energy and heat as a service models.

Figure 3-5 Cluster of financial and attitude barriers to be addressed to implement future energy business models. Citizens advice and Future Energy Consumers (2019)[367]



[366] Based on: UK Energy Research Centre. (2019.) Heat as a Service: Understanding evidence needs and research gas – Workshop Report.
[367] Tom Crisp and Krista Kruja. (2019). Future for all: Making a future retail energy market work for everyone. Citizens advice and Future Energy Consumers. Available at: https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/Future%20for%20all_FINAL.pdf

Investor certainty

A recent study shows that a business model based on heat purchase agreements could be used to lower the barriers to heat pump adoption associated with their high upfront costs. The study is the first to consider economic analysis of heat purchase agreements as a third-party ownership model for electric heat pumps.[368] Such new business model for efficient heat pumps, significantly reduces or even eliminates (depending on the scheme design) the user's initial cost. If appropriately designed, the business model could also include provisions enabling the access to wholesale electricity markets and services, decreasing the fuel-costs (or adding some revenues), and facilitating the integration of renewable generation into the power system. Such business model could accelerate the adoption of technologies like heat pumps, leveraging the economic interest of both parties (supplier & consumer) in the most cost-effective way.

Textbox 3-6 Business model based on heat purchase agreement

Heat pumps' upfront costs can be very high, and their lifetime costs are only competitive with incumbent technologies when their design and operating conditions are appropriate. This leads heat pumps to be very sensitive, and less attractive than incumbent technologies for many end-consumers. However, with an appropriate business model based on heat purchase agreements, those barriers to heat pump adoption can be lowered.

In this business model, a user uses a heat pump owned by an aggregator, which installs the heat pump at low or no initial cost to the user. The user purchases the heat (or cooling) produced by the heat pump from the aggregator. The aggregator buys the input electricity to run the heat pump, in the wholesale energy market selling flexibility services of their aggregate electrical load in ancillary service markets. The "Heat purchase agreements could lower barriers to heat pump adoption" paper presents the first economic analysis of heat purchase agreements as a third-party ownership model for electric heat pumps. The paper derives conditions under which a heat purchase agreement is beneficial to the consumer and the aggregator (or service provider). It also provides a method for the fair pricing of heat (& cooling). The paper shows how a typical United States home case's heat purchase agreement could more than double the value of a heat pump investment, compared to the reference situation.

More globally, new business models would increase the attractiveness of renewables, addressing the increasing willingness of households to move to carbon-responsible or green solutions. This would stimulate the market and increase the cost-competitiveness of renewables for all.

[368] Kircher, K. and Zhang, K. M. (2021). Heat purchase agreements could lower barriers to heat pump adoption. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0306261921000490

Textbox 3-7 Examples of Geothermal Heat Purchase Agreements

Corporate sourcing of geothermal heat - The heat and cold supply to industry allows for several business models: Self-Consumption with integrated project development, public-private partnership, HPA real or virtual, ...This is a growing market and dependent on geothermal plants supporting the development of local infrastructure to link to specific customers:

1. **Vapori di Birre brewery in Tuscany, Italy – The brewery purchases heat from the local geothermal power plant operated by Enel. The heat contract is for a long-term and comes at a discounted price. The brewery uses this geothermal heat for the production of beverages and also in its marketing of geothermal beers;**
2. **TORK Paper Mill, New Zealand - TORK Paper Mil entered into an agreement with Ngati Tuwharetoa Geothermal Assets (NGTA), the local geothermal power plant, in efforts to drive down production costs, reduce greenhouse gas emissions and support local communities. A percentage of the profits of the mill are spent on improving the social economic and cultural well-being of the local Maori community. Total CO2 emissions were reduced by 42% by replacing gas-powered steam with geothermal steam;**
3. **ECOGI - ECOGI is a joint venture between Electricité de Strasbourg Group (supplier), Roquette Frères (industrial heat consumer), and the Caisse des Dépôts (public infrastructure fund) to supply geothermal heat which is used for industrial processes to convert plant-based raw materials into products for the pharma, nutrition, food, and selected industry markets. The Rittershoffen geothermal plant in France provides 25% of the heat required by the bio-refinery. The €55 million project also received €25 million from the Fonds Chaleur operated by ADEME, the French environment agency. This included a €13 million guarantee fund to de-risk the project during the project development phase. A 15 km loop was created between the geothermal plant and the bio-refinery.**

Subsidiarity

These schemes and contractual arrangements are still in their infancy, but look very promising with already some success stories (in UK, USA). The legal basis would probably be very limited, while some framing, or backstopping (finding demonstration or pilots) of the authorities may be required to provide guidance, and suppress potential barriers (e.g. in the case of heat pumps as in the textbox above, aggregators should be allowed to participate in the wholesale market with all types of electrical units, such as small-scale heat pumps). The design of these instruments would be left to the MS, to comply with the implementation of the market design at national level, and possibly with building codes or requirements (addressing comfort), although inviting MS to develop such schemes would incentivise their development. As these schemes would depend on many national/local factors, more requirements from the EU would be counterproductive, although the EU could support the sharing of best practices, and possibly provide some guidance.

Coherence

The “heat as a service” schemes, and renewables heat purchase agreements would also, e.g., require the service provider (like an aggregator) to understand the physics of the building and the corresponding H&C system, in order to maximise the potential for flexibility. Consideration in relation to relevant synergies as regards the building installations, envelope and H&C system focusing on performance and energy efficiency are:

- A heat purchase agreement framework should ensure the respect of building codes and requirements, including comfort, indoor air quality, therefore liaising with the Minimum Energy Performance Requirements (art 4 of EPBD) and the Energy Performance Certificate framework (art 11 of EPBD);

- The installer may not install the H&C system appropriately, potentially reducing the efficiency of the system during its entire life. This entails the most of the Energy Efficiency First principle (EEF), where it's not only the material and the quality of the installation but also the operation of the H&C appliance (across the whole value chain) which provides the assurance of the most efficient system. A heat purchase agreement framework should ensure alignment with the notion of "energy service" (article 2(7) of EED), which may include the operations, maintenance and control necessary to deliver the service. Such services could lead to a holistic accompanying process, addressing the building performance and the potential improvements, with dedicated professionals, facilitating the implementation of Building Renovation Passports. Therefore, a possible framework setting up BRPs under the EPBD should consider the use of heat purchase agreements as an option to accompany the renovation works and investments;
- The Market Design is tackling the possibility for more small-scale systems to provide services, as illustrated above in the case of heat pumps, but also in the case of CHP.

A comprehensive carbon pricing (ETD or ETS extension) would also directly have an influence on supporting such heating purchase agreement framework, increasing the attractiveness for renewable H&C, and the interest to develop adequate business models, possibly based on a service concept. A stable framework is a prerequisite (e.g. avoid changing fiscal rules, such as for electricity which is key for the deployment of heat pumps; a secured incentive scheme). For HPA providers, it is key to properly manage all risks related to the evolution of the price of fuels, depending to a large extent on the magnitude of carbon pricing. Therefore, a very clear carbon pricing long-term perspective (e.g. progressive increase of the level over the years/decades) and a strong and stable political commitment (e.g. Nordic countries using a carbon pricing as backbone of their decarbonisation policy, with a long term and stable scheme) would be a main component to manage market-related risks of all potential low carbon solutions, providing more security to Heat Purchase Agreements to be deployed.

Furthermore, the success of this option is dependent on the availability of all potential technologies, their infrastructure and carrier, on the development of the adequate delivery infrastructure (heat network, but also electricity or gas grids), increased digitalisation of buildings and smart meter roll out.

By tackling these issues, authorities will support different professionals in developing new business models, helping coordination between heat markets, electricity market, building design and performance.

Administrative burden and regulatory costs

Given the novelty of this concept and the lack of experience, to guarantee the success of HPAs, some preparatory regulatory work on behalf of the MSs may be required. HPAs, unlike PPAs, face an **infrastructure** challenge, but also a lack of capacity (at least for households) which slows down the market. E.g there is a lack of dedicated renewable heating and cooling infrastructure which means that surplus heat (from industry, incinerator, geothermal drilling, ….) is often fed into local communities, at the expense of the network operator and/or heat producer. There is also a growing trend for companies to **invest in their own heat energy capacity** (e.g. geothermal) to provide on demand renewable heating and cooling. Large industrial and retail users are turning to this solution.

Long-term heat purchase agreements are a crucial mean to secure investments in capex intensive district heating and cooling projects (mainly in geothermal), and often a prerequisite. Public authorities in France commit to purchasing a percentage of heat from district heating systems to meet their consumption needs

in buildings, social housing, etc. This serves as a de-risking mechanism and allows for private entities to join into the DHC system to purchase the remaining heat from the project.
However, the market for HPA is in its infancy, and will be deployed on a case by case basis, therefore reducing the importance to set up exhaustive regimes.

The use of “heat service contracts” or renewables heat purchase agreements would not be mandatory and would therefore be feasible only if these are manageable in the frame of a business case. As a prerequisite, national and/or local authorities would need to ensure that there are **consumer protection instruments** in place, that **heat networks and appropriate building regulations** are in place, that **rules are aligned** to incentivize the efficient use of heat, and that there are protection rules for poorer households, etc. Thus, the cost and administrative burden of implementation can be important to deal with all linkages with different instruments and rules, which could be very complex and imply heavy coordination costs, although increasing the resilience of the H&C system in the long run. Heat Purchase Agreements cannot be seen as a standalone instruments, but have to be mainstreamed in a comprehensive set of market and regulatory instruments. In several places (MS), many of these instruments already exist, or will be implemented in the frame of the LTRS, therefore reducing the administrative starting cost of setting the frame for Heat Purchase Agreements. Some regulatory barriers may remain under these other areas also, jeopardising the progress and achievements of such schemes. Therefore, at national level, an assessment of the boundaries would be required to ensure such schemes are appropriate and would deliver in a cost-effective way. Such assessment does not require necessarily heavy work, building on projects under development, to identify the barriers, and address them where needed.

In the long term, contractual arrangements providing guarantees to the consumers are expected to lead to decreased complaints against fuel suppliers, although such evolution would probably require additional attention from the authorities (or regulators) during a transition period.

Administrative burden and associated costs, and the success of the deployment of HPAs will depend on the existing administrative frameworks in place, and the global policy context to decarbonise the building sector. In addition to the above-mentioned aspects, some minimum administrative requirements foreseeable could include:

- It is key for the concerned parties (service and heat providers, large consumers) to have a comprehensive understanding of all parameters influencing all heat markets (renewable and fossil), starting with regulations and policies. New business models and HPA can emerge only if the global heat market framework is very clear, and appears stable to the players, in order for them to manage the risks (of supply and demand). This is key in a fast moving environment. Access to information is key;
- MSs would then need to assess the remaining regulatory and administrative barriers to long-term renewables heat purchase agreements (like for the power purchase agreements under art 15(8) of RED). This could be tackled on a case by case basis (on project under development), and therefore save time and efforts;
- In order to strengthen consumer protection and global effectiveness, heat purchase agreement schemes might be required to address all above-mentioned aspects. These would apply first in the case of district heating and cooling, and then extend progressively to individual systems (large-scale first). Such schemes should support HPA to be transparent and comparable, should help avoiding lock-in effects and therefore potential stranded assets (as HPA are concerning two parties on the long-term, this is a crucial element to consider).

Some policy and regulatory challenges and possible solutions as identified by participants of a “Heat as a Service” workshop are presented in the figure below.

Figure 3-6 Policy and regulations: knowledge, opportunities, challenges and solutions for implementing Energy as a Service [369]

Policy and regulation			
Existing knowledge	Opportunities	Challenges	Solutions
- Decarbonisation heat policy - Government work on transforming heat - Heat networks - 2050 Carbon neutral target - Policy Connect report - Freedom project heat pump research - Government energy white paper - Committee on Climate Change reports - Gas network price review - Heat Trust for DH - Building regulations - ESC Smart Energy Services for Low-Carbon Heat - Circular economy - Association of Decentralised Heat (ADE) - Heat suppliers code of practice - Clean growth strategy pathway - Social responsibility - New London heat map - Ofgem future energy series	- Need more supportive policies for HaaS/ market enabling regulation - Need for regulation around sustainability	- The policy ‘strategy’/for converting to low carbon - Financial viability of business model for suppliers - What happens when someone moves to a new house? - Switching regulation (between energy suppliers) - Policy focuses on homeowners - No clear policy on social equity - Focis on new build not retrofit - Government fear of vested interests - Regulations restrictive and not set up for HaaS - Not enough incentives for decarbonise - (Mis)Aligned incentives - Lack of proven market for HaaS - Policy which is truly tech-neutral and properly integrated with data and technology - Strong policy missing - Renewable Heat Incentive does not incentivise energy efficiency	- Ban gas - Making gas more expensive - Equitable carbon pricing - Emissions pricing - Empowered sandbax to test new policy - String policy signal - Modular regulation to break down barriers to innovation - Licensing overhaul - Move to local energy systems - Link HaaS to Hydrogen switchover - smart heating - Ensure no one is penalised for missing a payment - Regulatory support for utility bundles with rent - Appropriate competition framework - Policy regulation to interact with academics and industry - New regulations and polices - More subsidies and incentives from the government - Public access to consumption data - Relax current regulations and move to principle based

[369] Own elaboration based on UK Energy Research Centre. (2019). Heat as a Service: Understanding evidence needs and research gas – Workshop Report. Available at http://geography.exeter.ac.uk/media/universityofexeter/schoolofgeography/images/researchgroups/epg/Workshop_Report_Heat_as_a_Service_(2019).pdf

		- Standard Licensing Condition tariff rules	

As expressed above, most of the challenges are beyond the frame of HPA, and should be considered as prerequisite.

Regarding compliance costs, these are relatively limited, and in any case would be recovered by de-risking capital intensive investments with long-term contracts. To illustrate, minimum aspects to consider for setting up heat purchase agreement schemes are, among others[370]:

- the nature of the service to be provided;
- this aspect should consider the potential heat sources available, physical assets subject to the delivery of heat (generation, distribution, supply), pre-existing market and regulatory framework etc.;
- the standing and creditworthiness of the parties;
- minimum service standards;
- remedies for poor supplier performance;
- customer and supplier responsibilities;
- calculation of charges;
- price review mechanisms;
- break points and termination;
- insurance and liability;
- dispute resolution; and
- arrangements upon the expiry of the supply period.

An interesting approach could be, like in France, to invite (or even mandate) public authorities to commit to purchasing a percentage or determined amount of heat from DHC systems to meet their consumption needs in property buildings (administration, social housing, sport infrastructure, etc.). These could serve as de-risking mechanisms and allow private entities to connect to the DHC system to purchase the remaining heat from the project, and even later for other private developers to get inspired with the contractual arrangements, and make use of such contracts.

Variant 3 - Risk mitigation framework for RES heat supply projects (heat production and related infrastructure) with large upfront investment

Effectiveness

The Energy Efficiency Financial Institution Group (EEFIG[371]) identified four reasons why financial institutions should consider deploying capital into energy efficiency:

- energy efficiency represents a large potential market, given the carbon neutral ambition of Europe and the large untapped potential to increase the energy performance of the EU building stock;
- reducing risks in two ways. Firstly, increasing energy efficiency improves the cash flow of clients, thus reducing their risk. Secondly, there is a risk of financing assets that could become stranded when energy efficiency improves (the market will be more and more driven by Energy Performance Certificates, putting owners of low performing buildings at risk);

[370] Scottish Futures Trust. (2018). Guidance on the development of Heat Supply Agreements for District Heating schemes. Available at: https://www.districtheatingscotland.com/wp-content/uploads/2018/02/HSA-guidance-final-Feb-18.pdf
[371] EEFIG. (2017). EEFIG underwriting toolkit – value and risk appraisal for energy efficiency financing. Available at: https://www.bpie.eu/wp-content/uploads/2017/06/EEFIG_Underwriting_Toolkit_June_2017.pdf

- improving energy efficiency has a direct impact on reducing emissions of carbon dioxide and other environmental impacts such as local air pollution;
- bank regulators are increasingly looking at climate-related risks.

Although the majority of energy financing was focusing on renewable energy generating assets (electricity) until the last decade, private finance in energy efficiency is only taking up now, and obtaining adequate financing for small renewable projects (especially in the building sector) still remains a challenge.[372]

Therefore, increasing access to long-term debt and renewable installation finance through adequate instruments is needed, and should be bundled with energy efficiency instruments. The EEFIG should be explicitly extended to RES H&C, and foresee the possibility for aggregation of small units to facilitate or leverage de-risking.

The cost to include RES into the EEFIG would remain limited, building on already existing tools. Specific additional costs would come from increasing awareness on RES H&C technologies especially, on setting procedures into place for aggregation. But these costs would remain limited compared to the expected decrease of the cost of capital (by de-risking) or simply by making more finance available.

Textbox 3-8 De-risking Energy Efficiency Platform

The De-risking Energy Efficiency Platform (DEEP[373]) was developed by the EEFIG De-risking Project consortium and launched in the end of 2016 in close coordination with the Commission's "Clean Energy for All Europeans" package. DEEP is an open-source database for energy efficiency investment performance monitoring and benchmarking, based on evidence from implemented projects. The main objective of the DEEP is to improve the understanding of the real risks (especially performance risks) and benefits of energy efficiency investments based on market evidence. At launch, the database included more than 7,800 energy efficiency projects in buildings and industry from 25 data providers. DEEP provides anonymized historical data structured along major project characteristics (geography, energy efficiency measures, verification status, industry / type of building, multiple benefits, etc.). It provides insight on financial performance indicators such as payback and discounted avoidance cost. Financial institutions can use this evidence in market assessment, performance risks calculation and to benchmark their own individual projects or portfolios against user-selected sub-sets of the projects in DEEP.

Policy makers can help address the exploration risk barrier and attract investment by supporting the collection and sharing of data on resource potential, and providing de-risking loan guarantees and grants and risk insurance funds. By de-risking the upfront investment in the projects, these could become attractive to investors looking for relatively secure long-term revenue streams as opposed to a quick return on investment.[374] In the case of, for example, DHC projects long-term contracts with customers known to have a high demand for heat such as hospitals, industry and swimming pools could constitute a relatively easy solution to managing risks associated with new project development.[375] These are covered under the previous variant (HPA).

[372] The Lab Driving Sustainable Investment. (2016). Small-Scale Renewables Financing Facility. Available at: https://www.climatefinancelab.org/project/small-scale-renewables-finance/
[373] De-risking Energy Efficiency Platform (DEEP). Available at https://deep.eefig.eu/
[374] Bertelsen, N. et al. (2021). Integrating low-temperature renewables in district energy systems: Guidelines for policy makers.
[375] Ibid.

Adequate de-risking instruments would require some public funds as illustrated in the case of France and its GEODEEP fund for covering the natural risk associated with deep geothermal drilling. This kind of fund, if well designed, should recover automatically as the experience would lead to globally decrease the risk associated and therefore reduce the likelihood to activate the guarantee, which provision would therefore be used for the next investments. Further, the initial high-investments can be balanced by costs of energy provision, the French environment agency (ADEME) found that geothermal district heating in France costs between €15 and €55/MWh compared to €51 for fossil gas provision.[376]

In the Netherlands, the geothermal risk mitigation scheme is insurance-based. Eligible projects pay a premium of 7% of the total drilling costs to the scheme. In returns, they are compensated if the realised geothermal output from a drilled well is less than the 90% probability expected geothermal power output. Furthermore, if the project is unsuccessful the developer can recover 85% of the total costs (capped at 11.05 million EUR for shallow geothermal and 18.7 million EUR for deep geothermal). Since 2009, the scheme has supported 11 successfully realised projects.[377]

Therefore, de-risking instruments would have a negative entry impact, but with the ability to improve the impact over time.

Textbox 3-9 GEODEEP fund de-risking deep drilling in France [378]

Endowed with 50 million euros, of which 25 million are provided by the French Energy Agency ADEME, 15 million by private operators and 10 million by the French Development Bank Caisse des Dépôts, the GEODEEP Fund will ensure project holders against the risk of finding poor geothermal resources. The fund indemnifies developers against unsuccessful exploration or exploitation drilling.
It represents a real support for developers to engage in new investment by decreasing project risk. By securing the financial risk taken by industrialists in deep geothermal projects, this fund supports the development of the industry.

This fund was expected to support the development of more than 10 deep geothermal heat generation plants, to carry out investments of more than 500M Eur, creating more than 700 jobs for the study, drilling and construction, and more than 120 jobs for the operation phase (over a period of more than 15 years).[379] This fund is also expected to boost innovation by incentivising demonstration projects (including in using Organic Ranking Cycling (ORC) technologies).

[376] ADEME. (2020). Coûts des énergies renouvelables et de récupération en France – données 2019. Available at: https://www.geothermies.fr/sites/default/files/inline-files/couts-energies-renouvelables-et-recuperation-donnees-2019-010895.pdf
[377] Ibid.
[378] GEODEEP project (accessed on 10/05/2021). Available at: https://www.geodeep.fr/
[379] Un fonds de garantie pour accompagner le développement de la géothermie. Available at: https://www.enerzine.com/un-fonds-de-garantie-pour-accompagner-le-developpement-de-la-geothermie/18436-2015-03

Textbox 3-10 Goethermal district heating in Munich [380]

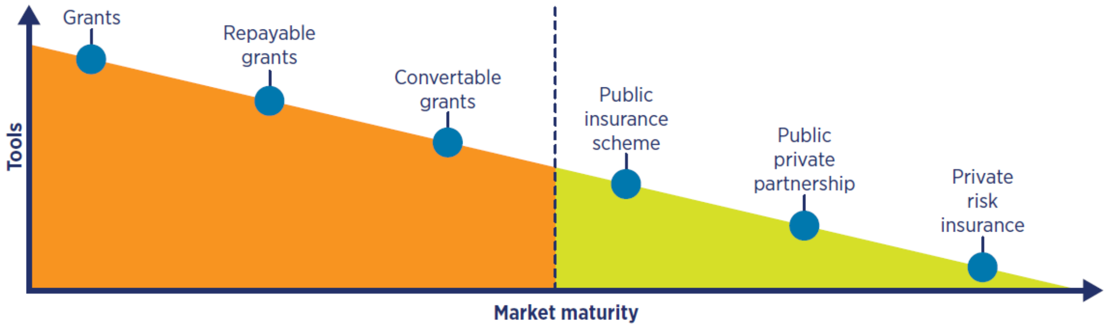
Stadtwerke München (SWM), the utility of the city of Munich, Germany, is moving ahead with a plan to supply 560,000 households (based on an estimation of the usable geothermal energy potential at 350 to 400 thermal MW) in the city with geothermal heat via district heating by 2040. Munich's geographical location allows it to tap into large amounts of hot water underneath the city. Although, drilling is still subject to uncertainty as there is no guarantee of successfully taping into geo-sources, new technology has improved the process, for example, three dimensional images of the subsurface can be now created using sound waves (seismic). Currently, SWM is already constructing "the largest geothermal energy project in Europe" with a capacity of 50 MW in the middle of the city on the premises of a gas-fired combined-cycle CHP plant. Drilling has already been performed successfully.

The EU-funded project GEORISK[381] also aims to support mitigation of resource and technical risks of geothermal projects, by first assessing the de-risking tools available in the market and then proposing a risk-mitigation scheme that can be applied in Europe and in selected countries in other regions (Irena, 2020).[382] The project has shown that for technologies such as geothermal energy, the most effective risk-mitigation instrument will depend on the level of market maturity as shown in Figure 3-7.

Different countries/regions in the EU might be at different stages of market maturity and thus might differ in the most appropriate design of financial instruments to mitigate project risks. As the technology becomes more market ready, it will become increasingly more attractive for private investors and thus public spending will diminish. Research to analyse the impact of technical and economic uncertainties of a deep geothermal heat system in Groningen, The Netherlands finds that the current Dutch subsidy scheme provides insufficient support to overcome the technical challenges of the project. A scheme designed to have a shorter duration but more impact in the post-development phase of the project could provide a better counterweight for the high initial investment costs.[383] This example shows the importance of appropriate design of support schemes that are suitable for addressing project-specific characteristics.

Figure 3-7 Relationship between risk mitigation scheme and geothermal market maturity. (Aalborg University, 2021)[384]

[380] Think Geoenergy (2020), Munich targeting geothermal district heating for 560,000 households. Available at: https://www.thinkgeoenergy.com/munich-targeting-geothermal-district-heating-for-560000-households/
[381] Developing Geothermal Projects by Mitigating Risks with Financial Instruments. Available at: https://www.georisk-project.eu/
[382] IRENA, IEA and REN21. (2020). Renewable Energy Policies in a Time of Transition – Heating and Cooling. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_IEA_REN21_Policies_Heating_Cooling_2020.pdf
[383] Daniilidis A.; Alpsoy, B.; Herber, R. (2017). Impact of technical and economic uncertainties on the economic performance of a deep geothermal heat system.
[384] Aalborg University. (2021). Integrating low-temperature renewables in district energy systems: Guidelines for policy makers. Aalborg University & IRENA. Available at: https://vbn.aau.dk/ws/portalfiles/portal/406326231/Integrating_low_temperature_renewables_in_district_energy_systems_Guidelines_for_policymakers_2021.pdf



More global EU funded de-risking initiatives exist, such as the Horizon 2020 project TrustEE[385] which, aims at financing and realising energy efficiency and renewable energy projects in industry. First, it reviews and assesses an investment project proposal, streamlining technical due diligence by using benchmarks versus state-of-the-art technology/systems. A financial assessment is also conducted based upon financial risk/return requirements. TrustEE[386] is driven by the need to de-risk capital intensive investments, to support the development of feasibility studies and attract more investment.

The RenoWatt[387,388] **project is another type of de-risking instrument** aiming at improving the energy efficiency of public buildings. It is a one-stop-shop that is responsible for the conclusion of Energy Performance Contracts (EPCs), by selecting buildings that are suitable candidates for renovation, launching the public procurement procedure and assisting municipalities with the implementation of EPCs. This project will be partly financed by a grant from the EU's ELENA programme via the European Investment Bank (EIB). The RenoWatt project will support municipalities in their energy transition by focusing on three areas: energy performance contracts, pooling of buildings and central purchasing. The objective is to offer free technical assistance to Wallonia's 262 municipalities with a view to carrying out at least EUR 100 million of investments under EPCs covering more than 500 buildings. The pooling of buildings is an excellent example of how the risks can be mitigated, and addressed appropriately.

Investor certainty

De-risking instruments could allow operational renewable energy projects to finance into long-term debt and increase the financial leverage by "discounting" the future cashflows, possibly from a heat purchase agreement. These cashflows could serve as guarantee, reducing the amount of equity needed and improving financing terms, for increasing the capacity to invest, addressing more holistically the investment in renewable H&C system. While such instruments would focus on financing, their goal would be to increase new investments in one specific situation (in one building, one district heating and cooling network, one geothermal generation plant, one industrial process) when all energy efficiency and renewables are not addressed in a coordinated way, especially when the new investments would have a longer payback time.

[385] TrustEE. Available at: https://www.trust-ee.eu/
[386] TrustEE. (n.d.) Financing and de-risking industrial efficiency and renewables. Available at: https://www.trust-ee.eu/files/otherfiles/0000/0004/TrustEE_FolderMay17_955_Crop.pdf
[387] The Renowatt concept explained by Renowatt. (4 October 2018). Available at: https://renowatt.be/fr/confrence-de-presse041018/
[388] European Investment Bank. (2018). Belgium: with the EIB and ELENA, the RenoWatt project, energy for jobs, opens to all Wallonia. Available at: https://www.eib.org/en/press/all/2018-242-renowatt-lenergie-au-service-de-lemploi

Investor's certainty is directly linked to the de-risking instrument, raising investors' confidence to provide capital for the targeted investments such as DHC network, geothermal drilling and changes in industrial processes. Therefore, a risk-mitigation framework will increase the confidence of investors.

Macroeconomic impacts

According to the EEFIG, evidence from the market strongly suggests that simply providing capital does not necessarily lead to successful deployment of that capital. It is necessary to consider the factors that drive demand for financing energy efficiency and put in place mechanisms to help drive demand such as technical assistance and marketing. The same applies for small-scale renewable, with some distinctions.

All renewable investments, whatever their size or nature, face various types of risk such as performance risk (e.g. poor quality material and/or installation), economic risk (e.g. recovery of waste heat), natural risk (e.g. geothermal deep wells not providing the expected heat), market risks (e.g. bio-energy price subject to worldwide market fluctuations) and/or delivery risk (e.g. when the carrier relies on infrastructure like an electricity grid not adapted to manage the increase number of heat pumps, or on longer transportation routes). Addressing appropriately the categories of risks is key to define the approach to risk mitigation and financing. Databases for heating and cooling investments (RES and EE), adapted to the final application (small scale individual unit, district heating and cooling or industrial systems) could support de-risking those investments.

Setting up risk-mitigation instruments are no-regret measures and should be adopted in a structured way to frame the decarbonisation of the whole heating and cooling sector, building on existing tools and initiatives.

Innovation

As illustrated by the French case, de-risking instruments can spur demonstration, delivery of innovative solutions and concepts, and ensure a learning-by-doing process along the whole value chain, involving research centers and academics, financing institutions, investors and the public sector to collaborate on solutions with a long-term impact, and level of replicability. Innovation could directly benefit from these de-risking instruments.

Distributional impacts

De-risking instruments decrease the cost of capital, and therefore reduce the cost of renewable H&C technologies, increasing their attractiveness to all. Policy makers can help attract investment by providing de-risking loan guarantees and grants and risk insurance funds. Like in the case of the geothermal fund in France, such funds could be supported by public funds, to be complemented by private means.

No additional costs would have to be borne by low income households. However, such instruments would not directly tackle the distribution of the benefit or of the cost. In the case of developing new DHC project, there is a danger that starting with the most profitable areas for new project development, those with high internal rates of return (IRRs), will result in excluding less profitable areas which might never get connected to district heating grids. Thus, the recently developed guidelines for policy makers suggest that it is important to assess new project profitability in function of the socio-economic parameters rather than from a purely business economic perspective.[389]

[389] Bertelsen, N. et al. (2021). Integrating low-temperature renewables in district energy systems: Guidelines for policy makers

MS with less financial means would have less resources to set up such instruments, even by involving private actors. An EU guarantee fund could be an option to tackle this barrier.

Therefore, globally these instruments may have a neutral impact on the distribution, allowing more consumers to use renewable H&C as a positive effect, but without considering low income to benefit more nor providing additional capacity to MS with lower financing means as negative effect.

GHG emission reductions and environmental impact

The environmental impacts are the same as all other measures accelerating RES H&C deployment. These de-risking instruments may have an additional positive effect by directing the RES H&C deployment towards locally available resources, and more capital intensive investments such as solar heat, geothermal heat, district heating, heat pumps (large and small-scale) instead of more fuel and operating expense intensive technologies (mainly bio-based, but also possibly RFNBOs). This would increase the share of these capex intensive technologies, and possibly decrease the share of the opex and fuel-cost driven technologies.

Financing instruments

Access to finance is a key consideration for many projects focused on decarbonizing the H&C sector and significant investment is still required for the widespread deployment of renewable and low-carbon solutions in the sector. In this context, financial incentive schemes in the form of grants, loans, guarantees etc. can facilitate the overcoming of market barriers and speed up the transition process in the H&C sector. They can be used to reduce upfront investment cost and stimulate market development and availability of RES H&C technologies among other benefits.[390] Investments in H&C projects, energy efficiency and renewable energy, still have relatively long payback periods or/and are perceived as high risk. To have a convincing business case such investments often require the maximization of public funding. Although, there are currently no dedicated financing instruments for H&C at EU level, many generic energy subsidies and grants are available and can be accessed for the purpose of financing H&C initiatives.[391] Given the lack of dedicated instruments, stakeholders need to have a good understanding of the different financial instruments available to exploit them for the purpose of financing green and low-carbon H&C projects.

A barrier associated with financing is that the amount of public financing needed is difficult to estimate. A recent review of the NECPs submitted concludes that there is a wide variation of methodologies and cost/benefit results. As a consequences, the NECPS do not give the EU a useful guide to understand the spending needs. As an example of the range, the EU-average expected total investment cost to cut one ton of CO_2 is €522/annum. The highest-cost countries are Portugal (€1,645), Italy (€1,312), and Bulgaria (€1,174). The least-cost ones are Estonia (€47), Lithuania (€67), and Denmark (€82). The review suggests that the EU Commission needs to help the MSs revise their NECPs and make them consistent and

[390] EREC. (2007). Financial Incentives for Renewable Heating and Cooling. Available at: https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/k4res-h_financial_incentives_for_renewable_hc.pdf
[391] PNO and JRC. (2019). Identification of EU funding sources for the regional heating and cooling sector. Available at: https://op.europa.eu/en/publication-detail/-/publication/782b29a2-4159-11e9-8d04-01aa75ed71a1

transparent.[392] Although the example is not focus specifically on the cost of increasing RES, it provides a good illustration of the challenges associated with financing, also in the case of RES for the H&C sector.

Subsidiarity

Several de-risking instruments exist, such as de-risking loan guarantees, grants and risk insurance funds, but also other instruments less direct but tackling investment risks through the mutualisation of the risks (e.g. pooling buildings), or by providing the required expertise via contracting schemes, such as EPCs. Many of these schemes could benefit the EU financing and funding capacities, and could benefit the existing framework (e.g. ELENA by the EIB), while ensuring they fit to the national context. EU action is required to deliver economies of scale and Union-wide coverage as well as to ensure a competitive single market for energy.[393]

A number of stakeholders have pointed out that to further support the competitiveness of DHC systems, these should be recognised as Projects of Common Interest within the framework of the Connecting Europe Facility (CEF) and the Trans-European Networks for Energy (TEN-E).[394] This could also lead to develop EU de-risking instrument(s), providing dedicated funding for the large systems.

However, the design of these instruments would also be left to the MS, therefore more requirements from the EU would be counterproductive, although the EU should continue to provide additional funding, and should probably also support the sharing of best practices, and possibly provide some guidance, as the experience implementing such instruments remains limited.

Action at MS-level would not have been completely sufficient to significantly contribute to deploying renewables in the H&C, as these de-risking instruments are not completely new but still remain not broadly developed and implemented across EU MS. Therefore, by reason of the effects of the variant, EU action would have an added value, at least to incite MS to take the required action.

Coherence

The effectiveness of these risk mitigation measures and de-risking instruments would also strongly depend on other related instruments, such as:

- the ETS and ETD price level and stability are key factors to increase the attractiveness of renewable options in H&C by increasing the revenue streams (or decreasing the operating cost compared to a fossil reference). With high and stable carbon prices, the cost of de-risking instruments would reduce accordingly (e.g. risk insurance would be reduced to reflect the risk). Such risk mitigation framework should recall that stable and visible energy price evolution (incl. the carbon pricing components) would have a key role in mitigating the risk;
- The EU Innovation Fund could be used to set up EU de-risking instruments (e.g. loan guarantees, grants and risk insurance funds);
- A revised version of the LTRS framework (art 2a of EPBD) could broaden the scope of article 2a(7), suggesting each MS to use its LTRS to address risks (see above, e.g. geothermal or natural risks,

[392] Stagnaro, C.; Di Bonifacio, C. (2021). Wide variations in National Energy and Climate Plans: how can the EU seriously budget for emissions reduction? Available at: https://energypost.eu/wide-variations-in-national-energy-and-climate-plans-how-can-the-eu-seriously-budget-for-emissions-reductions/
[393] Dumas P. (2021). Five steps to delivering the geothermal decade. Available at: https://www.euractiv.com/section/energy/opinion/five-steps-to-delivering-the-geothermal-decade/
[394] Ibid.

market risks for DHC, waste heat recovery stopped due to bankruptcy of the waste heat supplier, …) possibly affecting important heat projects;

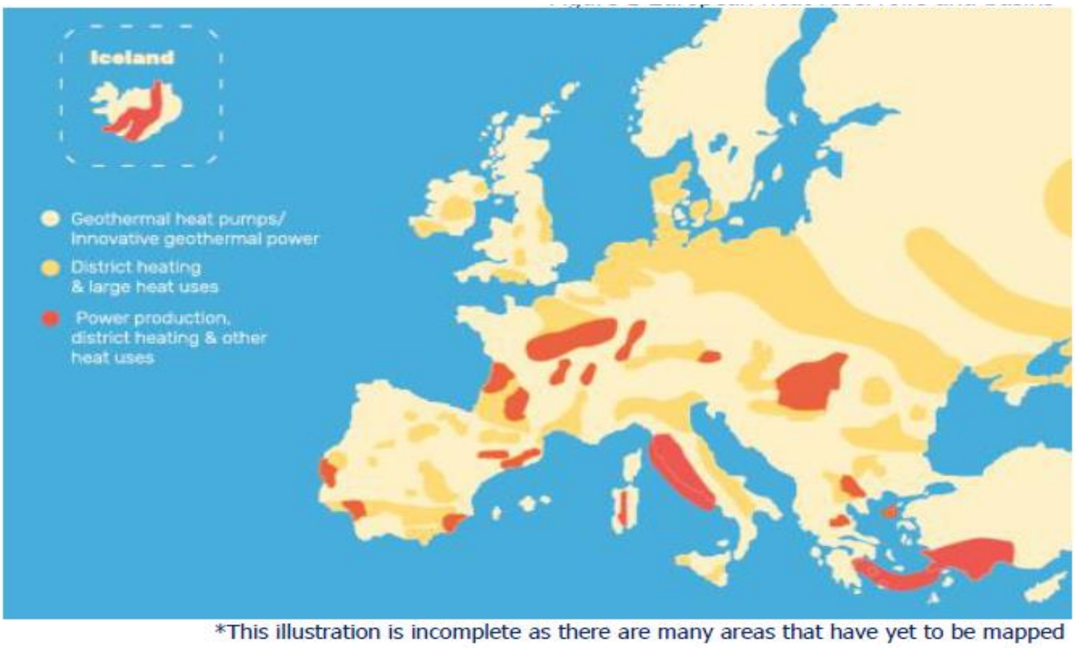
- The same applies for the comprehensive assessment under article 14 EED.

Authorities should have an active role in designing and implementing these instruments. They could support the coordination between different professionals to help developing the instruments.

De-risking requires to ensure high quality systems and performance, and professionals with the appropriate knowledge and skills, during the installation and operation. This entails the most of the energy efficiency first principle (EED), where the material, the quality of the installation and the operation of the H&C system is taken into account across the whole value chain.

At the moment under the Trans-European Networks for Energy framework, geothermal and district heating and cooling projects are not recognised as Projects of Common Interest (PCI) to access funding and they are also not eligible for fast-track licensing and permitting rules under the Connecting Europe Facility. However, the regulation is currently being revised and it has been argued that the inclusion of geothermal and DHC would result in strengthening the internal energy market while delivering on the RED II targets, especially in relation to Article 23 and Article 24. [395] Currently, an argument for excluding heat under the TEN-E is that heat is more localised and not transboundary. However, the figure below shows that European heat reservoirs and basins within the EU are not constrained to national boundaries. Adding heat infrastructure projects under the revised TEN-E would provide important resources and lower implementation barriers for the development of large, trans-national, heat projects.

Figure 3-8 European geothermal heat reservoirs and basins. EGEC (2021)[396]



Administrative burden

These instruments require upfront discussion with all concerned parties, such as investors, research and academics, public bodies, financing institutions, engineering, and demand side representatives (industries

[395] EGEC (2021), Geothermal energy: Renewable heating, colling, baseload electricity and sustainable lithium. EGEC Position paper. https://www.egec.org/wp-content/uploads/position_papers/TEN-E-Position-paper_EGEC.pdf
[396] Ibid.

and building owners/designers). Therefore, some initial efforts are required to set up the instruments and develop them to maturity. Best practice sharing and lessons learned (such as from the French case) would be very useful. The following textbox illustrates an existing tool to assess risks related to deep geothermal plant.

Textbox 3-11 GEORISK TOOL[397]

The GEORISK project works to establish risk insurance all over Europe and in some key target third countries to cover risks associated with the development and the operation of a deep geothermal plant. The GEORISK project aims to develop financial schemes to mitigate the impact of the resource risk by spreading it in such a manner that project developers can accept their fair share of it. This mitigation of the risk through financial instruments allows to lower the financial exposure of developers in case of failure to develop a geothermal reservoir.

The web based GEORISK TOOL provides a risk register that is essentially a list of all plausible risks faced by developers of deep geothermal projects. Each risk is accompanied by corresponding de-risking measures. The tool provides the opportunity to deepen each risk, and to select them according to the requirements of a project. This register serves as a starting point for developing a risk management framework adapted to the needs of a particular project by selecting the more appropriate risks from the list. A ranking of these risks was submitted to stakeholders, and provides a good understanding of the investor's perception of risks.

The risks are framed in a broad way, so they need to be adapted to each project, but are also adaptable to a more global scale. Some risks are interlinked and may overlap with other risks, to ensure a full coverture of all situations. Finally, some risks can cause other risks, without addressing specific hierarchy as treats depend on specific contexts. Each individual risk should be perceived as an event that should be prevented.

Although such tool has been developed for de-risking specific projects, it can support developed national or even European risk mitigation frameworks for RES heat supply projects, and support the mobilisation of public finance via a dedicated fund or insurance mechanism.

Key administrative and regulatory elements to consider include setting up such risk mitigation frameworks for RES heat supply projects, and comprise among others:

- First step would be to define precisely the scope. Eligible investments could concern large scale geothermal drilling; large or medium scale district heating and cooling (also depending on their type, and related risk, DHC supplying residential may not face the same risk as DHC supplying industry); large scale H&C plant (e.g. innovative high temperature heat pump, solar thermal to supply high temperature heat, …); large scale and innovative waste treatment plants (e.g. waste wood treatment plant); waste heat recovery (e.g. from an incinerator, or high temperature industrial process). The two main criteria to be used to define the scope are the strategic importance (for EU or a MS) to support the deployment of a specific application and the related risk depending on the maturity level (level of innovation) and on other intrinsic risks (e.g. natural risk for geothermal drilling will not disappear with a more mature technology – which is already mature enough – but underground exploration knowledge will increase with the experience and will certainly decrease the related risks, as already experienced in the Paris region);
- Availability of existing funds and financing mechanisms and potential need to develop these further. Furthermore, complementarity of financial instruments at EU and MS level is important.

[397] Georisk tool. Available at https://www.georisk-project.eu/georisk-tool/

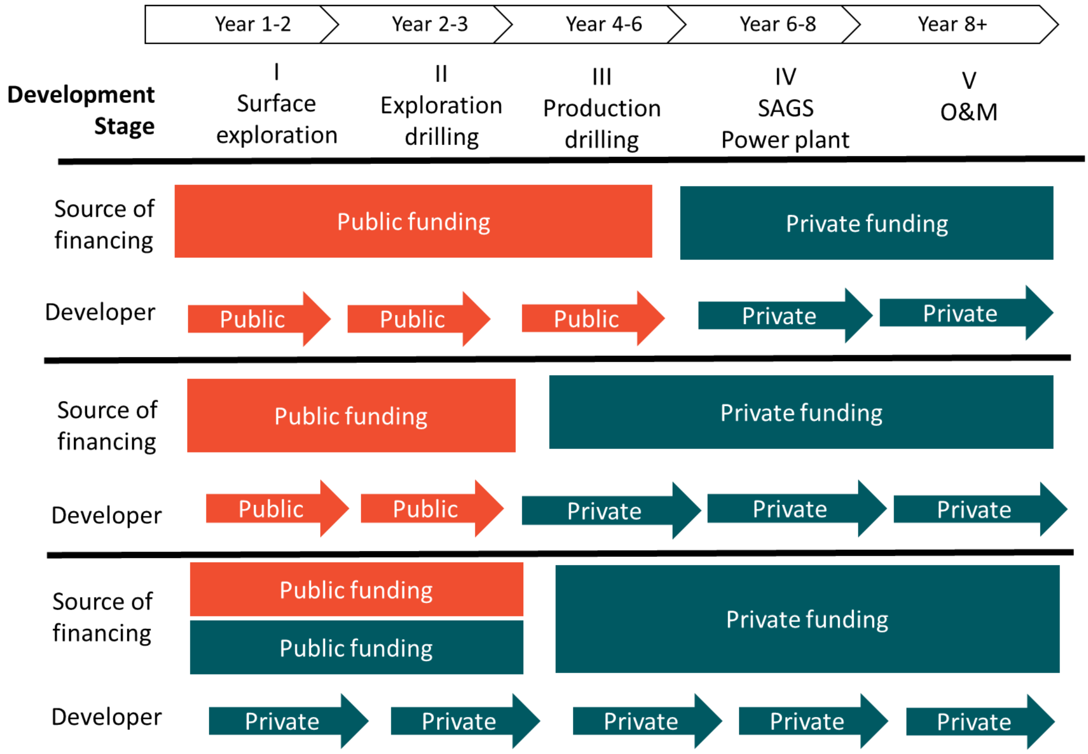
Options considering cost-sharing modalities as shown in Figure 3-8 should be considered and adapted including based on the level of technology maturity as discussed above.
  - Including geothermal and DHC projects under the TEN-E regulation could provide a significant boost to develop more European large-scale heating projects.
  - EU funds like the Innovation Fund or the CEF can be used.
- Regulatory framework to facilitate investments and project development. Different instruments are possible such as early-stage fiscal incentives, facilitating permitting, …
- Development of public insurance schemes, which would certainly require to develop new legal frameworks

Depending on the existing national frameworks, especially in the frame of the NECP, these steps would be straightforward as they are already mainstreamed in the actions plans. This should be the case for the identification phase, where the NECP should ideally have identified the most strategic investments, which could then be directly addressed by such risk mitigation schemes. NECP could also have foreseen the mobilisation of dedicated funds to support such investments. As these are the two most critical steps and ensure the integration of the underlying instruments within a global vision to deploy renewables, the regulatory framework & public insurance could become easier to develop, and mainly built on best practices, therefore drastically reducing administrative costs.

On the long term, it's not the aim to remain with public insurance mechanisms. With the increase of maturity in the development stages, and a better understanding and management of the risks, the private sector will be more involved and support de-risking capital intensive investment developments. The source of financing would progressively move from the public to the private, as illustrated in figure 3-9. This is illustrated by the geothermal drilling scheme in France, where the private is taking over the public's role to cover the most important risks.

Figure 3-9 Different options for cost sharing modalities [398]

[398] Own elaboration based on Fridriksson, T. (2016). Comparative Analysis of Approaches to Geothermal Resource Risk Mitigation and Energy Sector Management Assistance Program (ESMAP) Comparative Analysis of Approaches to Geothermal Resource Risk Mitigation. Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/24277/Comparative0an0on000a0global0survey.pdf?sequence=1&isAllowed=y



Variant 4 - Planning and implementation of renewable and waste heat & cold deployment projects and infrastructure in heating and cooling, specifically Articles 15(3)

Effectiveness

Coordinated infrastructure planning with more involvement of local and regional authorities could result in important economic savings and avoid issues of mis-planning, mis-communication, mis-information and lack of understanding of the local particularities, needs and opportunities resulting in inefficiencies. The costs related to administration, coordination and communication are not expected to be significant compared to the savings of avoiding inefficient planning.

Macroeconomic impacts

Heating and cooling goes hand to hand with urban planning. Therefore, the Energy Transition Partnership of the Urban Agenda[399] for the EU is focusing on both planning and H&C in its action plan released in April 2020, while ensuring local needs and interests remain an important concern. Collaboration is central to the approach and should be emphasized in all. The Energy transition is one of the 12 priority themes within the Urban Agenda, an initiative that aims at integrating cities both in the development and in the implementation process of the urban policy.

[399] Urban Agenda for the EU. (2019). Energy Transition Partnership, Action Plan. Available at: https://ec.europa.eu/futurium/en/system/files/ged/uaetp_final_action_plan.pdf

Textbox 3-12 Aalborg heat decarbonisation planning for 2050 [400]

The city of Aalborg in Denmark implemented a strategic energy planning approach in preparation of its Energy Vision 2050. The process involved multi-stakeholder representation and dialogues between concerned parties including the municipality, the Environment and Energy Administration, the Urban Landscape Administration, the Aalborg district heating utility, local industries and business.

In the case of Aalborg, results show that the least-cost option for decarbonising the H&C sector is based on flexible utilisation of power using heat pumps to generate heat for district energy systems in combination with thermal storage.

Heating and cooling planning presents several advantages, one of the first being that it reconnects urban policy to energy policy.[401] New energy master plans developed at municipality or city level can spur the urban deployment and bring cost—effective synergies between energy supply and new infrastructure (e.g. service or residential). This is evidenced by case studies in large cities, such as Copenhagen or Stockholm, but also in new areas of cities like Hafencity (Germany), Saclay (France) or Barcelona (Spain), where new DHC grids were planned and implemented as a mean of meeting two sets of targets simultaneously, while keeping a required level of price competition[402]:

- **making the best of a very broad spectrum of local energy resources**: the DHC grid project provided an incentive to search, evaluate and use them, and developing new supply schemes, in line with carbon reduction targets;
- providing cities new areas with **a flexible, collective infrastructure, the implementation of which can be linked to the city development**, at a flexible pace, and in a way that provides ground for constant technical evolutions of the grid.

Consequently, heating and cooling planning at city level helps to keep control of energy installations on the territory while ensuring the local energy transition has the common interest at its centre. Furthermore, urban permitting rules may be adapted at city level (or municipality), providing DHC operators the right to use public domain to building and maintain H&C pipes, speeding the administrative processes, and even providing an automatic authorization when the delay is over (and no answer was provided).

Prior to planning, mapping would be recommended, using existing tools and best practices, like with the Horizon 2020 project HotMaps[403], aiming at designing a toolbox to support public authorities, energy agencies and urban planners to plan H&C at local, regional and national levels.[404] Building the capacity of planners remains at the centre of the approach, and should also building on past experience. Heating and cooling mapping exercises have also been undertaken for 29 localities under the STRATEGO project co-financed by the Intelligent Energy Europe (IEE) Programme of the EU. In addition the project developed a guide to support localities in mapping local heating and cooling demand and supply.[405]
The aim of strategic local heating and cooling planning, is to promote the transition to a more flexible integrated energy system with focus on energy efficiency and renewable energy, considering local

[400] Bertelsen, N. et al. (2021). Integrating low-temperature renewables in district energy systems: Guidelines for policy makers.
[401] Energy Cities. (2019). Heating and cooling planning: a "must have" for all cities. Available at https://energy-cities.eu/heating-and-cooling-planning-a-must-have-for-all-cities/
[402] Galindo Fernández, M., Roger-Lacan, C., Gährs, U., and Aumaitre, V. (2016). Efficient district heating and cooling systems in the EU - Case studies analysis, replicable key success factors and potential policy implications, EUR 28418 EN , doi: 10.2760/371045
[403] Hotmaps Toolbox. Available at: https://www.hotmaps-project.eu/hotmaps-project/
[404] Ibid.
[405] STRATEGO. (2016). Low-carbon Heating and Cooling Strategies for Europe.

infrastructure and resources. In most European cities and regions, there is a need to better identify, analyse and map resources, demand and solutions to make energy supply more efficient and to meet the demand with efficient, cost-effective and greener energy sources. Strategic heating & cooling planning means developing an action plan to achieve a long-term vision of the heating and cooling supply.

Building on the success of past experiences, projects and toolboxes[406], many cities and regions are currently preparing ambitious climate and energy strategies and action plans, committing to net-zero carbon by 2050. Seven European pilot areas have been successfully developing their integrated heating and cooling strategies: Aalborg (Denmark), Bistrita (Romania), Frankfurt (Germany), Kerry County (Ireland), Milton Keynes (UK) and San Sebastián (Spain). As illustrated by the textbox below. This example of strategic planning in San Sebastián illustrates the importance of such integrated approach to plan H&C supply in the most cost-effective way.

Textbox 3-13 example of successful integrated planning [407]

DONOSTIA "SAN SEBASTIÁN, SPAIN Donostia - San Sebastián is a city of around 180 thousand inhabitants in the northern part of Spain, on the Atlantic coast. Currently around 600 GWh/yr of heat are needed for space heating and hot water generation in the buildings of the city. At the moment, this demand is almost entirely supplied with natural gas. The municipality published in 2018 its climate plan to become carbon neutral by 2050.

The municipal company Fomento De San Sebastián is leading the Smart City transition. It promotes sustainable development models and efficient energy systems based on renewable energies. In this sense, Fomento De San Sebastián has built the first municipal district heating system, powered by biomass, in a new part of the city. San Sebastián started the heating and cooling planning thanks to the Hotmaps tool. The technical analysis done with Hotmaps showed that district heating could potentially supply considerable parts of the buildings' heat demand in the area.

A waste incineration plant has recently started operation nearby and it is generating electricity. A first analysis shows that transporting the excess heat of the plant to the city and using it in a potential district heating system leads to lower costs than more ambitious heat savings and a higher share of decentral heat supply. The results also show that very ambitious saving targets in San Sebastián lead to higher overall system costs compared to lower saving levels together with supply from district heating.

Therefore, a detailed analysis of the costs and effects of renovation measures in the different buildings of the city should be performed taking into account also the state of renovation and the occupation of the buildings. This should feed into a renovation strategy for the city. The next steps on the road to a low carbon heating system in San Sebastián are a feasibility study for the integration of the heat from the waste incineration plant into a potential district heating system and a more detailed analysis of the heat savings in the buildings of the city."

Managing an integrated planning, in most cases, would require additional skills and human resources. Mapping and quantifying heating and cooling demand and sources is a complex task. It requires a high level of knowledge and skills to act wisely, and most cities are ill-equipped for this. Before investing in a long-term heating & cooling solution, access to reliable data is key, which usually requires involving a large number of stakeholders like municipal services, building owners, facility managers, utility companies

[406] Hotmaps Toolbox. (2020). Supporting strategic heating & cooling planning at local level. Available at: https://energy-cities.eu/publication/the-hotmaps-toolbox/
[407] Ibid.

including transport and distribution system operators, civil groups, industrial companies, social property owners and energy companies. If municipalities or cities become responsible for the decarbonization of the H&C, they would probably need additional financial means to start.

In any case, the economic impacts of such integrated planning have demonstrated to be beneficial in almost all case studies, to achieve a structural and long term decarbonization of the heating and cooling sector, at local level. Such planning allowed the cities to estimate the cost optimum integrating both energy efficiency and renewable (or DHC) in their planning. Efficient collaboration between the national and local levels is paramount. Previous work has identified various challenges in establishing national-local dialogue:

- local authorities often do not have an established role to inform the national H&C planning process;
- it is often difficult to find the right government departments and officials responsible for H&C planning;
- governance set-up at national, regional and local levels needs to be considered. For example, Spain has 8,000 local authorities thus, the appropriate mechanism to collect experiences and perspectives needs to be established in order to be able to manage the data.[408]

Distributional impacts

The decarbonisation of H&C in buildings is characterized by its local nature, such that the policy mix at EU, national at local level needs to provide support and guidance for municipalities and regions to support the transition. Regarding the local level, urban planning and zoning regulations play an important role in the transformation of H&C, not only with respect to district H&C but also for decentralised solutions. The JRC (2021)[409] found that in successful cases of efficient integration of RES and waste energy sources in DHC systems, a key success factor in most of the cities analysed is that their energy planning was an integral part of urban planning. [410] This involved not only undertaking a long-term cost benefit analysis for heat planning, but also establishing zoning measures and areas with favoured or mandatory connections to DHC networks, maximum CO_2 emissions for heating or specific environmental requirements for buildings in urban development codes.

The collection and integration of fragmented and often inconsistent data for the preparation of integrated planning is tedious and concerns many different sources. Strategic planning would require the involvement of many different stakeholders, working at increasing the resilience of the heating and cooling system, with the flexibility to address specific consumer's groups, such as poor households. Involving both the public and private sector provides also the ability to stress the economics of the system, and to appropriately distribute the costs and benefits of the transition.

This collaborative scheme would also increase local skills considerably and build experience of the authorities, the building owners (landlords and occupiers), the engineering companies, the infrastructure operators, the utilities and/or suppliers, the renewable energy producers. Sharing best practices would play a crucial role in building these capacities.

[408] STRATEGO. (2016). Low-carbon heating and cooling strategies for Europe.
[409] Galindo Fernández, M., Bacquet, A., Bensadi, S., Morisot, P. and Oger, A. (2021). Integrating renewable and waste heat and cold sources into district heating and cooling systems. Publications Office of the European Union, Luxembourg. ISBN 978-92-76-29428-3 (online), doi:10.2760/111509. (online), JRC123771
[410] The key success factor energy planning as an integral part of urban planning was found in the following case studies: Taarnby (Denmark), Jaegerspris (Denmark), Paris-Saclay (France), Barcelona (Spain), HafenCity (Germany), Milan(Italy).

When assessing local potential and resources, local authorities (in rural areas) and all other involved stakeholders would also feel more concerned by ensuring and verifying the sustainability of the used biomass.

Subsidiarity

Given the complexity to deploy renewables in the heating and cooling sector towards its full decarbonisation by 2050, planning is needed to gather the required expertise, to build on the assessment of resource potentials, to approach all infrastructure, to integrate the demand pattern, to ensure appropriate coordination, to develop on the most cost-effective options, to consider local influencing factors, to mainstream renewables and energy efficiency actions (investments, projects, programmes or strategies).

Such planning is costly and may be compromised by the lack of human and financial resources. Without the involvement of the local authorities (e.g. major cities or municipalities), planning may be inappropriate or not adapted to local conditions and constraints. Thus, planning should be guided from the EU level, but its design should be left to MS.

There are currently very limited integrated planning in the MS, according to the JRC in 2018 only 26 %[411] of European cities had a climate action plan or an energy transition strategy.[412] Table 3-1 lists some of the European cities with climate change and/or emission reduction targets by 2030 and /or 2050. Meaning MS action would probably not have been sufficient to contribute to deploy renewable in the H&C. Therefore, by reason of the effects of the variant, EU action would have an added value, at least to incite MS to take think about integrated planning.

Table 3-1 Cities with climate action plans for 2030 and 2050[413]

Cities that have a climate change/emissions reduction target by 2030	Cities that have a climate change/emissions reduction target by 2050	Cities that have a climate change emissions reduction target by 2030 and 2050	Cities that have no local target
Albania - Tirana Belgium - Brussels Croatia - Zagreb Czechia - Brno Czechia - Prague Finland - Espoo Italy - Genoa Italy- Turin Latvia - Riga Norway - Oslo Poland - Katawice Portugal- Porto Slovakia - Bratislava	Belgium - Antwerp Germany - Dusseldorf	Austria - Vienna Belgium - Ghent Denmark - Copenhagen Estonia - Tallinn Finland - Helsinki Finland - Oulu Finland - Turku France - Brest France - Lille France - Lyon Italy - Bologna Italy - Milan Italy - Venice Norway - Bergen Poland - Wroclaw Portugal -Braga Portugal - Guimaraes Portugal - Lisbon Spain - Barcelona Spain - Malaga	Romania - Timisoara

[411] Including cities in the UK.
[412] Galindo Fernández, M., Bacquet, A., Bensadi, S., Morisot, P. and Oger, A. (2021). Integrating renewable and waste heat and cold sources into district heating and cooling systems, Publications Office of the European Union, Luxembourg. ISBN 978-92-76-29428-3 (online), doi:10.2760/111509 (online), JRC123771
[413] Eurocities. (2019). Cities Leading the Way on Climate Action. Available at: https://eurocities.eu/wp-content/uploads/2020/08/EUROCITIES_cities_climate_action_2019.pdf

Finland - Tempere Finland - Vantaa France - Angers France - Toulouse Greece - Athens Greece - Thessaloniki Ireland - Dublin Italy - Florence Slovenia - Ljubljana Spain - Murcia Sweden - Nacka The Netherlands - Utrecht UK - Birmingham UK - Glasgow		France - Nantes France - Nice France - Paris France - Strasbourg Germany - Berlin Germany - Bonn Germany Chemnitz Germany - Dresden Germany - Essen Germany - Frankfurt Germany - Munich Germany - Munster Hungary - Budapest Iceland - Reykjavik Sweden - Gothenburg Sweden - Karlstad Sweden - Malmo Sweden - Stockholm Sweden - Umea Sweden - Uppsala The Netherlands - Amsterdam The Netherlands - Eindhoven The Netherlands - Groningen The Netherlands - The Hague The Netherlands - Tilburg UK - Leeds UK - Liverpool UK - London	

An ongoing EU-funded project DecarbCityPipes 2050[414] is bringing together seven European cities (Bilbao, Bratislava, Dublin, Munich, Rotterdam, Vienna and Winterthur) to learn from each other and coordinate their work in tackling the local challenges they might encounter in their efforts to decarbonise heating and cooling in buildings by 2050. As part of the project the cities will develop transition roadmaps for the heating and cooling sector in cooperation with their local utilities. Furthermore, the project expects to motivate and support >80 more cities across Europe to start the same roadmap process. Previous projects, such as the STRATEGO project have also emphasizes the importance of interaction between local authorities from different countries to share experiences and develop capacity build up. In the context of this project, international coaching to support local delivery of H&C plans proved to be successful. The EU could plan an important role in facilitating such exchanges.

Textbox 3-14 City planning of buildings decarbonisation - Decarb City Pipes project[415]

The Decarb City Pipes 2050 project is an important, under Horizon 2020, to provide an example on how cities can play a key role in the decarbonisation of the buildings though the phasing out of natural gas and what are the key factors to consider for planning a roadmap towards decarbonisation. In addition, the project highlights the added value of cities learning from one another and the importance of dialogue and capacity building through exchanges with peers and experts. The planning is based on the following approach:

- Determining the “What” → based on an assessment of the existing energy demand for H&C, estimating the future demand and analysing the potential of renewables for supplying it. The approach takes into account technoeconomic megatrends vis-à-vis local circumstances.
- Determining the “Where” → based on spatially differentiated plans to ensure that the most cost-optimal solutions are deployed based on the needs of each district (considering e.g. the infrastructure available, buildings density and the availability of local energy sources).
- Determining the “When and How” à considering how to implement the solutions, at what pace and what are the stakeholders that need to be involved in different steps of the process. In this step it is key to consider which legal and financial instruments can be used.

The Long-Term Renovation Strategy of Ireland is one of the few integrated planning, which is mainstreaming renewables into the renovation of the building stock, as described briefly in the textbox below.

[414] Decarb City Pipes 2050. (2020). Transition roadmaps to energy efficient, zero-carbon urban heating and cooling. Available at: https://cordis.europa.eu/project/id/893509
[415] Ibid.

Textbox 3-15 Irish LTRS[416]

> The Irish LTRS includes advanced performance requirements in the current regulations combined with a mandatory renewables requirement, creating a rapid transition to low carbon heating systems in new dwellings. The NZEB requirements also make it more attractive for builders and homeowners to further incorporate renewable technologies and move away from traditional fossil fuels.
>
> Further regulation will phase out further installation of oil boilers from 2022 and the installation of gas boilers from 2025 in all new dwellings. This will be achieved through the introduction of new regulatory standards for home heating systems, and ensure the supply chain for the installation of renewable heating systems is in place. Ireland's Building Regulations (for Buildings other than Dwellings) was amended in 2017 in order to establish the NZEB performance requirement and this sets a performance level representing an improvement in the order of 60% over previous standards. It also includes mandatory renewables on all new buildings and major renovations to a cost optimal level.

According to its NECP, Ireland foresees to triple its share of renewables in the heating and cooling sector (from a current share of 7.8% in 2018 to 24% in 2030). This is the clearly the higher increase among of all MS, probably due to the establishment of the Long Term Renovation Strategy which integrates the deployment of renewables in the building sector. Such integrated planning gives the required clarity to develop realistic scenarios and the needed accompanying measures.

However, planning renewable deployment in the H&C could be mainstreamed in other frameworks than the LTRS, and should be left open to the MS. This variant would leave more freedom to the MS, and therefore comply with the subsidiarity rules, than obliging these other frames (such as the LTRS) to integrate renewable planning.

Coherence

Local H&C planning is the most appropriate approach to handle the cost optimum and find a cost-effective balance between energy efficiency and renewable sources and waste heat recovery, considering local conditions and constraints, such as the local climate and weather patterns, the energy density, the kind of buildings and infrastructure surrounding it, the renewable energy resource potential and proximity to sources of waste heat, but also the local skills.[417]

Planning is the instrument that allows considering appropriately all existing instruments such as

- the ETS, to incentivise and start deploying technologies that may become competitive, but that may still face a lack of recognition, of capacity and knowledge;
- the ETD, as key parameter to consider when planning renewable heat at national and local levels;

[416] Ireland's Long-Term Renovation Strategy. (2020). Available at: https://ec.europa.eu/energy/sites/default/files/documents/ie_2020_ltrs.pdf
[417] European Technology Platform on Renewable Heating and Cooling. (2011). Common Vision for the Renewable Heating & Cooling sector in Europe. Available at https://www.globalccsinstitute.com/archive/hub/publications/155918/common-vision-renewable-heating-cooling-sector-europe-2020-2030-2050.pdf

- Renewable heat planning should integrate the phasing out of fossil fuels and their replacement by renewable-based alternatives (cf. variant on planned replacement schemes of fossil fuels systems);
- Requiring the integration of global renewable heat planning and fossil phase out within existing planning instruments:
  - the revision of the LTRS (article 2.a of EPBD) should encompass renewable heat planning (to reach long term full decarbonisation of the building stock)
  - the next update of the comprehensive assessments of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling (art 14 EED) should be linked to the renewable heat planning;
- when addressing the need for coherent policies for buildings, soft and green mobility and urban planning, under article 8(8) of EPBD (on technical building systems, electromobility and smart readiness indicator), an extension of the scope to renewable heat planning could be considered;
- under article 20(3) of EPBD, MSs shall ensure that guidance and training are made available for planners, designers, and decision makers enabling the optimal combination of energy efficiency, use of renewable energy and use of district heating and cooling when planning, designing, building and renovating industrial or residential areas. Training provisions for planners under the RED should ensure coherence and the link with EPBD (art 20(3)).

H&C planning should be properly combined with the phasing of carbon pricing schemes (like ETD or ETS extension). In order to deliver the cost optimal solutions, the H&C planning should be fully synchronised with the market evolution and trends, including the possibly progressive increase of carbon price. This synchronisation is necessary to ensure the most competitive solutions are deployed (with an increasing carbon price, renewables will become more attractive and deploy faster).

Hence, H&C planning, addressing renewable and energy efficiency in an integrated way, would be reinforced, or even facilitated by an adequate carbon pricing, especially when the income generated by carbon pricing (e.g. carbon taxes) is allocated to support the low income households, addressing the worst performing buildings in priority.

One of the key issues of a carbon pricing is to ensure that low carbon alternatives are available in any situation, at an affordable cost, which should be considered at the core of the H&C planning.
H&C planning can also be considered as an important instrument accompanying a carbon pricing, in order to progressively diminish or suppress the negative (cost) effect of an increasing carbon price on the worst performing buildings.

For long term planning, it is key to properly manage all risks related to the evolution of the price of fuels, depending to a large extent to the magnitude of a carbon pricing. Therefore a very clear carbon pricing long term perspective (e.g. progressive increase of the level over the years/decades) and a strong and stable political commitment (e.g. Nordic countries using a carbon pricing as backbone of their decarbonisation policy, with a long term and stable scheme) would be a main component to manage market-related risks of all potential low carbon solutions, providing more clarity to H&C planning.

To conclude, the appropriate combination and phasing of these two instruments would be beneficial. However, it should be ensured that H&C planning also includes the energy performance of the buildings, and not only the replacement of fossil fuels by renewable fuels. Strong alignment with the EPBD instruments is required, such as a Minimum Energy Performance of the Buildings Standard (MEPS).

Administrative burden

Planning of renewable and waste H&C deployment projects and infrastructure in heating and cooling should ideally be at the core of the NECP section on the deployment of renewables in the H&C sector. Given the high dependency of the different energy infrastructures (in the frame of energy system integration, moving e.g. partially from gas networks to electricity and/or DHC). The LTRS should also address, at least partially, the issue of planning, as the deployment of renewable heating systems and the increase of energy efficiency in buildings should go hand in hand. Planning the deployment, reinforcement, extension or dismantling of existing infrastructure, need to consider the expected evolution of heat demand (which influences the alternatives), and the existing alternatives that can replace fossil fuels, including the potential for low carbon liquids and gases (from biological origin or not). Therefore, the planning process would encompass the whole decarbonisation of the H&C sector. Most of the MS have already started to plan, or at least to define planning the deployment of renewables in H&C, but their progress depends on their global commitment and the set of policy measures they foresee in the frame of their NECPs. For some, planning would be a question of progressively mainstreaming H&C infrastructure considerations in other policy areas (e.g. urban policy), to ensure full coverage of the H&C concerns. For others, planning would be required as a kind of overarching framework, and would therefore encompass the complete process of H&C decarbonisation, including the Comprehensive Assessment (article 14 EED). Such planning could also be seen as a part of the LTRS, where a more dedicated focus on supply should be mainstreamed, highlighting the importance to address the deployment of all heat market and related infrastructure (gas, liquid, electricity, and heat).

For those MS starting from the beginning, administrative overburden is probably the higher risk that could jeopardise the whole planning process, due to the lack of human and financial resources, and the need to take into account local parameters. A balance has to be found between the details and the efficiency. Therefore, guidance would be useful to support MS planning in an effective way. A recent study for the EC on the competitiveness of the H&C industry and services finds that easing administrative costs and barriers via better alignment of procedures and requirements (e.g. technical requirements, certification and licencing) would make it substantially easier for renewables to enter markets and become more competitive.

For those MS having a set up a clear vision on the way to decarbonise the H&C, and especially to deploy renewables, planning would then be a kind of reminder of the important and integrated issues to address.

Key steps to consider in the planning of deployment of renewable heat and associated infrastructure include[418]:

- **Developing strategic H&C plans** – this is a first step and needs to consider the local context, resource availability, existing infrastructure, socio-economic conditions etc. The three-step

[418] Bertelsen, N., Mathiesen, B. V., Djørup, S. R., Schneider, N. C. A., Paardekooper, S., Sánchez García, L., Thellufsen, J. Z., Kapetanakis, J., Angelino, L., & Kiruja, J. (2021). Integrating low temperature renewables in district energy systems: Guidelines for policy makers. International Renewable Energy Agency.

approach described in the textbox 3-14 on Decarb City Pipes 2050 project could be a suitable template for H&C plan development in cities.

- **Stakeholder engagement** – the type of stakeholders and extent of their engagement will, to an extent, depend on the H&C plans developed.
- **Assessing and mapping H&C demand and energy resources** – this step would expand on the initial information considered for planning. In the case of the H&C sector the location of the demand and supply is of critical importance in order to enable connecting them to one another. The planning should also take into account other energy sectors in the analyses to maximise synergies and ensure energy system integration where possible.
- **Integrating energy resources in the existing and new infrastructure to match the demand** – future demand can be deduced through measurements of actual demand in buildings, bottom-up modelling for building consumption and top-down modelling of heat demands.
- **Assess the required investments, operational and fuel costs, including all technical challenges** – for many heating technologies upfront investments and high capex costs constitute a barrier for competing with current, fossil-based technologies. Thus, appropriate instruments to lower this barriers and promote uptake are crucial. A level-playing field for operational and fuel costs, by, among others, eliminating subsidies or other fiscal incentives for fossil-based fuels is important.
- **Enabling regulatory conditions, financing, and business models to deploy –** this aspect is closely linked to the point above. Government authorities need to establish financial and regulatory measures to ensure that the benefits of renewable heating systems are captured by the established pricing regimes.

As explained above, these steps are already tackled by the MS, to varying extents, meaning there is no one single approach to assess the administrative costs related to their implementation.
National authorities will be strongly involved, but local authorities (municipalities, cities, or regions) will also need to progressively commit and engage in the process of planning renewable H&C deployment projects and infrastructure. In several MS, major cities have already started and provide good examples on the best planning approach, such as in Denmark and Baden-Württemberg, as illustrated in the textbox 3-16 below.

Textbox 3-16 Experience with heat planning in Denmark[419] & in Baden-Württemberg

The Danish Energy Agency plays a leading role at guiding municipalities and regional authorities in Denmark, but also abroad (e.g. municipalities in Baden-Württemberg) on municipal heat planning.

Danish heat planning was kickstarted in the late 1970's as a response to the two oil crises in 1973 and 1979, which had huge implications for the Danish economy. The reason for commencing heat planning in Baden-Württemberg is even more serious, namely the wide recognition of the global climate crisis. Though the backdrop for planning is different, this report shows that a lot of the experience from Denmark have high relevance for Baden-Württemberg. In addressing the Danish experience with heat planning, the region has put special emphasis on the learnings from the beginning of 1980's when the framework for Danish heat planning was created.

[419] Danish Energy Agency. (2019). Experience with heat planning in Denmark, input for developing a heat planning in Baden Württemberg. Available at: https://www.ea-energianalyse.dk/en/front-page/

In order to meet its climate and energy targets Baden-Württemberg has a strong focus on energy efficiency improvements in housing and green heating. This entails an expansion of district heating through municipal heat planning with a particular focus on supply from fuel free energy sources.
The German region recently required its 103 cities of more than 20 000 inhabitants to develop a vision for their CO2-neutral heat supply 2050.

While the total population of the Baden-Württemberg is approx. 11 million people, the 103 largest cities hold a population of approx. 5,5 million people, that is roughly the same number of inhabitants as in Denmark. Therefore, planning at city level requires guidance and commitment at regional or national levels.

Despite its long experience in district heating (over 40 years), the Danish heat planning was implemented over a relatively short time span. The first heat supply act was introduced in 1979 - before that there was no fixed framework for heat planning- and by the mid 1980's almost all Danish municipalities (there were about 300 at the time) had developed heat plans. The main objective of the heat planning was to determine, which areas in the municipality should be supplied with district heating or natural gas, and which areas were still supposed to use individual heat sources such as oil boilers, biomass boilers or electric heating. All these considerations are still valid, although they could be expanded with the new fuels and technologies. A key selection parameter in the heat planning was the energy density of the different areas of a municipality. The principal approach was that most densely populated areas would usually be supplied with district heating, less densely populated areas with natural gas and the more sparsely areas with individual heating.

The heat planning also provided directions on how district heating should be supplied. This in turn influenced the location of district heating systems in a way where cities with large amounts of surplus heat from power generation or industries would typically expand district heating to less densely populated areas that would otherwise have been supplied with natural gas.

Since the late 1980's, heat planning in Denmark has developed on a more ad hoc based approach. During the 1990's a lot of mainly smaller cities, which previously had not had collective heat supply, developed district heating systems based on combined heat and power plants, mainly gas-fired, and in the last 10 years quite a few areas, that were originally designated for gas boilers, have been converted to district heating. The conversion contributed to the increasing share of district heating of total heat supply from around 46% to around 50% in the past decade. Since 2011, the number of district heating installation in both new and existing buildings has increased by 9%. Whereas the heat planning that took place in the early 1980's aimed at reducing oil dependency, the later steps of heat planning have focused on reducing the environmental impacts, particularly the CO2 footprint, of heat supply.

Among the main lessons to be used for the Baden-Württemberg :

1) **Heat planning needs to be locally anchored**
2) **Capacity building and knowledge sharing was key to successful heat planning**
3) **Multilateral municipal coordination groups were key to human capacity building**
4) **Developing common planning assumptions improved the quality of the planning process**
5) **Educational programs linked to the concrete planning contributed to human capacity building**

6) Policies need to ensure that solutions that are desirable from a social perspective are also advantageous from a consumer viewpoint
7) District heating projects need to prove that they benefit society as a whole
8) Requirements for mandatory connection has been a powerful but debated tool in Danish heat planning
9) Both normative and financial policies were applied to incentivize green heating
10) Political attendance at the highest level ensures resources and commitment to heat planning
11) Public involvement was key to get commitment to the plans among citizens
12) New district heating systems and extension of existing systems were driven by existing district heating companies and cooperatives with strong local support.

The main actors of the energy sector involved in the process of municipal heat planning counts: municipal authorities and administration, regional/county authorities, energy companies, energy suppliers, consumers, research and development, consultants, manufacturers, funding and finance.

All these steps and lessons learned illustrates the importance of an integrated and complete approach, requiring certainly additional capacities at all levels, and especially at local levels, although the Danish cities did carry out their heat planning in a short time span, apparently without additional resources. The importance of DHC shows that the heat planning process should be built on the Comprehensive Assessment of article 14 EED. Depending on their maturity level, and comprehensiveness, the efforts to expand the scope will depend on the MS contexts.

1.1.1 D2 - Accelerate the share of renewables in District H&C – DHC targets (options 1 to 3)

In dense urban areas, district heating networks may offer the only option for using a significant share of renewables and other low-carbon H&C, as individual systems (e.g. biomass boilers, solar thermal systems or heat pumps) often face important obstacles (e.g. lack of available space, access or noise restrictions, air quality, cost, resource availability). District H&C also provides opportunities for integrating short-term and seasonal thermal storage, for using waste heat from urban activities or from industries, and for providing flexibility for variable renewable electricity generation through options such as power-to-gas, electric heat pumps, electricity-driven CHP.[420] District heating also makes it possible to achieve other societal and political goals, such as fuel independence or decarbonisation. To leverage the deployment of renewable in the heating and cooling sector, it is much simpler to change fuel originating from one central place and supplying a district heating, than changing a huge number of individual boilers.

District heating production is very flexible, giving access to several fuel types. This flexibility increases the security of supply, the production efficiency and the ability to balance the electricity system, as a way of energy system integration. Should one unit break down, there are alternative production units available. The district energy company can choose the cheapest fuel at any time, certainly using the excess or variable energy (e.g excess renewable electricity, or waste heat from the industry or from urban activities, from CHP), use baseload energy with a low marginal cost such as geothermal, or use other direct renewable heat such as solar.

[420] IEA. (2018). Renewable heat policies *Delivering clean heat solutions for the energy transition*

DHC need to increase focus on exploiting all available sustainable energy resources in the most optimal way. This means that advantage must be taken of surplus heat from any source, replacement of fossil fuels with renewable energy, such as solar and biomass, as well as ensuring systems integration between electricity and heat. Options to facilitate the storage of heat from summer to winter in the form of large-scale seasonal storage should also be considered in the transition to renewable DHC.
District heating provides an answer to many challenges faced by the deployment of renewable energies in the H&C sector, and should therefore pave the way by quickly switching to more sustainable energy, while at the same significantly increasing its efficiency. Examples of successful conversions of formal fossil-based DHC to renewables exist and can support the transition.

The availability of district heating infrastructure can improve the competitiveness of centralised solutions such as large-scale renewable heating and cooling technologies, for example within the solar-thermal segment. Some RES H&C technologies such as solar-thermal can be much cheaper at scale but require a district heating grid for the distribution.[421]

District heating is financially feasible for communities with heat densities that are comparable to inner and outer cities areas, especially if local waste heat from industry or a power plant is available. This assessment concerns both existing and new district heating, while it is mainly focusing on increasing the share of renewables in existing infrastructure.

There are many reasons to significantly accelerate the uptake of renewables in existing DHC. With district heating, it is possible to take advantage of market forces driving price changes on different types of fuels, and especially on renewables. Today, all renewable energy sources and energy carriers (renewable electricity, gases, liquids or solids) can be used to produce heat in DHC, and benefit from different markets forces, including energies with zero marginal cost (e.g. excess electricity, waste heat, …). Individual heating solutions only allow one specific type of renewable fuel which is driven by many different constraints. For the end user, this means that their heating bill is fully financially exposed to price increases of a specific fuel, which would be less the case for a DHC.

A number of factors drive the expansion of renewable in DHC systems. These factors vary between regions and have different impacts on the various potential renewable technologies. Nevertheless, some basics can apply generally, such as fixing emission targets[422], specifically to the district energy system (or at a municipal/city level[423]) which can be considered as the primary driver of many transformations of existing DHC.

In their NECPs, MSs were requested to describe the implementation of both articles 24(4a) and 24(10) of RED II, if applicable. In accordance with article 24(4a), MSs should increase the annual share of energy from

[421] European Commission ENER/C2/2016-501. (2019). Competitiveness of the heating and cooling industry and services. Available at https://www.euneighbours.eu/sites/default/files/publications/2019-08/20190822%20MJ0319513ENN.en_.pdf
[422] IEA. (2018). Renewable heat policies Delivering clean heat solutions for the energy transition
[423] e.g. Munich 100% renewable by 2040, Copenhagen CO2 neutrality by 2025. All city names refer to the corresponding case studies which are available online at www.irena.org/remap

renewable sources and from waste heat and cold in district heating and cooling by at least 1% point counting for the periods 2021 to 2025 and 2026 to 2030, starting from that share in 2020.

To estimate the Total Final Energy Consumption for DHC and their share of RES, the JRC's report on the NECP assessment[424] uses the national trajectories and objectives. Table 3-1 shows data on final energy consumption by district heating and cooling, FEC of renewables in DHC, and the RES share in the DHC in 2018, 2020, and 2030. Summaries of plans described in the NECPs to retrofit their DHC networks in Central and Eastern Europe are also available in a report of the KeepWarm project.[425]

[424] JRC. (2020). Assessment of heating and cooling related chapters of the National Energy and Climate Plans (NECPs)
[425] Keep Warm: Renewing district heating (2020), Improving the performance of District Heating Systems in Central and Easter Europe. Available at: https://keepwarmeurope.eu/learning-centre/policy-recommendations/

Table 3-2 Current and future final energy consumption for DHC, and RES share in the DHC sector (based on number provided in the NECPs), not underlined numbers are values which come directly from the NECPs) [426]

Member state	Share of DHC in total FEC for H&C, %	Final energy consumption by DHC, ktoe			Final energy consumption of RES for DHC, ktoe			RES share in DHC, %		
	2018[21]	2018	2020	2030	2018	2020	2030	2018	2020	2030
Belgium										
Bulgaria										
Czech R.	15.4[22]		2133	1933						
Denmark	42	3191[23]	3145	2997	1924	2223	2376	60.3	70.7	79.3
Germany										
Estonia	40	625[24]		516	323	430	413	51.6		80
Ireland	0.8	38[25]								
Greece					46[26]	43	39			
Spain	0.15	42.5[27]								
France										65
Croatia					950					
Italy	7.8	830								
Cyprus				6						
Latvia		709						46.7	44.9	58.4
Lithuania	29[28]		915	959		656	863	67.5	71.7	90
Luxembourg						51	58			
Hungary										
Malta		0	0	0				0	0	0
Netherlands	5.1	1380		1810						
Austria										
Poland	6	2342[29]	2123	1391				2[30]	47[31]/4[32]	72/29
Portugal										
Romania					54[33]	76	264			
Slovenia	16.2	213[34]			34			16.2		
Slovakia	30.9	1767			281			15.9		
Finland	20[35]	2855[36]		2838[37]				40[38]	50[38]	75[38]
Sweden		4700		4400						

[426] JRC. (2020). Assessment of heating and cooling related chapters of the National Energy and Climate Plans (NECPs)

Trajectories for DHC were often missing in the NECPs. Only two countries estimate an increase in energy consumption in DHC. The decrease is mainly explained by efficiency improvements of the district heating networks and of the buildings.

Most of the MS did not provide information on gross final consumption of waste heat and cold from DHC, although some mentioned that they intend to recover waste heat for district heating.
Only eight countries addressed article 24(4a) in their NECPs. Based on the estimations for the final energy consumption of RES from DHC and criteria from art 24 (4a), the following conclusions can be extracted:

- Denmark automatically fulfils art 24(4a) as it has a RES share above 60% in 2020;
- Estonia significantly exceeds the requirements of art 24(4a) by increasing its RES share from 51.6% in 2020 to 80%;
- France only indicates its share in 2030, not allowing to verify whether it complies with the requirements;
- Latvia exceeds the requirements of art 24(4a) by increasing its RES share from 44.9% in 2020 to 58.4%;
- Lithuania, where DHC plays an important role in the overall decarbonization of H&C, significantly exceeds the requirements of art 24(4a) by increasing its RES share from 71.9% in 2020 to 90%;
- Poland is not fully clear concerning RES in DHC. At the lowest the RES share is expected increase from 2% in 2015 to 29% in 2030, meeting the art 24(4) requirements;
- Finland significantly exceeds the requirements of art 24(4a) by increasing its RES share from 50% in 2020 to 75%.

In addition Ireland has a current share of RES in DHC of approximately 0.8%, below the 2% set in Article 24(10) of RED II, and is therefore not required to apply article 24(4).

Cost-effectiveness

As a market instrument, the EU ETD could result intrinsically in cost-optimal emission reductions in the buildings. Hence, pushing for emission reductions through specific measures such as forcing RES deployment will be less cost-effective as long as the carbon price is not high enough to enable H&C RES to become competitive in DHC.

However, the currently limited uptake of renewables to support the DHC to reduce their emissions can be linked to the low competitive advantage of renewable fuels (due to the current low carbon price level, and to the other more cost effective solutions such as fuel switch – from coal/oil and natural gas), and to the lack of knowledge and risk management compared to individual fossil based appliances. With an increasing carbon price, renewables may become more attractive and deploy without any further intervention or policy action than the ETD (or even ETS). But there is probably no such guarantee without additional intervention in the frame of the RED, either with additional measures, or with a specific target for H&C in DHC. The table below provides a comparison of upfront costs, O&M costs, payback periods and number of jobs created per MW for both fossil-based DHC and renewable supply of heat in DH networks.

Table 3-3 Comparison of Financial data for different DHC supply technologies [427]

	Natural Gas	Coal	Biomass	Solar Thermal	Geothermal	Heat Pumps
Upfront costs	0.5 M€/MW	1.2-2.8 M€/MWe	0.3-.07 M€/MW	200-500 €/m^2	0.7-1.9 M€/MW	0.45 – 0l85 M€/MW (elec) 0.35 – 0.5 M €/MW (absorption)
O&M costs	3% of investment + 40-60 €/MWh variable fuel costs	1.5% of investment + 3 €/MWh variable fuel costs	1.8 – 3% of investment	1-3 €/MWh	2.5% of investment	2-3% of investment
Payback period	N/A	N/A	3-13 years	6-15 years	5-10 years	8-9 years
Jobs	0.95/MW	1.01/MW	0.78-2.84/MW	0.81/MW	1.7/MW	NA

Without specific measures to increase renewable's competitiveness, the risk remains high that renewable would not take up in the DHC. The two options would then be either to increase carbon pricing significantly (which is out of scope), or to enforce the uptake of renewables via specific instruments. In the first, accompanying measures would be necessary to guide the integration of renewable in all DHC. In the second, accompanying measures will also be necessary, in addition to specific renewable targets. For the simplification of the assessment, we will not take into account any hypothetical intervention on ETS or ETD, while possible synergies, and amendment of EED and EPBD may still be required and deemed relevant.

Increasing and binding the RES share target may put some DHC at risk (the less cost-efficient), as such an obligation would not lead to competitive heat generation investments compared to individual alternatives. Without internalisation of external costs, natural gas and other fossil fuels would remain a preferred cheaper option in many situations, and customers moving to these alternatives should be of a high concern. Without taking systemic measures to set up a level playing field, the risk of disconnections would increase. This risk would be exacerbated if customer's rights to disconnect are re-enforced. Disconnection should therefore be conditioned by using individual renewable instead of DHC.

Cost effectiveness of DHC compared to individual heating systems

A recent analysis of the cost-effectiveness of district heating compared to individual heating solutions under conditions based on the Danish system including the Danish taxes and tariffs shows that new district heating is highly competitive vis-à-vis individual heating technologies. Looking at a heat demand of 13 800 kWh/year corresponding to an energy renovated building and considering DH produced with a wood chip boiler or electrical compression heat pump, the results shows that the annual costs of DH are ~ 19% (EUR 430 cheaper) lower compared to an individual natural gas boiler and ~ 30-31% cheaper (EUR 805) than an individual biomass boiler or individual air-to-water heat pump.[428] The study assumed no pre-existing heating systems in the area (neither DH nor individual heating). Interestingly the results show that heat

[427] KeepWarm: Renewing District Heating project. (2020). Keeping our cities sustainably warm – facilitating a switch towards sustainable district heating. Available at: https://keepwarmeurope.eu/fileadmin/user_upload/Resources/Promotional_materials/KeepWarm-marketing-brochure-A5-www.pdf

[428] Green Energy Association. (2018). The competitiveness of district heating compared to individual heating: When is district heating the cheapest source of heating?

demand and district network length are important variables. The figures below show the assumed costs, efficiency, lifetime and other parameters used to make the assessment. The results cannot be extrapolated to other MSs are they are dependent on fuel prices, tariffs and taxes which vary from country to country. However, it can be concluded that densely populated areas should be the starting point for establishing new DH networks in other countries/cities outside of Denmark.

Table 3-4 Parameters for individual heating technologies and the district heating unit[429]

Type of heating	Investment (€)	Efficiency (%)	Lifetime (years)	Maintenance (€/year)
District heating unit	6175	100	25	65
Oil boiler	7515	92	20	295
Wood pellet boiler	10740	80	20	605
Natural gas boiler	6440	92	19	255
Electrical panel/radiators	4965	100	30	65
Air-to-water heat pump	12485	233	15	360
Ground source heat pump	20000	263	20	360

Table 3-5 Parameters for district heating technologies[430]

	Wood chip boiler	Electrical heat pump	Storage tank	Electric boiler
Investment (mio.€/MW_{heat})	0.74	0.7	155	0.08
Efficiency (LHV) (%)	108	400	95	99
Lifetime (years)	20	20	20	20
Fixed O&M (€/MW_{heat})	10335	2010	0	1210
Variable O&M (€/MWh)	25	15	0	4

[429] Ibid.
[430] Ibid.

Figure 3-10 Comparison of the price of heat for new DH heat (wood chip boiler) and individual heating. Heat demand at 13 800 KWh/year, Network Scale of 1 (small pipe grid). Green Energy Association (2018)[431]

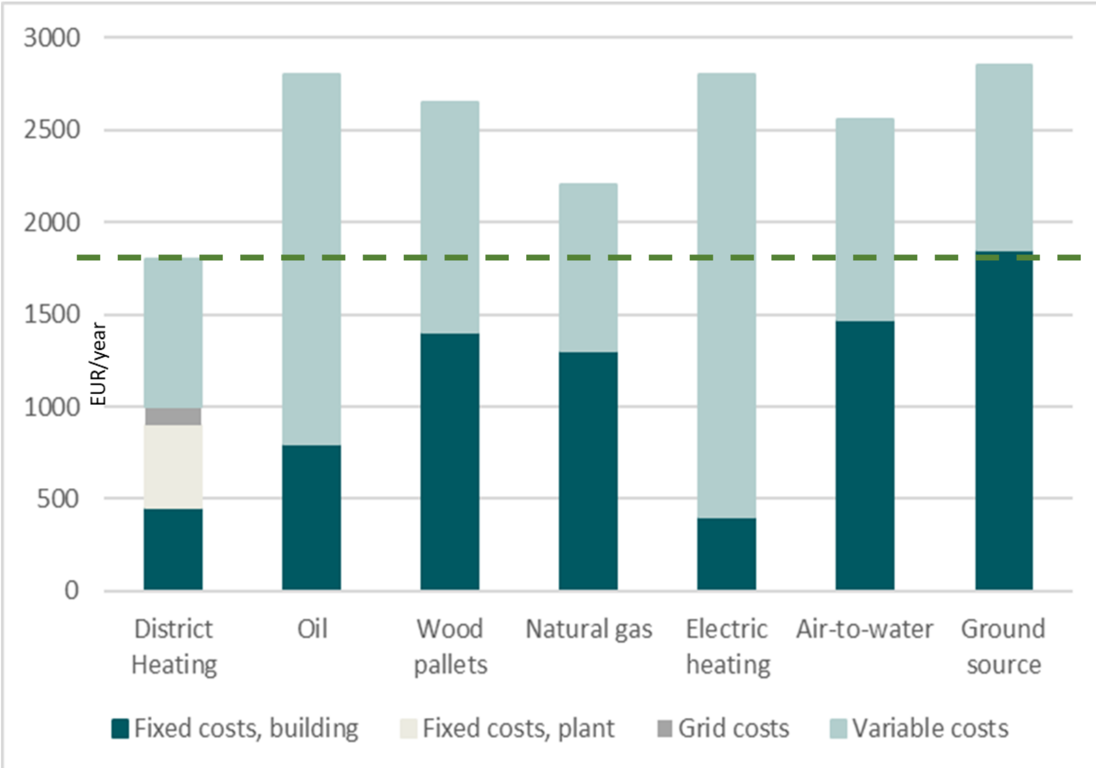


Figure 3-11 Comparison of price of heat from new DH (wood chip boiler) and individual heating. Heat demand of 4 900 kWh/year and Network Scale 1 (small pipe gird)[432]

[431] Own elaboration based on: Christian Holmstedt Hansen and Oddgeir Gudmundsson. (2018). The competitiveness of district heating compared to individual heating: When is district heating the cheapest source of heating? Green Energy Association. Available at https://www.euroheat.org/wp-content/uploads/2018/05/03052018-The-competitiveness-of-district-heating-compared-to-individual-heatingv2.pdf
[432] Ibid.

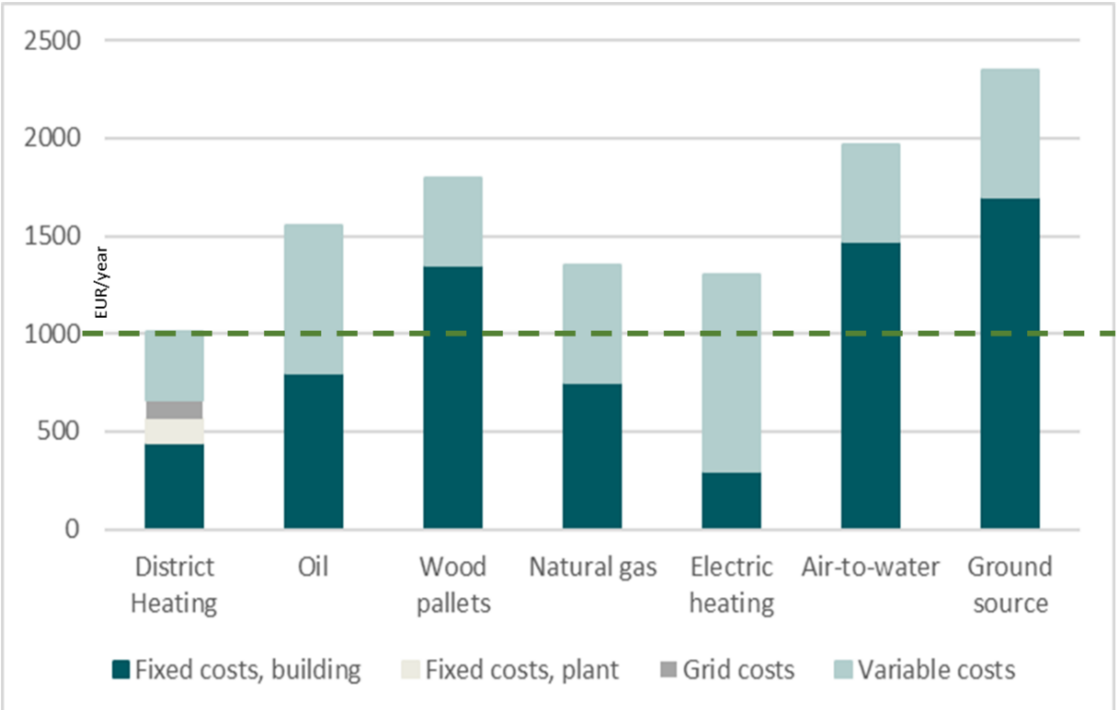


Figure 3-12 Comparison of costs of individual heating systems. ADEME (2020)[433]

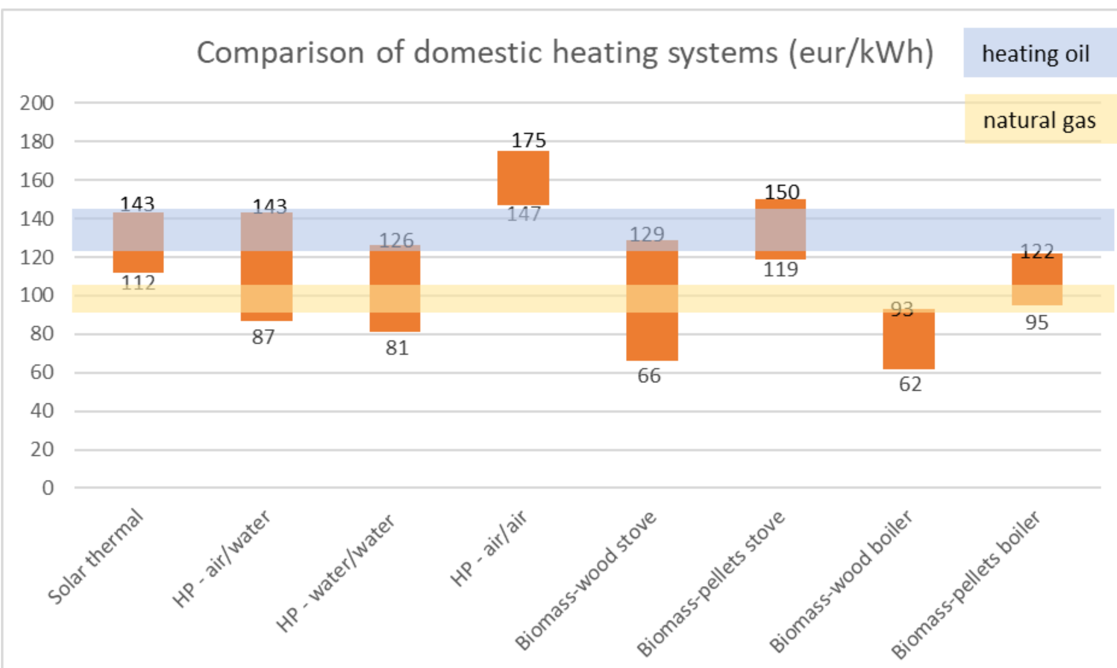
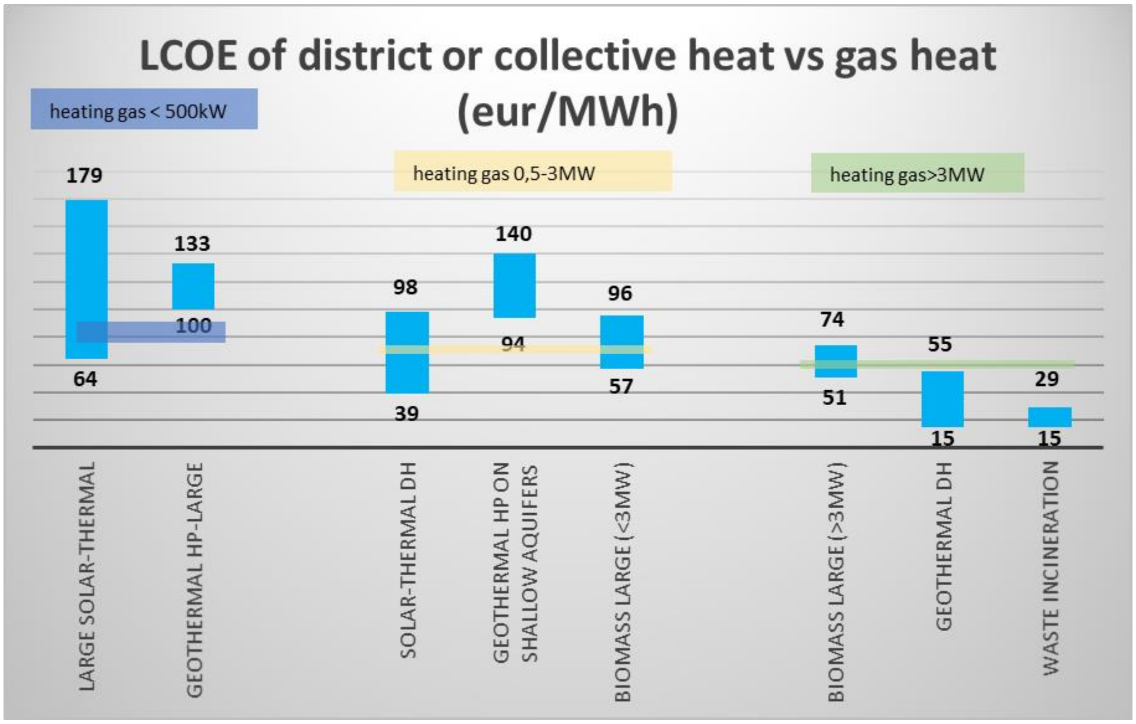


Figure 3-13 Comparison of costs of district heating systems. ADEME (2020) [434]

[433] Own elaboration based on ADEME (2020), Coûts des énergies renouvelables et de récupération (data 2019). https://www.geothermies.fr/sites/default/files/inline-files/ADEME_couts-energies-renouvelables-et-recuperation-donnees-2019-010895.pdf
[434] Ibid

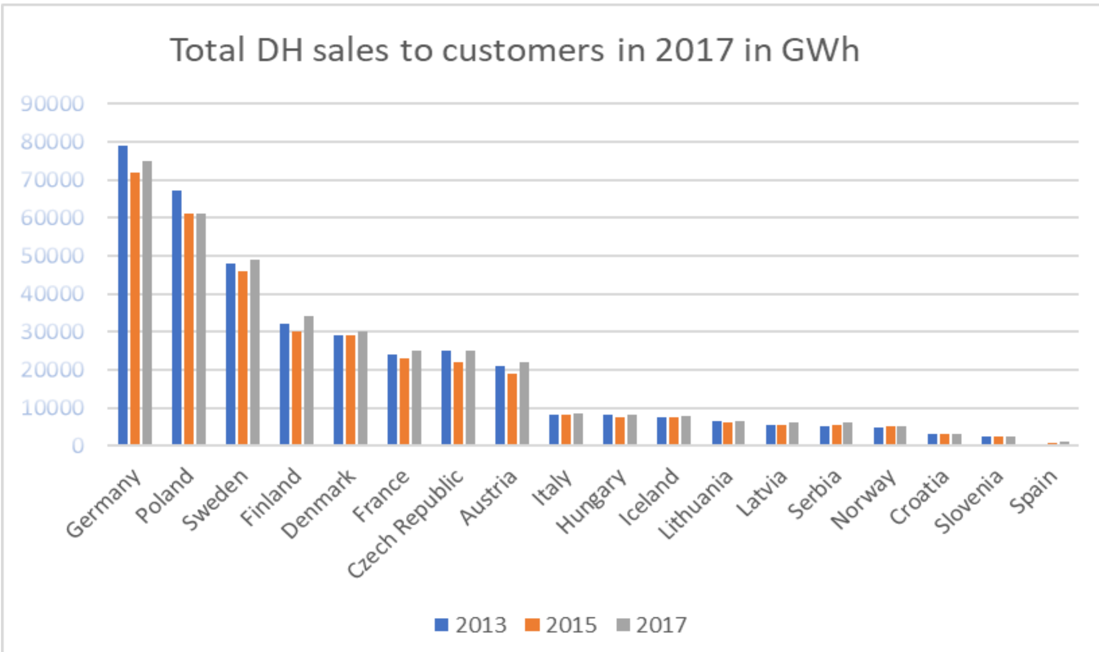

LCOE of district or collective heat vs gas heat (eur/MWh)
heating gas < 500kW
heating gas 0,5-3MW
heating gas>3MW
179
64
133
100
98
39
140
94
96
57
74
51
55
15
29
15
LARGE SOLAR-THERMAL
GEOTHERMAL HP-LARGE
SOLAR-THERMAL DH
GEOTHERMAL HP ON SHALLOW AQUIFERS
BIOMASS LARGE (<3MW)
BIOMASS LARGE (>3MW)
GEOTHERMAL DH
WASTE INCINERATION

Existing situation

At its core, district heating and cooling is about connecting local energy sources with local needs. District energy is a community-based solution that will play a key role in the sustainable cities we want to live in. District heating currently accounts for around 12% of heating in Europe. With the right investments, this share could grow to 50% by 2050.[435]

District H&C are mostly used for heating and are most widely applied in Scandinavia (among others, to their long term experience in DHC and commitment to decarbonise their energy system) and the Baltic states.

Figure 3-14 Total DH sales to customers in 2017 in GWh. Source: Euroheat and Power, 2019[436]



More than 80% of the total sales of DHC is currently concentrated in 8 MSs, with limited evolution over the past few years.

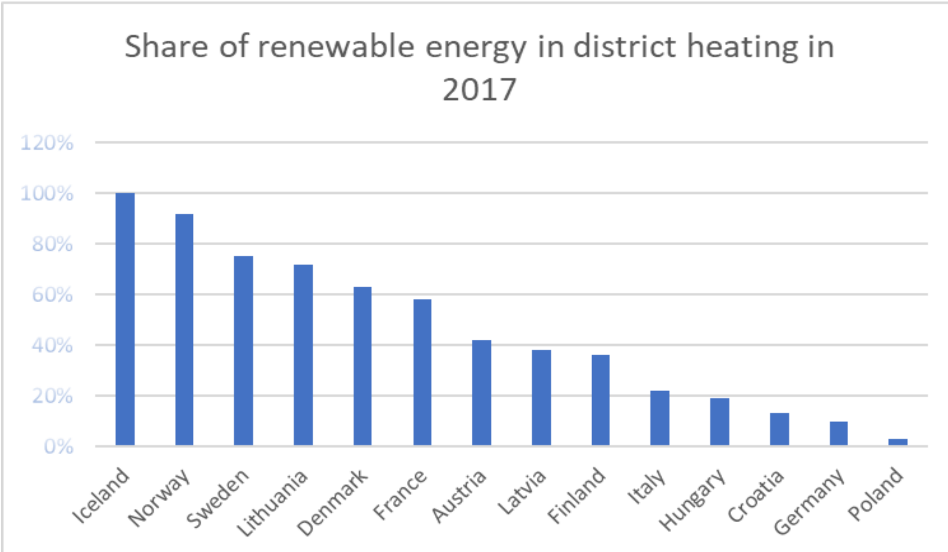
The current five major heat source options are normally identified as combined heat and power (CHP), waste incineration, industrial surplus heat, geothermal heat, and combustible renewables such as biomass. However, heat pumps and solar heat are raising in importance and becoming more adapted to the new technologies (4th generation).

The fuel and heat supply to district heating systems are dominated by the use of heat from CHP plants, corresponding to 68 % of all district heat generated. The renewable part in the district heat supply is around 14 %.

[435] Become a #DHCitizen! (2020). District heating and cooling, a modern solution to traditional challenges. Available at: https://dhcitizen.eu/wp-content/uploads/2020/05/brochure_EuroHeat_2020_1.5.pdf
[436] Own elaboration based on data and country profiles from: Euroheat and Power. (2019). Available at: https://www.euroheat.org/knowledge-hub/country-profiles/

The share of renewable in DHC varies significantly across EU27 MSs, with Sweden, Lithuania and Denmark currently having the highest share, as illustrated in figure 3-15.

Figure 3-15 Share of renewable energy in DHC in 2017. Source: Euroheat and Power, 2019[437]



During the period 1990-2017, renewables, mainly driven by solid biofuels expanded significantly its share in the district heating production.

[437] Ibid.

Figure 3-16 Share of fuels in EU28 DH production (1990-2015). Source: Aalborg University, 2019[438]

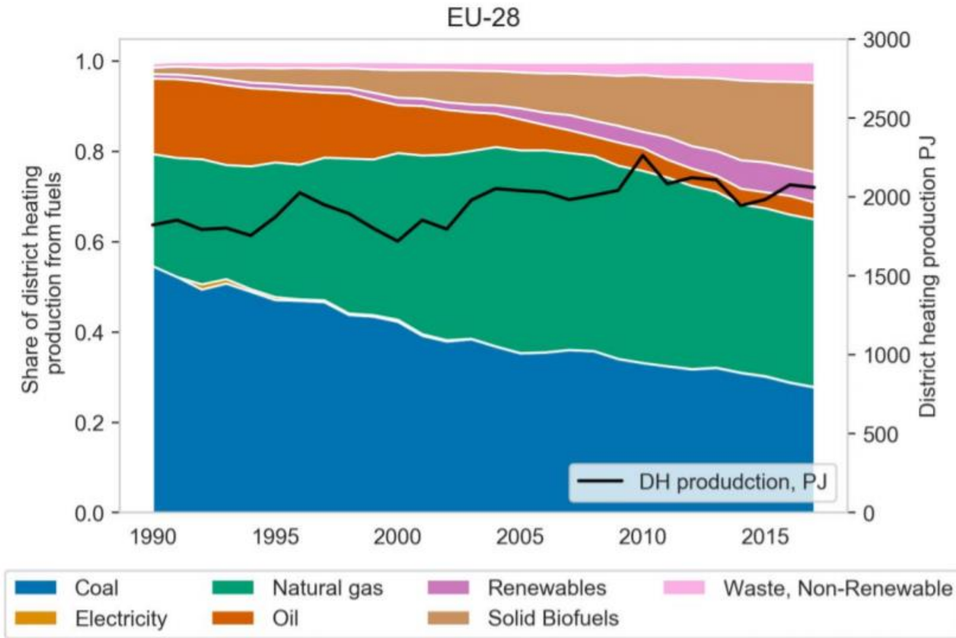


Figure 2-6. Share of fuels in EU-28 district heating production. [19], [78]

Important progress has been made during the last 2 decades regarding the uptake of solid biofuels, waste (non-renewable) and renewables. Although there is still room to increase this share, and to phase out coal and natural gas.

[438] Aalborg University (2019), Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy (based on "Database - Eurostat" 2019: http://ec.europa.eu/eurostat/web/energy/data/database). Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

Textbox 3-17 Need to upgrade existing DHC [439]

The Upgrade DH project aims to improve the performance of district heating networks in Europe by supporting selected demonstration cases for upgrading, which can be replicated in Europe. The Upgrade DH project aims at initiating the DH upgrading process (retrofitting approaches); increasing the share of waste/residual heat (currently 7 % in the demo cases) by more than 6 % and the share of renewable heat (currently 28 % in the demo cases) by more than 20 % in eight demo cases and beyond; replicating the proposed upgrading solutions across Europe; developing regional / national action plans for the retrofitting of district heating networks by including the results of the retrofitting approaches.

The Upgrade DH project supports the upgrading and retrofitting process of DH systems in different climate regions of Europe, covering various countries: Bosnia-Herzegovina, Croatia, Denmark, Germany, Italy, Lithuania, Poland, and The Netherlands. On these 8 cases, the following 3 cases explicitly include the use of additional renewables: Bosnia-Herzegovina plans the integration of solar thermal collectors; Denmark intends to convert the CHP to biomass; the Netherlands intends the installation of a second 16MW biomass boiler.

However, in most cases, the focus of the upgrading was to increase the relative share of renewables in the heat production as well as to improve the use of the available resources, and to optimize the management of the network.

In some cases, by reducing the environmental effect, especially the emissions of the local pollutants, the health of the local population increases, which is one of the main social benefits of such a project, but also the fact that the public opinion towards DH would increase due to such project promoting efficiency and increasing the share of renewables in DH production.

Increasing the share of renewable should go hand in hand with the improvement of its performance, for efficiency reasons, rationale use of renewable resources, but also to increase public acceptance. However, despite the 2 last decades trend, the uptake of renewables is not yet guaranteed and still need to be mainstreamed and pulled to contribute to fully decarbonize DHC in 2050.

Textbox 3-18 Summary of some business cases upgrading existing DHC [440]

Summary of case studies - increasing efficiency & integrating renewables

1. **Sisak, Croatia**

It has been determined early in the project that the most interesting upgrading measure for the district heating system in Sisak is the implementation of the thermal storage unit in the form of the buffer tank. Given the high interest of the relevant stakeholders to significantly improve the efficiency of the system, the business model has been developed in a close cooperation with all of them (incl. heat production and heat distribution companies in Sisak (HEP Proizvodnja and HEP Toplinarstvo)), which enabled achieving a high level of detail and accuracy of the analysis. The investment cost of the 66.6MWh steel tank (incl. 12

[439] Upgrade DH. (Accessed on 10/05/2021). Upgrading the Performance of District Heating Networks in Europe. Available at: https://www.upgrade-dh.eu/en/about-upgrade-dh/
[440] UpGrade DH. (2020). Summary on business models and initiating investments for upgrading district heating. Available at: https://www.upgrade-dh.eu/images/Publications%20and%20Reports/UpgradeDH%20D5.5.pdf

MW heat exchanger, foundations, measurement equipment and connection pipes), was about 1.6M€, with linear depreciation through different time periods (i.e. equipment 10 years, civil works 15 years). The thermal storage was to be owned by the HEP Proizvodnja, owner and operator of the existing biomass cogeneration unit (storage was expected to improve the efficiency of the CHP). Since this project would fall into the category of small projects in the HEP Group portfolio based on its investment costs, it is most likely that the funds would be provided by the HEP Group itself, i.e. no loan would be needed. However, both the scenario with 50% bank loan and the scenario without the loan have been analysed to cover both cases. For thermal storage integration in Sisak, revenues would consist of reduced peak load boiler use and the reduced use of steam line during the summer period. These are both reflected in the lower consumption of natural gas and amount to 312,440 €/a. On the other hand, the costs of the project are rather lower, since there is no need for additional personnel or additional software. Therefore, they consist of the operation and maintenance costs and the insurance costs and amount to 10,539 €/a. By taking into account all these parameters, the lifetime of the project (20 years) and the discount rate (5%, to discount future cashflows to the present value), the net present value of the project has been calculated at ~1.5M€, giving the internal rate of return of 14.9% and the payback period of 6.1 years. The project would have a relevant socio-environmental impact at the local level, decreasing the emissions CO_2 emissions by 2,145 t, NO_x emissions by 382 kg, SO_2 emissions by 12 kg and CH_4 emissions by 115 kg.

2. Marburg, Germany

The municipal utility - Stadtwerke Marburg (SWMR) – is responsible for the whole district heating process chain, from generation to distribution and sales. Detailed hydraulic calculations of the DH grid with different scenarios and multiple upgrade opportunities identified the UM “optimisation of the pump operation” to be the most relevant topic, which could be the case for many other DH systems. The cost-effectiveness of replacing the network pumps often does not appear economic at first glance, as the investment costs only appear to be offset by small savings. The ownership model and the DH business itself will not be affected by replacing the pumps. In most cases, pumps prove to be robust components that, if operated and maintained properly, will still work properly after several decades. For the example in Marburg the pumps were built in the 60s and are still running with no major problems. If only the simple replacement of old pumps by new pumps of the same size is considered a business case, the investment costs are easy to identify. A typical DH system is designed for a specific maximum heat demand at a certain temperature level. In the last decades a lot has changed, new generation plants reach efficient operating conditions at much lower temperatures, still sufficient for space heating; the energy demand of individual consumers is decreasing (e.g. due to better insulation materials or warmer outside temperatures during winter). Hence, the initial planned pumping power is oversized, and the pumps are operating in inefficient part load situations all over the year.

For the reliable supply of the customers of a district heating system it is important, that the appropriate amount of heat can be transported through the DH grid. The technical analysis showed that the DH system could be operated reliably when the installed pumping capacity is reduced from ≈250 kW to ≈120 kW, for an increase in efficiency of ~25%. Yearly savings are estimated at ~74k€, with an investment around 95k€.

3. **Middelfart, Denmark**

The upgrading measures considered in the city of Middelfart are the result of a long collaboration between the local district heating company Middelfart Fjernvarme Amba, and the consultancy company COWI. Since the beginning of the Upgrade DH project, the focus of the upgrading was to increase the share of renewables in the heat production as well as to improve the use of the available resources, and to optimize the management of the network. Before 2018, approximatly 2/3 of the heat supplied to the DH transmission system TVIS was from a natural gas fired CHP plant. With increased focus on climate changes and the higher standards required by the Danish governments, the Municipalities (including Middelfart Municipality) supplied by the TVIS system, agreed to convert the CHP plant to biomass. It increases the share of CO2 neutral production units from 27% to 94% in 2020 and thereby decreases CO2 emission by ~83% (reduction of CO2 ~ 10,000 tCO_2 eq/y). The woodchip-based CHP plant (90 MWel & 230 MWth) supplies heat for the district heating transmission system TVIS (main heat supplier for the DH network). The initial investment is around 200 M€, which leads to an evaluation of the financing resources, which requires access to a bank loan. Afterwards, considering the operation and maintenance cost, the revenue of the heat sales and the savings obtained by using biomass, the expected payback period was calculated to be around 25 years.

The sensitivity analysis showed that the variation of natural gas and biomass prices have a high impact of the feasibility of the project. The utility Ørsted is the owner of the plant, which is the main actor involved. However, the conversion costs were covered with the contribution of the TVIS transmission system, which is a partnership of the four municipalities that are supplied by the system, where Middelfart Municipality has around 8% of the shares. The ownership of the production system and transmission system are going to be the same after the conversion.

Due to the high focus on the sustainability and CO2 reduction targets established by the Danish government, the project was further evaluated for the environmental costs/benefits and it was considered as feasible. The refurbishment of old service pipes was also considered, for network optimization, which was based on employees' knowledge of the network as well as based on not verified assumptions. By combining a Termis analysis of the service pipes and measurements allowed to identify the areas where the service pipes are in poor conditions. Based on that, it will be possible to plan the replacement of the existing pipes in a more efficient way, giving the priority to the service pipes that affect the network's performances the most. Middelfart DH company allocates every year around 1.35M€ of the income from heat sales for the renovation of the DH network, and more specifically for the service pipes. It guarantees a continued check and upgrade of the distribution network in the municipality. The evaluation of the investment considered an upgrade of the Termis system, which is installed in Middelfart of ~13k€, helping to replace the pipes in bad conditions at first (with a 2 year payback). There is a close collaboration between the district heating company and the consultancy company to use the results in the most efficient way and to further develop the tool.

4. **Bologna, Italy**

Berti-Pichat is a complex system, which features heat/chill/electricity provision. The 3 CHP engines do manage to provide for the base load, yet gas boilers are vastly used during the peaks of heating season.

The investment is about installing heat pumps in the system, allowing for a greater utilization of the CHP units, while recovering a share of heat not currently utilized (because of its low temperature) and decreasing the usage of gas-fired boilers. The implementation phase involves significant investment costs linked to mechanical/hydraulic interventions, as well as IT activities for SCADA connection. Cogeneration in Italy is subject to subsidies to the extent its "high efficiency" can be proven. The other main revenue driver is constituted by the avoided costs of gas boilers consumption, whose usage should decrease significantly as the heat pumps are operating in the heating season. The operating costs connected to the upgrading measure are constituted by the electricity consumption of the heat pumps (in terms of missed electricity sale) and the maintenance costs for the asset.

The significant capital investment is expected to reach breakeven within 3 years, leveraging also on regulatory incentives (related to high-efficiency cogeneration). Sensitivity analyses were carried out, in order to assess the investment parameters in case of a fluctuation of the main drivers (gas prices, cogeneration incentive structure, electricity market prices), outlining that the returns were still very interesting even in the most negative scenario. The concept of smart substations involves a significant infrastructural effort, requiring to enable the metering on both the primary and secondary side with fine granularity. The measure aims at achieving a better customer knowledge and profiling through advanced analytics, while decreasing pumping costs (better regulation).

5. Salcininkai, Lithuania

"Salcininku silumos tinklai" is the municipality's district heating company that operates 14 boiler houses in Šalčininkai county in which it produces and distributes heat to residents and institutions in 10 different locations. The total installed heating capacity is 48 MW. Heat is supplied via 18.7 km long pipelines which are connected to 2,168 consumers, 96.8% of whom are residents. The heating systems at user size are usually designed for 80/60°C temperatures. The design temperature for hot water is 52°C. The supply temperature varies from 70 to 95°C throughout the year. most significant areas of impacts that the company seeks to improve is heat distribution. Investments in infrastructure of pipelines in the district heating network of Salcininkai started more than 30 years ago. Throughout the existence of this DH system, millions were invested. The seriousness of the issue and necessity of network optimization was identified by comparing DH system parameters to other DH systems of the country. Technological heat losses in 2018 were 10.2 GWh, which stands for 26.1% of the total heat produced. Network insulation is outdated in many places and does not ensure the thermal conductivity requirements which leads to considerable heat losses. Network optimization is a long-term step by step strategic approach which will lead to more efficient DH network.

The boiler used to meet the low summer demand is 6.5 MW to deliver peak demand ~1MW, hence decreasing the lifetime of the boiler and highly reducing its efficiency. The installation of a solar collector field with a possible heat storage implementation to the current boiler house would eliminate the inefficiency of low summer demand supply. It would increase the annual average efficiency of the current biomass boiler by eliminating the need of boiler for summer. The heat production would be more flexible, efficient, and diverse. The lifetime of the current main heating source would be prolonged and primary energy demand would decrease.

The integration of solar thermal energy into existing DH system is a complex combination of finding the right balance between size of investment and the right selection of working modes. In such system, to ensure optimum system performance and maximum usage of solar energy, it is necessary to install the heat storage and use the existing heat source (biomass boiler) only if the energy produced and stored by the sun is not enough. The total investment for solar thermal implementation (combination of 11,600 m2 solar collector field, 2,600 m3 volume heat storage and other auxiliary equipment) in the main district heating system of Salcininkai would cost ~ 4M€. The only potential funding sources for the pipe refurbishment will be funds of the DH company and loans depending on the scale of the project and the company's financial situation during the implementation moment. The solar thermal system combined with thermal storage would lead to elimination gas boiler usage during the short-term peak demand periods, and to reduce CO2 emissions (~236 tCO_2eq/a).

Taking into consideration subsidy schemes for solar thermal energy available today, the project could be financed from the European Structural Funds by up to 50% of the eligible costs. Due to the fact that the loan will be quite significant for the company and its capital might not be sufficient enough therefore municipality might give guarantee to the bank in order to help DH company to implement the project. Private capital of DH company is usually used as security deposit (mortgage) for the bank.
Finally, the network optimization will most likely be a 30-year refurbishment plan which means revenue will increase on a year by year basis, leading to increasing primary energy demand reduction.

From these cases, it seems clear how important technical guidance helps the upgrade (EE & RES) of existing DHC, even when the business cases are very attractive. In all cases, an external guidance (via the Upgrade DH project) was necessary to initiate, support the identification of upgrading measures, and coordinate all works.

Another important aspect to consider, is that for the longer pay back investments, the economic feasibility would not be sufficient and therefore would need additional policy, like support from public authorities, or emission reduction targets, to steer and incentivize the concerned parties (heat producers or network operators).

A key issue to tackle, as illustrated by several cases (Middelfart, Bologna), is that the sensitivity is very high when it comes to variations of natural gas and biomass prices. Hence, there is a need for an overall regulatory environment, including from the EU level, that levels the playing field with gas and other fossil fuels, like the ETD and ETS (including ETS extended to building). This level playing field should work at large scale (such as in the case of Middelfart) to incentivise the switch to renewable in existing DHC. It also become critical for the deployment of new DHC systems, where those would compete with individual heating systems, particularly gas boilers as it would deploy mainly in urban areas, which are more connected to gas than rural areas.

Last but not least, from these cases (especially the replacement of gas supply by biomass, solar heat, or heat pumps), additional financial support may be required, to bridge the gap and, for these renewable investments, to reach the competitiveness level of gas (CHP or gas). To conclude, guidance at MS (and possibly EU) level has to be combined with an overall regulatory framework and certainly complemented by financial support.

Long term refurbishment and optimization plans of existing DHC (incl. their extension) are useful approaches to continuously look for efficiency improvements, regarding operation but also new investments and refurbishments. Such approach would also tackle all changes in demand pattern, such as lower demand, or decrease in temperature requirements. A good example of long term planning is given by the utility of the city of Munich, Stadtwerke München (SWM) with the implementation of its climate targets, replacing coal from lignite plants by geothermal district heating for 560,000 households by 2040.[441] The Upgrade DH cases also illustrate (e.g. in Lithuania) the interest of diversifying the energy supply side, providing additional flexibility, also linked to market opportunities, to the overall DHC system.

A specific target for the H&C in DHC (from option 1 to 3) remains important and would complement existing instruments (ETS or ETD) and market stimuli, by providing the needed trend to fully decarbonise DHC. Having in mind the full decarbonisation of the DHC by 2050, such target also supports overcoming no-economic barriers, such as the basic lack of awareness (e.g. in the industry where renewable is not associated to the core business), the administrative barriers, the lack of information (to final consumers) and public perception, the high upfront investments. However, a DHC RES target without a strong policy framework setting up a real level playing for renewable would lead to disproportionate costs and loss of value, putting the existing assets at risk.
Binding the target would be a complex task, given the huge differences between MS (e.g. comparison of Germany and Lithuania), regarding the current share of RES, the total heat delivered via DHC, but also the available options to significantly increase the production of renewables. It would also compromise the freedom of MS to increase their share of renewables in the most cost effective way. As binding the target would require a precise calculation method adapted to national contexts (cost of upgrading DHC, cost and available RES, competitiveness of DHC compared to individual supply), while only addressing 12% of the supply of H&C, remaining with an indicative target seems therefore more appropriate.
Increasing the target (options 1 to 3) should also consider seriously the competition with individual heating systems, especially with natural gas which is cheap across Europe. It is therefore essential to address the deployment of renewable in DHC in combination with other instruments such as the ETS, but mainly the ETD regarding the building sector.

Increasing the 1%-point RES share increase target (options 1 to 3), to reach the CTP ambition (39% H&C RES in 2030), would give the concerned MS the need trend to the global RES target by 2030.
Option 1 would give all MS an appropriate EU target to meet, highlighting the importance to accelerate the uptake of renewable in existing DHC, where it usually makes sense (scale effect) if combined with efficiency improvements.

Including a national renewable target (option 2) would require a calculation method, which should be inspired from the EU gap filler mechanism for the overall RES target from the Governance Regulation, as

[441] Think Geoenergy (Accessed on 10/05/2021), Munich targeting geothermal district heating for 560,000 households. Available at: https://www.thinkgeoenergy.com/munich-targeting-geothermal-district-heating-for-560000-households/

detailed in Annex II. The current criteria set in Annex II of the Governance Regulation (concerning the overall RES target) are:

(a) the MS's national binding target for 2020 as set out in the third column of the table Annex I to Directive (EU) 2018/2001;
(b) a flat rate contribution (CFlat);
(c) a GDP-per-capita based contribution (CGDP);
(d) a potential-based contribution (CPotential);
(e) a contribution reflecting the interconnection level of the MS (CInterco).

But this may not allow to capture the national heating and cooling specificities of DHC (as those criteria are more addressing the electricity sector). Therefore, an alternative could take into account other objective criteria addressing the purpose of heating and cooling, by :

- Replacing criteria (e) replaced by a new criteria specific to heating and cooling infrastructure & not considering interconnection, including electricity distribution grid, district heating and cooling, gas infrastructure;
- Focusing criteria (d) on H&C potential, considering all renewable fuels and technologies, including the availability of local resources such as waste heat;
- Adding a criteria related to the H&C demand pattern, integrating the energy performance of the building stocks (and possibly the pace of renovation), the density of heat demand, the possibility to upgrade the DHC.

Without integrating those criteria it would probably remain complicated to reflect MS's specific ability to deploy renewables in the DHC, and the associated costs that cannot be fully captured at macro level. Therefore option 2 would probably remain less efficient than option 1.

By eliminating the exceptions and making access to networks mandatory for renewables and other carbon-neutral sources (waste heat), including from prosumers, in large DHC networks, option 3 would slightly increase the efficiency of option 1.

Option 3 would be the most cost-effective, providing to MS a clear direction, while letting them all freedom to select the most cost-effective option, and also simplifying the process to calculate the MS contribution.

The cost-effectiveness of all options could be improved with the deployment of accompanying measures under RED (see variants below), by mainstreaming renewables in DHC in the frame of EED, and with the reinforcement of market-based instruments (ETS & ETD).

New developments

European energy systems could be decarbonised by 2050 by expanding district heating in urban areas to meet up to 50% of heat demand, as assessed by Heat Roadmap Europe (HRE4), having drawn up low-carbon heating and cooling strategies for 14 EU countries.

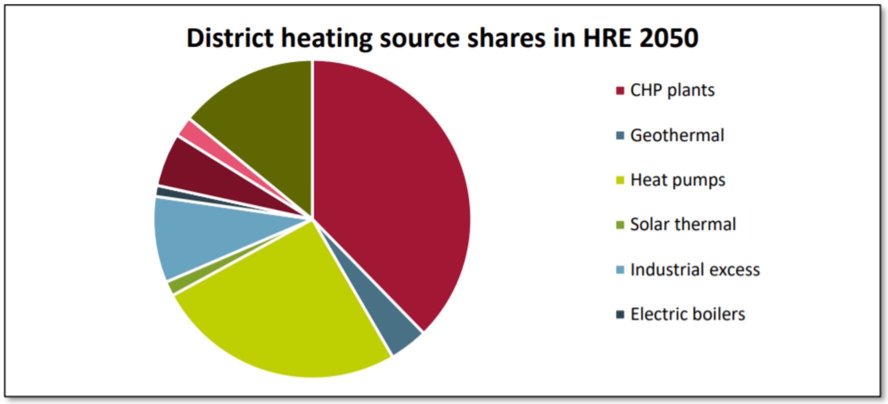
In the vast majority of urban areas, district energy is technically and economically more viable than other network and individual based solutions, and can be 100% decarbonised through the use of renewables, large heat pumps, excess heat, and cogeneration.

As highlighted by the LTS, a study HRE4 estimates that there is the potential to expand district heating and cooling to supply at least 50% of the heat demand (based on detailed assessment of 14 countries) in a cost-effective way, while reducing the primary energy demand and CO_2-emissions.[442]

One of the strengths of DHC (cost-effective, versatile and flexible) is the ability to use a broad variety of sources. In the HRE4 scenario, district heat would be supplied by the available renewables (between 5 and 10%), large heat pumps and cogeneration (around 30% each), around 25% of excess heat from industry and fuel production, and the remainder through boilers (as illustrated by Figure 3-17).

[442] Aalborg University. (2018). Heat Roadmap Europe 4 : Quantifying the Impact of Low-Carbon Heating and Cooling Roadmaps. Available at: https://vbn.aau.dk/ws/portalfiles/portal/288075507/Heat_Roadmap_Europe_4_Quantifying_the_Impact_of_Low_Carbon_Heating_and_Cooling_Roadmaps..pdf

Figure 3-17 District heating source shares in HRE 2050 combined for all the 14 countries. Source: Aalborg University, 2018[443]



***Remark**: in this study, all individual heating (50%) is supplied by heat pumps as a modelling method due to the purpose of the analysis and their distinct advantage of efficiency and integration with the electricity sector. This assumption influences the results of cost.*

The simulations of energy systems are designed to be operational (in the sense that they can provide the energy demanded in every hour of the year), so they include the costs required for the electricity production for the heat pumps and supply technologies for the district heating systems. The district heating systems are supplied according to the above-mentioned shares (which is based on a typical merit order, without considering any optimisations towards the design of the district heating and electricity systems). The iterations of district heating exclude areas where technical feasibility of district is challenging and assume the remainder of the heat demand is provided by (highly efficient) heat pumps. The level of savings for the residential sector is considered in addition to the current policy ambitions.

The matrix shown in figure 3-18 represent the results found for Czech Republic when comparing residential heat savings with different levels of district heating or heat pumps. For the purpose of modelling in the Heat Roadmap scenarios, the level of heat savings and the balance between district energy and individual solutions is chosen using the lowest value in the array which represents the total energy system cost. This analysis allows to optimise the system cost on the two parameters: level of energy savings & share of heat supplied by DHC. It allows to better analyse the link between energy efficiency and the deployment of DH.

[443] Ibid.

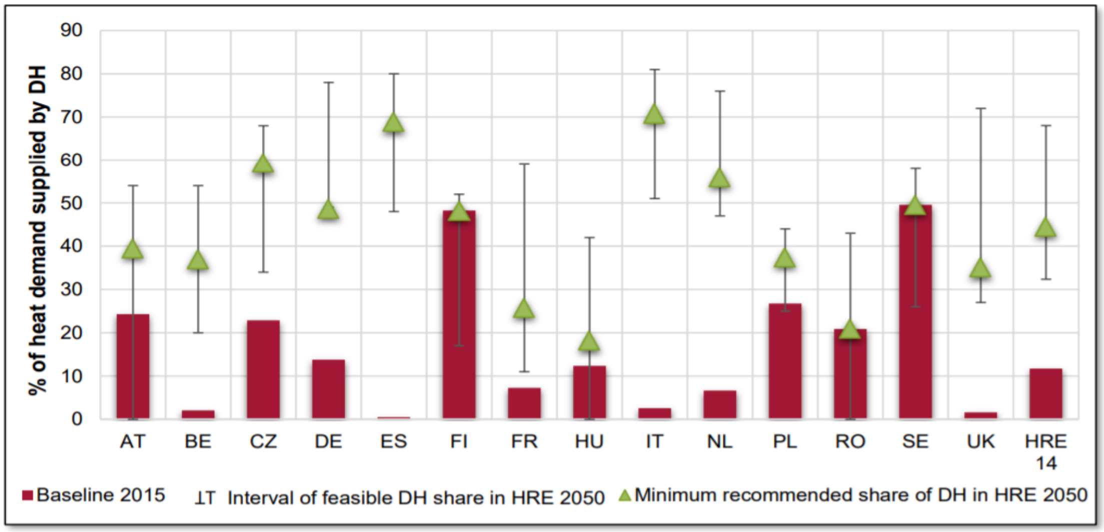
Figure 3-18 Comparison of residential heat savings with different levels of district heating or heat pumps in the Czech Republic. Source: Aalborg University, 2018[444]

Czech Republic: total energy system costs (M€/year)		Residential sector space heating savings (additional to a 20% reduction already in the Baseline)					
		0	5%	10%	15%	20%	25%
Percentage of market share covered by DH	0%	23407	23344	23328	23341	23369	23287
	4%	23384	23320	23302	23314	23340	23255
	10%	23322	23258	23235	23246	23271	23185
	18%	23245	23177	23154	23163	23186	23097
	26%	23165	23096	23071	23077	23099	23008
	34%	23086	23014	22988	22994	23013	22920
	42%	23041	22967	22940	22943	22959	22866
	51%	22995	22920	22890	22891	22905	22811
	59%	22997	22921	22890	22889	22902	22806
	68%	23091	23012	22979	22976	22987	22889
	78%	24032	23952	23917	23912	23922	23822

However, one of the first observations from all matrices is that in terms of total energy system costs, the differences are not that great. The study shows that a 0.5% total cost change interval gives a market share of district heating in a 32-68% range in combination with the 30% end demand energy savings (as illustrated by figure 3-19 for each of the 14 countries of the study). The scenario level where about half of the heat market is covered with district heating is based on economic metrics and effects on the energy system only (not considering all other benefits, like jobs or industrial development).

[444] Ibid.

Figure 3-19 Baseline share of district heating in 2015 and the minimum recommended level of district heating share in HRE4. Source: Aalborg University, 2018[445]



In addition, such level of district heating is robust against a situation where the implementation of energy savings and refurbishments fails to reach its target.

Future storage units for district heating must be more varied and versatile to integrate low-carbon sources and enable energy system flexibility. The capacity of boilers can cover the peak demands over the year. Heat only boilers play a marginal role in the heat supply mix (less than 6%).

Full electrification of the heating supply via heat pumps would globally be more expensive. With 50% district heating in combination with electrification overall the grid costs are spread between thermal and electricity grids. Lower shares of district heating will increase the cost for electricity grids in decarbonised energy systems. Less district heating would also miss the opportunity to potentially recover energy from industry and power generation, increasing the overall efficiency of the system and the possibility for more energy system integration by coupling electricity, heating and using heat storage.

In areas with limited district heating and cooling feasibility, individual supplies should be from heat pumps that can contribute to the integration of variable renewables. In rural areas, heat pumps, possibly biomass-based heating systems, solar thermal, and hybrid systems (heat pumps can in reality be combined with solar thermal and biomass boilers) should form the individual solution, providing about half of the heat demand. The level depends on the local conditions for the built environment. High standards of energy performance and deep renovations are necessary in order to implement heat pumps effectively and ensure high coefficients of performance along with a high level of comfort.

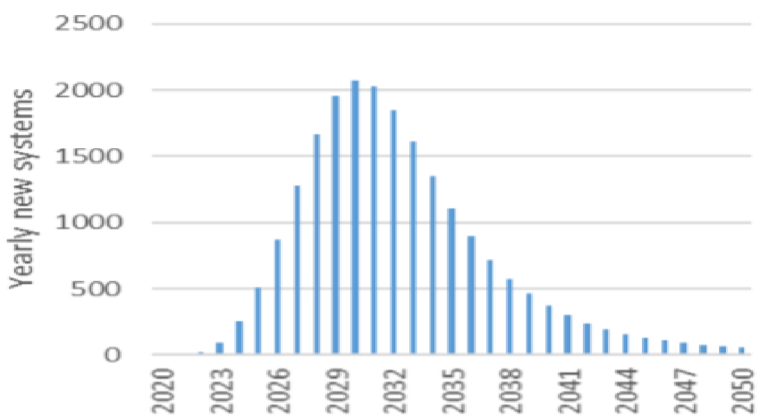
While district heating remains economically viable without cogeneration, the whole energy system overall is more expensive, has significantly more difficulties integrating variable intermittent renewable electricity

[445] Ibid.
"Note that the range bars represent the amount of district heating that is economically feasible within a 0.5% total annual energy system cost change sensitivity. The recommended minimum levels that into account cost efficient levels and current level of district heating. Going beyond this level can generally increase energy efficiency."

sources, requires more electric capacity and requires either more fossil fuels or an unsustainable level of biomass.

The following figure illustrates the number of new DHC systems to be developed across the 14 MS of the HRE4, to reach the target of 50% heat supplied through DHC by 2050.

Figure 3-20 Approximate new DH systems in HRE4 scenario to reach 50% of heat supply via DH. Source: Aalborg University, 2019[446]



Based on the Pan-European Thermal Atlas geographical information system, the study conducted by HRE4 identified prospective supply districts areas with a potential for district heating. An annualised distribution grid investment cost of 4 EUR/GJ was used as minimum threshold for the identification, in addition to a minimum heat demand density of 20 TJ/km^2. A potential of around 25,000 areas in the EU was identified, allowing to reach the target of a 50% district heating share by 2050. This is a 7-fold increase in the number of district heating systems across Europe compared to the current situation (2019).

EU guidance and national best practices would provide technical, economical, but also institutional support, and would therefore ease the process of implementation, reducing the costs for national and local authorities responsible for the implementation, and certainly accelerate the process at regional and local levels, and among economic actors. Assuming renewables in DHC will count for the H&C global target, such guidance (from the Heat Roadmap) would already provide an adequate framework to accelerate the increase of RES in DHC. An increased target under options 1 to 3 would give a clear signal to accelerate the uptake of RES in DHC, while improving their performance.

District energy is part of the solution to seriously decarbonize the H&C and global economy and contribute to a competitive, green economy that employs limited resources in the most cost-efficient way (e.g. a Total Cost of Ownership of 27eur/MWh, in the City of Hillerod in Denmark[447]). Design of and choice of system for district heating networks have a major influence on performance in terms of energy efficiency, CO_2 emissions and operating costs. A good understanding of the economic case of DHC, via best practices and

[446] Aalborg University. (2019). Towards a decarbonised heating and cooling sector in Europe : Unlocking the potential of energy efficiency and district energy. Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf
[447] Euroheat and Power. (2020). Updated Danish White Paper on District Energy. Available at: https://www.euroheat.org/publications/reports-and-studies/updated-danish-white-paper-district-energy/

case studies, will support project developers but also decision makers to adopt the best approach, regulatory frame, planning, and specific design when it comes to investing. Sharing best practices will also increase skills to manage risks investing in DHC. The guidance should also cover risk assessment and management. This is key to leverage the potential of DHC expected by RED II.

Investor certainty

An indicative target set at EU level has little impact on investor's certainty, but as increased targets (options 1 to 3) would probably lead to increased actions at national level, at least in some MS, the investor's confidence would come from these national frameworks, and possibly increase slightly.

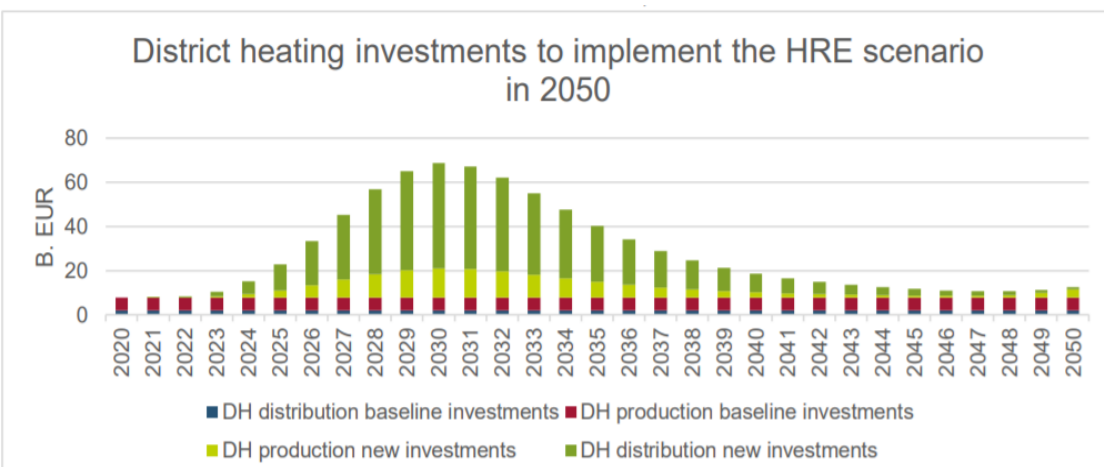
In any case, the most effective way to enhance investor certainty is provided by stable framework on the long term, including for support schemes where required. Therefore, if renewables in DHC are able to compete without additional incentives (e.g. if the ETS carbon price is high enough), these instruments would be more secure for investors than the binding targets.

Macro-economic impacts

For the existing DHC to uptake renewables, the three options would theoretically have the same impact as the level of the target would be identical.

Regarding the deployment of new DHC, from a Heat Roadmap Scenario, investments could start in 2020 and take up during the years 2025-2035, where most of new systems would be installed. In 2030, investments in new DHC infrastructure and in production units would peak at 13.2 billion EUR and 47.6 billion EUR respectively, as illustrated by Figure 3-21.

Figure 3-21 DH investments to implement the HRE scenario in 2050 (50% DHC in heat supply). (Aalborg University, 2019)[448]



[448] Aalborg University. (2019). Towards a decarbonised heating and cooling sector in Europe : Unlocking the potential of energy efficiency and district energy. Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

As assessed by the HRE4 2050, these high investments by 2050 will result in an overall cheaper energy system compared to a conventionally decarbonised scenario as lower fuel, CO_2 and operation and maintenance costs offset the increased investment costs.

The potential to increase the share of renewables in existing DHC is high and should be supported by clear regulations and incentives. The perspective to deploy DHC at large scale across EU MSs is also important and could benefit from the same measures as for existing.

Awareness among DHC customers (especially citizens) is currently very limited about alternative RES-H&C systems. Customers are lacking transparent and comparable data and energy performance indicators of DHC systems and competitive low-carbon alternatives. Therefore, they have limited capacities to press their DHC operators and heat suppliers to improve energy performance and switch to renewables. Even professionals, such as installers, builders, architects are prevented from making informed choices on best performing, most suitable and most competitive solutions.
An increased target (options 1 to 3) could increase awareness at the level of decision makers, planners, and local authorities, to support leveraging local existing potentials, and would engage potential suppliers of heat and consumers together, provide them with relevant information to make informed decision, or even increase pressure on their DHC operators to support higher share of renewable energy in the DHC system.

The availability of transparent and easy to understand energy performance indicators will become increasingly important as DHC network systems will move to provide flexibility and significantly support energy system integration, integrating various energy sources and carriers, and residual heat or decentralised energy production. All options would enable consumers at building level to make a choice between efficient and renewable DHC system connection or producing their own renewable heat at building level.

In municipalities, especially in cities, DHC planning is rarely coordinated with other urban planning, while the latter could support the deployment of new, performing and renewable DHC. Integrated planning would be essential to support such coordination.

The deployment of RES in DHC leads to an increased level of education and training. More local professionals are concerned (planners, designers, installers, renewable energy supplier, heat suppliers, DHC operators, and local authorities) and would be trained with all three options.

Security of supply

The benefit of most renewable energy sources for the district heating and cooling is that they would create value with locally produced energy, building mainly on the match between demand and supply (e.g. geothermal heat, solar heat, heat pumps using a local heat source, bio-energies, including the production/use of biomethane). It does not mean these sources are only locally based, as, e.g., massive import of pellets exist, renewable-based hydrogen would not regularly be produced locally, biomethane can be transported via the gas grid. But except for the cases of wood-based energy sources (such as pellets) and RFNBOs, these renewables would be produced intra EU, as opposed to fossil fuels for which the EU relies heavily on imports. Therefore, renewable deployment in DHC reduces import dependency and thereby enhances security of supply.

All three options increasing the RES target in DHC would have a positive impact on security of supply by reducing import dependency, with possibly a slight decrease of this positive impact for MS relying on imported bio-energies (such as pellets), which is however currently the first renewable source in DHC.

Innovation

The contribution to renewables supply in DHC is made by bioenergy (main source for heating purpose), active solar heat, geothermal, ambient, RE electricity (including RFNBOs). In the 2 last decades, the increasing focus on emissions (air quality and GHG) and energy performance has driven the improvement of biomass heating technologies. CHP production from biomass has been developed at all scales. The current R&D efforts are mainly focusing on further technology optimisation, emission reduction, increased energetic (thermal, or thermal-electric) performance, reduced costs, optimum integration or hybridisation with other RE sources and technologies and energy storage solutions on a building level, stable and adaptive heat delivery and improved user interaction and satisfaction. Biomass fuel is storable from season to season. However, its limited availability and its future increased use for transport and materials will certainly lead to decrease its relative contribution to renewables in DHC. Other renewable sources will take over and deploy massively.[449]

Solare district heating plants are large scale applications of the solar thermal technology, and are integrated into local district heating networks for both residential and industrial use.[450] The economic and environmental benefits derived from the acknowledged reliability of this solar heat application, relying on the technical expertise gained over the last decades, have contributed to the growing economic interest. There are currently plants in operation in Sweden, Denmark, Germany and Austria.

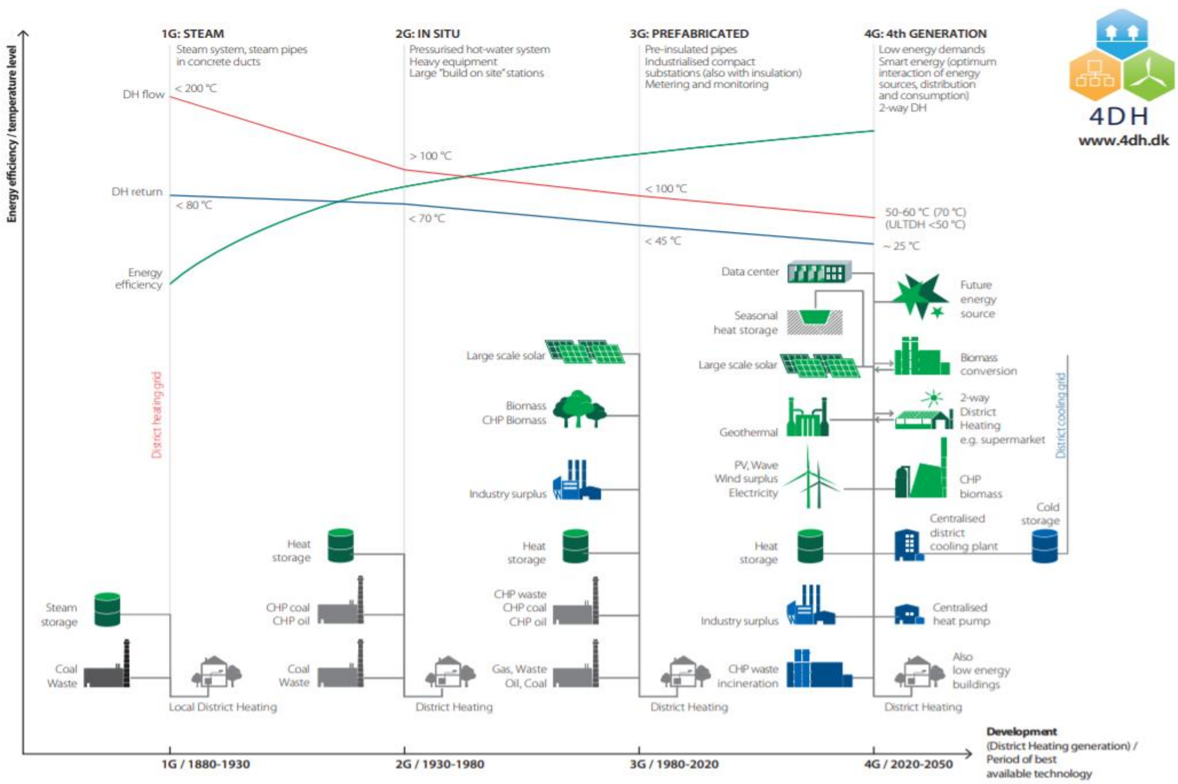
Geothermal District Heating (GeoDH[451]) uses geothermal energy (i.e. the energy stored in form of heat below the earth's surface) to heat individual and commercial buildings, as well as for industry, through a distribution network.

The first regions to install GeoDH, were those with the best hydrothermal potential, however with new technologies and systems, there is an ever increasing batch of regions that are developing geothermal technology for heating & cooling. Systems can be small (from 0.5 to 2 MWth), and larger with capacity of 50 MWth. There are some new District heating schemes that utilise shallow geothermal resources, assisted by large heat pumps. Innovation is continuous in integrating geothermal in existing DHC.

[449] Renewable Heating and Cooling ETIP. (2020). Strategic Research and Innovation Agenda for Climate-Neutral Heating and Cooling in Europe. Available at: https://www.rhc-platform.org/content/uploads/2020/10/RHC-ETIP-SRIA-2020-WEB.pdf
[450] Solar Heat Europe. (Accessed on 10/05/2021). Solar District Heating. Available at: http://solarheateurope.eu/about-solar-heat/solar-district-heating/
[451] GeoDH. (Accessed on 10/05/2021). What is Geothermal District Heating? Available at: http://geodh.eu/about-geothermal-district-heating/

The 4th Generation District Heating (4GDH) system is defined as a coherent technological and institutional concept, assisting the appropriate development of sustainable energy systems by using smart thermal grids. 4GDH systems provide the heat supply with low grid losses using low-temperature heat sources (usually for low-energy buildings), via integrated operation of smart energy systems. The concept is driving system performance and facilitate the injection of low temperature renewables such as solar or geothermal. Innovation is still ongoing, especially to tackle the challenge of existing DHC upgrading.

Figure 3-22 Progression of DHC - 1st to 4th generation. (Aalborg University, 2018)[452]



The intermittent nature of electricity production from wind and PV, which will continue to increase, requires demand flexibility, which can be provided by DHC. Replacing all fossil energy sources with renewable should be combined with upgrading and improved performance of DHC, with smart systems and storage capacities.

Increasing RES target in DHC and the resulting RES deployment will stimulate innovation, as those targets would create and enlarge market opportunities for all DHC applications and technologies based on renewable energy sources, and the enabling technologies such as those providing flexibility to the energy system. Most the RES DHC technologies are mature, however further innovation is still expected regarding cost and efficiency improvements. The EU value chain actors, starting with the EU manufacturers, would

452 Thorsen, J.E., Lund, H., Vad Mathiesen, B. (2018). Progression of District Heating – 1st to 4th generation. Aalborg University https://vbn.aau.dk/ws/portalfiles/portal/280710833/1_4GDH_progression_revised_May2018.pdf

get more confidence and possibly strengthen research. An accelerated deployment would support learning and ease new products or improvements components commercialisation. The EU industry can benefit from accelerated learning-by-doing and increased economies of scale, increasing the prospects of global leadership in renewables.[453]

There is no clear difference between the three options regarding the impact on innovation.

Distributional impact

The main concern regarding potential distributional impacts will be the effect of the options on DHC operators of small-and medium-scale DHC, on small and medium-size heat suppliers, on customers and the overall cost-efficiency and business case for district heating investments. Increased targets would increase the need for adequate implementation guidance, for roles and responsibilities clarification, for the identification of the remaining barriers. Increased targets would affect local DHC suppliers and DHC system operators, and customers through the conversion to new RES generation, leading to technical adaptation costs, switching to new business cases and upgrading existing DHC.

Support may be required in some situations where the integration of renewables could compromise the profitability of DHC systems and put them at risk. As in the case of other supporting schemes for renewable electricity, the distribution of such incurred costs could better managed than simply relying on a carbon pricing, being the ETS or ETD, where no distinction is made between consumers. Carbon pricing would simply increase the costs of carbon intensive consumption without any consideration for income levels, while specific support schemes can be financed in a way that does account for a just distribution of costs (e.g. taxpayers to bear the cost, or consumers with exoneration for certain consumer categories). The impact assessment carried out for the CTP confirmed that the scenario relying most on carbon pricing has the highest negative impact on low income households.[454]

However, the distribution could also be managed appropriately with the ETD if the revenues are directly used to support low income consumers to decrease their energy bill, by, e.g., focusing on these target groups with deep renovation programmes, or providing subsidies for the replacement of old and inefficient heating appliances (by renewable-based technologies), or providing lump sum support (possibly linked to the use of renewables). These revenues offer an opportunity to accelerate both energy efficiency and renewable in the DHC. Such programmes should be adapted to overcome the lack of capital and other barriers that may exist.

The distribution of the costs and benefits of an increased DHC RES target across MSs will rely heavily on how MS intend to design their framework in order to meeting the target. As in the NECPs, according to JRC's report, only 7 MS did provide RES targets to supply DHC and only 9 MS target for overall H&C supply via DHC, it remains hard to evaluate what will be the global impact yet.

[453] IRENA. (2014). Renewable energy technology innovation policy.
[454] SWD(2020) 176 final. Impact assessment accompanying the document "Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people".

Textbox 0-19 Limiting the negative impact on the environment of individual heating devices in areas with limited infrastructure opportunities - the case of Poland [455]

Reducing the negative impact of individual heat generation on the environment in rural areas is an important concern. In Poland there are 1555 rural communes, the majority of them, in need to exchanging individual heat sources for more ecological solutions. In Poland, the main source of low emissions (PM10, PM2.5 and benzo(a)pyrane) comes from heat generation for space heating and domestic water. In Poland, the majority of energy in households comes from the use of solid fuels, mainly hard coal, and firewood. In the case or rural communes lack of heating and gas network infrastructure and society wealth are identified as two key barriers to the deployment of cleaner solutions.

Analysis based on modelling found that the optimal model in the context of Polish rural H&C needs for individual households not connected to DHC is based on the use of biomass and heat pump technology. The model, of course, described the optimal solution based on average parameters however in practice differences in geography, topography, special and economic conditions need to be accounted for.

GHG emission reductions and environmental impacts

Half of the energy consumed in Europe is used for heating and cooling, and 75% of this energy is still coming from fossil fuels. Fossil fuel burning for heat generation is associated with GHG emissions and other air pollutants as shown by the information in the two figures below. Emissions from fossil-based heating are responsible for poor air quality in a number of European regions. For example, data shows that air quality standards in Poland are permanently exceeded especially as regards to PM10, PM2.5 and benzo(a)pyrene. High emissions can be linked to the prevalent use of hard coal and firewood for heating.[456] However, replacement of heating sources should also be carefully considered. For example, a study found that shifting from 20% of heating systems from oil to wood burning in Thessaloniki, Greece resulted in an 52% increase in particular matter, PM 2.5. It was calculated that this changes resulted in 200 excess deaths annually and a monetary cost of between EUR 200 million and EUR 1.2 billion.[457]

Figure 3-23 GHG emission factors for different boilers[458]

Technology	CO_2 (g/kWh)	CH_4 (mg/kWh)	N_2O (mg/kWh)	CO_2 eq. (g/kWh)
Oil boiler	267.837	10.850	7.233	270.658
Gas boiler	233.582	10.669	4.268	235.605
LPG boiler	269.995	21.326	4.265	272.912
Wood logs boiler	6.000	488.801	7.966	49.162
Wood chips boiler	19.000	129.406	5.176	31.237
Wood pellets boiler	22.000	12.430	4.972	24.357

Figure 3-24 Air pollutant emission factors for different boilers[459]

[455] Kaczmarczyk, M. et al. (2020). Energetic and Environmental Aspects of Individual Heat Generation for Sustainable Development at a Local Scale – A Case Study from Poland.
[456] Ibid.
[457] Sarigiannis, D.A. et al. (2015). Health impact and monetary cost of exposure to particulate matter emitted from bimass burning in large cities.
[458] Casasso, A. (2019). Environmental and Economic Benefits from Phase-out of Residential Oil Heating: A Study from the Aosta Valley Region (Italy) quoting IINAS.GEMIUS – Global emissions Model for integrated Systems. Available at: iinas.org/gemis.html
[459] Own elaboration based on: Casasso, A. (2019). Environmental and Economic Benefits from Phase-out of Residential Oil Heating: A Study from the Aosta Valley Region (Italy) quoting IINAS.GEMIUS – Global emissions Model for integrated Systems .

Technology	SO2 (mg/kWh)	Nox (mg/kWh)	PM10 (mg/kWh)	CO (mg/kWh)	NMVOC (mg/kWh)
oil boiler	168,723	154,994	3,617	51,665	10,850
gas boiler	1,812	237,090	0,593	118,545	10,669
LPG boiler	-	94,781	0,592	169,421	21,326
wood logs boiler	183,903	271,556	276,135	14.210,900	1.126,900
wood chips boiler	109,177	388,218	50,966	388,218	129,406
wood pellets boiler	131,935	298,325	70,797	248,604	55,245

Additionally, much of this energy is wasted due to inefficiencies in the heating and cooling systems. State-of-the-art, sustainable district heating and cooling systems offer a unique opportunity to make significant contributions to decarbonise EU cities through the efficient distribution of heat and cold from renewable energy sources.[460]

Modern (fourth-generation) systems operate at lower temperatures (typically around 50°C), resulting in reduced heat loss compared to previous generations, and making it feasible to connect to areas with low energy demand buildings. Fourth generation systems can use diverse sources of heat, including low-grade waste heat, fluctuating renewable energy and surplus heat, and can allow consumers to supply heat as well.

The renewable sources cover biomass (wood, bio-degradable waste, straw and bio oil), biogas, solar, geothermal and electricity (heat pumps and electrical boilers). District energy allows for sustainability and flexibility.

District heating can facilitate the deployment of renewable heat because of economies of scale. However, government policies facilitating a switch to renewables are still needed.[461] Guidance can support setting up such policies (based on several best practices).

There are still many inefficient DHC, that need deep renovation to reach new efficiency standards (pipe insulation level, digitalisation, low temperature levels, …), and significantly lower their current environmental impact.

The proxy used to measure the potential environmental impact is the direct link to the RES-H&C deployment in DHC, while the disconnection from fossil-based DHC systems to renewable solutions would be less efficient from a system perspective. However, in the case DHC systems are not able to increase their performance or to switch to renewable, the disconnection would remain the only viable possibility to phase out fossil from DHC. Integrating renewable in performing DHC always remain the best solution to leverage renewables such as geothermal heat, efficient and sustainable biomass systems, but even large heat pumps and highly efficient CHP.

[460] EU Smart Cities Information System. (2020). District Heating and Cooling solution booklet. Available at: https://www.euroheat.org/wp-content/uploads/2020/03/scis_solution_booklet_district_heating_and_cooling.pdf
[461] IEA. (2018). Renewable heat policies Delivering clean heat solutions for the energy transition.

Among the other potentially significant environmental impact is the effect of measures targeted at using sustainable biomass deployment, where large scale systems would lead to decreased impacts, if sustainability criteria for bio-energies are enforced (cf. options under sustainability of biomass). Geothermal and solar thermal don't emit. Regarding biomass burning, large scale plants minimise emissions of air pollutants and also improve the overall efficiency of the system. Waste heat recovery also avoids using other potential emitting energy sources, while avoiding wasting energy.
The current share of RES in DHC is pulled by solid bioenergy. While the deployment of all other renewable alternatives will accelerate, more than solid bioenergy, the later may remain the most important renewable source in the coming 2 decades. Therefore, great care about biomass sustainability should be taken, expanding the scope to small-scale systems.

Administrative burden

The impacts of an increased, but still indicative, RES target in DHC on the administrative burden will remain limited compared to the baseline.

The burden of option 2 could increase, requiring MS target calculations, and therefore follow up and gap filling calculation, in addition to the overall target requirement. Upfront, the calculation methodology will probably require assessing those factors that are essential in determining the national potentials, resources and needs before being able to mainstream them in a common formula fitting for all MS. Therefore, option 2 would have a strong negative impact, while option 1 and 3 would almost no impact, compared to the baseline.

Political feasibility

When fixing a target, the higher the level of granularity, the more it decreases the freedom of the responsible parties (EU & MS) to reach the overall target to deploy renewable globally, and thereafter to reduce carbon emissions and to increase security of supply at an affordable cost.
Increasing the share of renewable in district heating and cooling sector requires a systemic approach as it is at the core of energy system integration and requires also upgrading the old inefficient DHC systems.

The calculation methodology to determine the MS target and/or to monitor progress under option 2 should also ideally mainstream all these interlinked parameters, and it could be expected from the MS to request so. Therefore, agreeing on a common EU formula would probably become a complex task to negotiate to consider all very specific MS aspects.

In addition, given the many missing elements in most of the NECPs, defining the national contributions would require the MS to further study the penetration of renewable in DHC before being able to even discuss it. A new formula would include the interlinkages with all the sectors, based on the assessment of the RES-H potential, integrating many of these factors.

The following box illustrates policy packages can support improving the energy efficiency of buildings and the district energy system, at local or national level. These demonstrates how various instruments can support the use of DHC, without specific renewable energy target in DHC.

Textbox 3-20 Examples of policy packages that can support improving the energy efficiency of buildings and the district energy system, at local or national level

Local policy improving energy efficiency of buildings and district energy system:
A 2-steps approach in Milan, Italy

1. **Minimum building energy efficiency requirements that consider district energy**

Milan uses its building codes to promote an integrated approach to building efficiency and district energy. The building code stipulates specific minimum energy efficiency requirements for new and retrofitted buildings and is higher than national standards.

2. **Subsidies for new and retrofitted buildings connected to district heating**

Milan provides a reduction in infrastructure charges for new and retrofitted buildings that respect standards concerning energy efficiency and/or renewable energy sources, including connection to district heating. District heating does not represent a compulsory requirement for the reduced infrastructure charge, but can represent one of the elements that allow the achievement of the fixed standards. The absence of diesel oil as a fuel in heating is a pre-condition to benefit from the incentives provided by the infrastructure charge reduction measure. In addition, Milan previously provided incentives for district heating in the form of a direct subsidy to buildings to switch from diesel oil boilers to district heating to overcome initial capital costs. However, the payback period of this switch is today so low at 4-5 years that the city no longer provides incentives as building owners will switch anyway. In order to promote this opportunity to building owners, Milan has a municipality-run energy helpdesk that provides technical and financial information on energy issues to end-users and residents.

Requiring compatibility and/or connection of all new buildings, and those undergoing deep renovation, to the district energy system, Germany & Finland

Accounting methods used to develop efficiency ratings, labels and standards for buildings are usually based on energy consumption within the building. They rarely account for the ways that electricity and heat are produced, or for the use of non-renewable energy, creating a disincentive to use district energy and contradicting energy targets for its deployment. In Finland and Germany, building codes set primary energy efficiency standards for new buildings, and different sources of heat have different coefficients. Both countries require that a certain share of the energy used come from renewable sources. District heating based on CHP/excess heat and/or renewable energy is automatically considered to fulfil this criterion. The energy-saving ordinance in Germany aims to reduce the primary energy demand of buildings to save resources and lower greenhouse gas emissions. Insulation, efficient systems and primary energy sources can fulfil the obligations. The system therefore reflects the efficiency benefits of modern district energy.

Therefore, option 2 would have an important negative impact, while option 1 would require only an EU target and therefore leave some room for the MS to contribute. However, option 1 could also require to calculate each MS's contribution (a simplified version compared to option 2), and would have a more negative impact than option 3.

To conclude, setting up a higher indicative RES in DHC (at EU or even MS level), to comply with the new ambition of the CTP, would give the MS a clear direction on the way forward.

Overall RES target & H&C RES target

The cascading of sector and subsector targets, in addition to an overall RES target, may become counterproductive, bringing additional constraints while the freedom left to MSs without such targets would have led to cost-effectively deploy renewables, according to their strengths, needs and potentials to contribute to climate goals.

At the same time, given the complexity and specific challenges of each of the subsectors (RES in DHC in this case), and the fact they will need to fully decarbonise by 2050, it remains essential to provide the direction at the EU level, in compliance with the overall target.

With a share of renewable in DHC indicated to be above 60%, one MS is not subject to the renewable increase requirement (article 24(4) of RED II), while only six MSs planned to achieve the renewable increase requirement (article 24(4a) of RED II). The other 20 MS did not specify their target to increase RES share in DHC.

It should also be noted that such common target for all MS was not taking into account national renewable resources, nor current market dynamics, or existing situation.

1.1.2 D2 - Accompanying measures (variants)

Variant 1 - Enhanced coordination and common market operation of DHC systems with electricity distribution (DSO) and transmission system operators (TSO) (NEW) for flexibility services, demand response and related investment in infrastructure and generation assets

Effectiveness

The deployment of flexible DHC systems is important for both the performance of DHC systems as well as to increase renewable energies. Flexibility, performance and renewables are closely linked and driven by new technologies, and digitalisation. 4th generation DH (4GDH) allows the use of a broad set of H&C renewable sources, including low temperature waste heat. New business models and regulations need to be developed to encourage the use of all available and cost-efficient renewables (including waste heat). 4GDH as a technical concept focuses on lowering district heating temperatures to increase efficiency and the use of low-temperature sources. However, in doing this, the concept challenges conventional energy system regulation and will, in some regards, constitute a paradigmatic change towards an energy system which is more integrated in both technical and regulatory terms.[462] Guidance to accelerate the uptake of renewable in DHC will create opportunities to deploy more efficient DHC. Labelling will support raising awareness to push for higher efficiency.

A major potential for flexibility in the heat sector generally and especially in DHC comes from the low cost of storing heat, providing an opportunity to shift electricity demand, or even supply. The use of hybrid systems consuming either electricity or fuel to produce heat depending on the price variations of both fuels. This also includes options starting such as dual heaters in buildings, large district heating systems

[462] Aalborg University. (2019). Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy. Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

with combined CHP, fuel boilers or electric heaters. The use of the thermal mass of buildings or heat capacity of water flowing through a heat distribution grid are also potentials to store heat.

In addition to large fuel boilers, district heating offers the possibility to use combined heat and power plants (CHP). In some countries (e.g. Germany and Denmark) even small district heating systems have CHP units while in others (e.g. Finland) CHP units can be found mainly in larger systems that can accommodate larger plants.[463] When used alongside CHP plants, fuel boilers cover heating peaks and backup CHP units. Combination of CHP plants and fuel boilers enables sensitivity to power prices. Some CHP units can also change the ratio between heat and electricity production, which increases their flexibility. The flexibility of the district heating system can be further increased with heat storages (accumulators) that offer a very low cost form of energy storage at district heating scale (thousands of cubic meters in insulated steel tanks or caverns). When power prices are sporadically very low (e.g. high levels of wind or solar photovoltaics) and there are no regulatory hurdles, it can become feasible to install heat pumps and electric resistance heaters in district heating systems. The table below provides examples of policies in Central and Eastern European countries to support the use of CHP in combination with DHC networks.

Table 3-6 Examples of policies to support electricity from CHP [464]

Country	Exists	Effective	Comment
AT	YES		Feed-in tariffs only for small scale biomass CHP (<500 KW_e), the allocated budget is very limited. Currently there proceeds a political negotiation process about follow-up tariffs for existing large CHPs(> 500 kW_el). Lots of them are expected to cease the operation
CRO	YES		Defined according to the size of the cogeneration as referent price of electricity, depends on the date of the contract signature, since corrections lowering the FIT were introduced.
CZ	YES		Support to new installations is only approved until the end of 2020 and applies solely to installations of up to 1 MW. Only very limited number of installations up to 2 MW can be supported.
LV	YES		The costs incurred in supporting the generation of electricity from RES or high-efficiency CHP are covered by all Latvian electricity end-users in proportion to their electricity consumption (the price includes mandatory procurement component).

[463] Kiviluoma, J., et al. (2019). Available at: https://lirias.kuleuven.be/retrieve/439204
[464] Table adapted from: Engelmann, K., et al. (2020). Renewing district heating (2020) Improving the performance of District Heating Systems in Central and Easter Europe. Keep Warm project funded by Horizon 2020. Available at: https://keepwarmeurope.eu/fileadmin/user_upload/Resources/Deliverables/KeepWarm_D5.2_Development_of_Multi-level_policy_Plans.pdf

SRB	YES		Feed-in tariffs are regulated by Decree on Incentive Measures for Electricity Generation from Renewable Energy Sources and High-Efficiency Cogeneration of Electricity and Heat and mainly depend on the type of RES technology. The validity of the Decree has been extended till end of 2019.
SI	YES		NA

The combination of an increasing deployment of variable RES-E production with the building space heat electrification via heat pumps poses two challenges for the electricity system: coincidence of weather events (e.g. weather-dependence on both supply and demand sides) stressing the power system and increased net load demand requiring backup capacity, unless partially decoupling heat and electricity through flexibility.

Textbox 0-21 Solar district heating for urban areas and cities[465]

Large, urban district heating systems are usually based on generation of thermal energy from CHP plants, heating plants of industrial waste heat. However, if enough surface area is available solar district heating can be considered as means to increase the share of renewable energies in large DH systems. In Graz, Austria solar thermal collectors of 16, 5000 m^2 supply heat into the city's DH network and subsystems at several locations.

In Denmark, there are several smart DH plants. In Gram, such plant is composed of 44, 800 m^2 of solar thermal collectors, a heat pump, gas-fired CHP units, an electrode boiler and back-up fossil-based boilers. The plant's pit thermal energy storage provides flexibility in the use of energy generation technologies to offset power price fluctuations.

According to a study[466] model tested with a case study for the Irish energy system for 2030, it was found that different weather patterns considerably influence investment and planning choices. Also, coincidental effects of different weather variables – in this case, low temperatures and low wind speed - define the most critical situations in terms of adequacy. By utilising building thermal inertia, total system costs of residential heat electrification can be reduced to the level of the benchmark technology, gas boilers.

In order to make the distribution networks more flexible and resilient towards demand profiles with rapid variations, one of the solutions for a DSO is to use flexibility provided by the consumers, producers or network's components, among which DHC and all its capacities to provide flexibility services. These services allow the distribution system to better adapt to the current power demand situation and potentially evolve into an active distribution network. Long-term planning of the distribution networks[467], which before was considered almost independent of the system's daily operation and very static, will

[465] UnGradeDH. (2019). Upgrading the performance of district heating networks: Technical and non-technical approaches – A Handbook.
[466] Heinen, S., Turner, W., Cradden, L., McDermott, F., & O'Malley, M. (2017). *Electrification of residential space heating considering coincidental weather events and building thermal inertia: A system-wide planning analysis. Energy, 127, 136-154.* doi:10.1016/j.energy.2017.03.102
[467] Klyapovskiy, S., Shi, Y, Michiorri, A., Kariniotakis, G., & Bindner, H. (2019). Incorporating flexibility options into distribution grid reinforcement planning: A techno-economic framework approach. Applied Energy, Elsevier, 2019, 254, pp.113662. Available at: https://core.ac.uk/download/pdf/228098494.pdf

become deeply intertwined with the operational planning, as the DSO will have to handle increasing flexibility services provided by an increasing number of active elements.
It remains complicated and expensive to deploy district heating pipelines into existing cities. However, new neighbourhoods are a potential target for small scale DHC. These solutions are cost effective, as they decrease the relative cost of heat generation units with a limited investment in heat pipelines. In addition, these small scale DHC can offer considerable economies of scale for heat storages whose specific cost decreases nearly logarithmically with increasing size, which could provide interesting flexibility services, as these new projects could also require the adaptation of the electricity grid.

Given the increasing role DHC will play in providing flexibility services to the electricity system, coordinated planning is essential, to allow harnessing sector integration potential, while conducting to cost optimisation of both grid investment and operation. This should apply intensively for all new DHC, and ideally for existing DHC, when such potential for flexibility services exists (e.g. CHP with boiler, HP, etc.).

Subsidiarity

Given the challenges of sector integration and the expected role DHC may play, coordinated planning is needed to gather the required expertise and anticipate the future demand and generation on both heat and electricity side, and develop on the most cost-effective options, considering all local influencing factors.

Such planning is costly and may be compromised by the lack of human and financial resources or the administrative burden for the DSO and DHC operators. It could therefore be guided from the EU level, but its design should be left to MS, complying with the national rules and regulations.

There are currently limited DHC being used to provide flexibility to the electricity system, and possibly very limited awareness, meaning MS action would probably not have been sufficient to contribute to benefit from the DHC capacities to provide flexibility services. Therefore, by reason of the effects of the variant, EU action would have an added value, at least to incite MS to think about encouraging sector integration services.

Textbox 3-22 Helsinki DHC [468]

[468] Helsingin Energia (2012) Helsingin Energia's smart CHP/DH system – the most energy=efficient solution for heating Finland's capital. Available at: https://www.districtenergyaward.org/wp-content/uploads/2012/10/Modernization_Finland_Helsinki_2011.pdf

Helsinki's solution combines CHP, district heating (DH) and district cooling (DC) in the most energy-efficient way in the world. CHP DH is produced concurrently with electric energy with an efficiency rate of more than 90%. Fuel is turned into energy in the most extensive way possible. DH covers over 90% of Helsinki's heating need. CHP accounts for over 90% of DH production.

Produced in the same processes with DH, DC is the most energy-efficient form of cooling properties by far. In Helsinki, the heat gathered from properties with rapidly expanding DC is used fully in DH.
DH and DC are produced from the waste heat of purified sewage water and from sea water in the Katri Vala heating and cooling plant.

The data centre concept: The heat produced by computers cooled with DC is conducted to the DH network to provide heat to buildings in Helsinki.

Light district heat is a heating solution for low-energy houses built in the extremities of the DH network. The building automation of these houses supports the concept of lower temperature of the circulating water in the smart DH system.

In accordance with Helsingin Energia's development programme towards a carbon-neutral future 2050, increasing use of bio-renewable energy is being introduced in the DH system project by project.

The heat storage facility will provide flexibility to the energy system as it will balance variable heat consumption through charging and discharging.[469]

As reminded during the 7th plenary meeting of the Concerted Action[470] on Joint Session on Energy System Integration Strategy held on 05/03/2020, infrastructure is one of the main challenges for energy system integration, especially because there is a large lead time to install large-scale energy infrastructures therefore, strong coordination, not only on EU level, but also on national, regional and local level will be needed.

This variant would leave freedom to the MS to implement the coordination between DSOs and DHC operators in the most effective way.

Coherence

Coordinated planning between DSOs and DHC operators is the most appropriate approach to find a cost-effective way to take advantage of flexibility services provided by DHC, hence increasing revenues in electricity markets.

[469] My Smart Life. (2017). Transition of EU cities towards a new concept of Smart Life and Economy. Available at: https://www.mysmartlife.eu/fileadmin/user_upload/Deliverables/D4.5_Report_on_district_heating_and_cooling_improvements_and_new_concepts_stamped.pdf

[470] Concerted Action Renewable Energy Sources Directive. (2020). Joint Session on Energy System Integration Strategy. Available at: https://www.ca-res.eu/news/test-news/detail?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=52&cHash=8be245a0a00e9ae9ce3d08c1be1aac1d

Administrative burden

Electricity network development plans are not always necessary and would result in onerous costs and administrative burden of little additional value, overlapping with current regulations ensuring quality of supply. Therefore, requiring to coordinate with DHC operators may also become an administrative burden and should be addressed in the most efficient way, to avoid such onerous efforts. Therefore, planning at the side of the DHC (e.g. a new boiler installation) could also become the trigger for coordination between both planning processes. Adequate guidelines may be used to avoid useless efforts.

Variant 2 - Enhanced coordination and common market operation of DHC systems with gas distribution system operators, hydrogen and other energy networks

Effectiveness

Global planning of DHC (incl. coordination with gas infrastructure)
Several European countries have inefficient district heating systems[471], designed for high temperatures. These district heating systems face the double issue of establishing new systems as well as consolidating and expanding existing ones while improving efficiency and increasing the share of renewables in these systems and building sectors. Many of these systems will have to move from 1st and 2nd generation district heating to 3rd or 4th generation systems (cf. figure 3-22). This can happen with new production units, access to new renewable resources, efficient distribution infrastructure, highly efficient buildings that can utilise low temperature supply and with improved heating controls, heat metering and consumption-based billing. A starting point should be to move towards demand-driven systems where customers can actively control their consumption. New systems should be established using state-of-the-art technologies along the value chain.

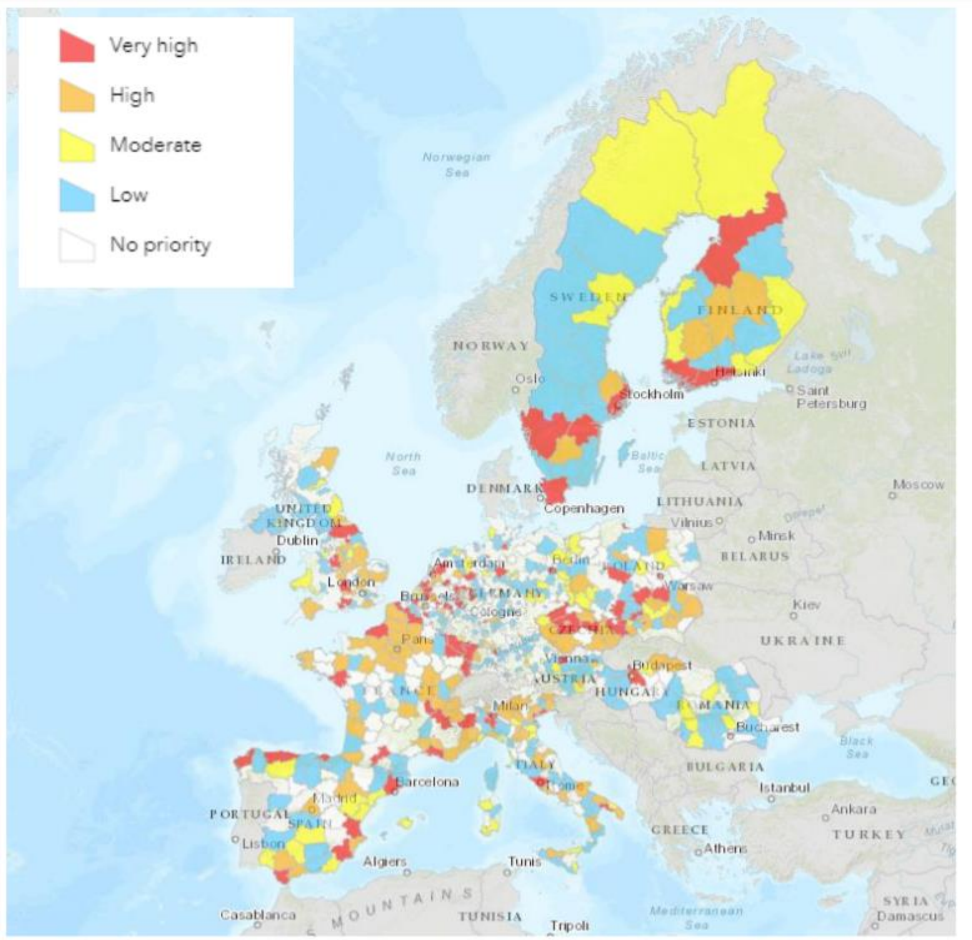
Clear district heating regulation and planning can be the determining factor in the decarbonisation of the H&C and especially in the widespread use of DHC.[472] Such regulation could address several principles involving local authorities, such as bearing the responsibility to approve new H&C supply and distribution projects, setting up rules to ensure the projects with the highest socio-economic benefits is selected, using local resources as much as possible in the most efficient way by combining heat and power, establish rules to ensure the most competitive end-consumer price (low market price), empowering the end-consumer.

A prioritisation of heat synergy regions/areas has been made for 14 MSs in the HRE4[473], based on spatial information for heat and cold demand and potential resources for heat production. This kind of mapping should help planning the deployment of DHC infrastructure, supporting planners, DHC operators and national/regional/local authorities.

The map in figure 3-25 shows 4 types of regions/areas in the 14 MSs of the HRE4.

[471] Mathiesen et al. (2019). Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy. Available at: https://www.districtenergyinitiative.org/sites/default/files/publications/towardsadecarbonisedhcsectorineufinalreport-111220191046.pdf
[472] The regulatory process, responsibilities and requirements when approving district heating projects in Denmark, as demonstrated in the District Energy – green heating & cooling for urban areas, State of Green 2020
[473] Heat Roadmap Europe available at: https://heatroadmap.eu/

Figure 3-25 Heat synergy regions prioritised in 14 MSs. (Aalborg University, 2019)[474]



Regarding the conversion to new RES generation, considering the rather long lead-time for planning and licensing new district heating and cooling systems and high upfront investment costs, medium and long-term planning of new DHC networks should be done by collaboration between local, and regional authorities and with national authorities overseeing these plans, but also with other infrastructure operators (such as gas DSO).

Building refurbishment programmes, electricity, telecommunication, water, or gas network investments and works are rarely implemented considering new DHC systems. Sustainable energy programmes targeting the decarbonisation and energy efficiency of buildings and the heating and cooling supply are often overlooked during the urban planning and design phase.
Decisions on investments in infrastructures and buildings at municipal or commercial levels may take place in an isolated manner without any consideration for the feasibility of long term sustainable solutions.

[474] Aalborg University. (2019). Towards a decarbonised heating and cooling sector in Europe : Unlocking the potential of energy efficiency and district energy. Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

Usually, no life cycle cost analysis is performed to assess the long-term cost-competitiveness of various options.

Enhanced coordination of DHC systems with other energy infrastructure would support cost effective decarbonisation of the H&C, especially in the case of gas networks that may either supply DHC (renewable gases such as biomethane or renewable hydrogen), either compete by extending their scope, and hence jeopardising DHC and/or becoming potential stranded assets. Therefore, any natural gas DSOs should consult energy planners & DHC operators to determine the most appropriate option for the long term decarbonisation of the H&C sector. Natural gas is mainly used for heating (space heating, warm water, process heat). therefore, natural gas and DHC could be competitors in many cases. Denmark, since several decades, has set a clear strategy to phase out gas DSO networks, and to rely on DHC infrastructure. Such an approach requires a strong and clear political choice and firm commitment, following a long-term well defined decarbonisation strategy. Without such political commitment, gas infrastructure (partially converted to hydrogen) will certainly continue to serve massively the H&C market.

It is crucial to take an integrated approach towards the energy systems' planning, development, and operations across all energy infrastructures. In order to minimise total life cycle cost, building design & operation with district H&C systems using various renewable sources and carriers can work together to optimise temperature levels, time of use based on tariffs and price signals, store energy in the most cost-effective way, record and regulate load profiles, integrate weather forecasts, and anticipate price formation. Appropriate cross-sectoral software interfaces need to be established to achieve interoperability[475] also with the gas system (including hydrogen). Energy efficiency and the use of renewable H&C should be maximised and the synergies between them optimised by tapping into existing local renewable and associated innovative design and technologies. Planning tools and methodologies specific to the decarbonisation of DHC are necessary, in order to coherently model, analyse, and design H&C systems as an integral part of the entire energy system. Close collaboration between all network and infrastructure operators is required to ensure appropriate integrated planning.

In order to promote all types of energy utilisation and supply (all renewable sources), interaction between supply and demand as well as efficient operation, a new generation of energy systems which treat the district heating network as the centre piece is emerging. Unlike traditional energy systems, the DH network, electricity and gas networks in the new generation of energy systems are closely linked through CHP units, HP and other electricity and/or gas-driven heating systems and influence each other. Therefore, to ensure the safe operation of the future DH network and gas & electricity networks, the integrated framework for generation and infrastructure planning need to be carried out. While ensuring to meet all operation constraints, a multi-stage planning model for the combined generation, infrastructure, can minimize investment and operating costs of the combined systems. Combined generation, DH, electricity and gas networks expansion or adaptation planning is a large-scale, high-dimensional, nonlinear optimization problem, which is difficult to solve (sophisticated mathematical optimization method to quickly obtain the optimal solution may be required). This would first require the different operators to coordinate efficiently.

[475] Renewable Heating and Cooling ETIP. (2019). 2050 vision for 100% renewable heating and cooling in Europe. Available at: https://www.rhc-platform.org/content/uploads/2019/10/RHC-VISION-2050-WEB.pdf

Subsidiarity

Given the double challenge of sector integration with renewable gases supplying DHC and of the potential shift (in some places) from individual gas supply to other renewable carriers (to avoid stranded assets), coordinated planning is needed to gather the required expertise and anticipate the future demand and generation on both heat and gas side, and develop on the most cost-effective options, considering the whole strategy for heat decarbonisation.

Such coordination is costly and may be compromised by the lack of human and financial resources or the administrative burden for the DSO and DHC operators. It could therefore be guided from the EU level, but its design should be left to MS, complying with the national rules and regulations.

Such coordination would also ideally require a clear H&C decarbonisation strategy, with the steps to fully phase out fossil fuels in the most cost effective way, to provide clear guidance to DHC operators and gas DSOs.

There are currently limited coordination efforts between DHC & gas DSO to determine together the option that would optimise the social welfare, with probably very limited willingness as these may compete in some cases while collaborating in other situations, meaning MS action would probably not have been sufficient to engage these operators to coordinate. Therefore, by reason of the effects of the variant, EU action would have an added value, at least to incite MS to think about encouraging coordination and avoiding stranded assets.

Coherence

Coordination between gas DSOs and DHC operators is the most appropriate approach to tackle the complementarity and scale effect of individual gas supply and DHC.

Administrative burden

Coordination between gas network development plans & DHC plans would result in onerous costs and administrative burden, possibly with limited additional value. Therefore, requiring to coordinate with DHC operators should be addressed in the most efficient way, to avoid such onerous efforts. Upfront clarity on the pathway for H&C decarbonisation and appropriate guidance would support finding the most balanced approach.

Variant 3 - Requirement to include specific RES share and a numerical energy performance number (PEF) in the information on district heating/cooling systems provided to consumers (e.g. on bills, suppliers/regulators’ websites)

Effectiveness

Usually, in supply-driven systems, billing is often based on lump sums and hence the system is frequently seen as unfair and outdated. By evolving to more demand-driven systems thanks to disclosure, consumers would adjust their energy consumption to their needs. Therefore, if consumption-based billing is paired to metering, consumers would also have an incentive to more rationale energy use, which in turn, would pave the way to increasing energy efficiency. The importance of metering in a demand-driven system reaches far beyond a proper billing of the energy consumed, since the deeper knowledge of the consumer patterns and conditions may enable the detection of faults in the consumer installations or demand-side management.[476] All these are mainly driven by efficiency purposes, but by providing information on the renewable and carbon content of the heat consumed, consumers would also more deeply follow the logic behind price formation and the energy sources used to produce heat.

Customers' role

A more active role of consumers in promoting high shares of renewable energy in district heating and cooling through the disclosure of district heating and cooling energy performance certificates, to be compared with building level energy performance certificates, would be supportive to make the adequate choice. This would incentivise the competition between most efficient energy performance solutions at the energy system or building level. Such competition is increasingly relevant as consumers are encouraged to invest in local renewable heating solutions, such as solar thermal systems, wood-pellet systems or heat pumps, under the EPBD. These local solutions could be complemented or replaced with renewables-based district heating and cooling systems to provide additional flexibility and performance. This variant increases competitiveness, and therefore economic impacts.

Customers' rights

Regarding potential disconnections, since efficiency standard does not include minimum energy performance thresholds and since no data is available on how different DHC systems can be categorised based on efficiency levels, estimating the impact of a better information of the customers and increased rights to disconnect remains hypothetical.

Higher disconnection risk and impacts could be expected in MSs with proportionally higher DHC market shares, and globally lower energy efficiency of these DHC. Where the share of inefficient DH systems is large, stronger disconnection rights could severely impact the economic viability of these networks. However with other enabling instruments such as planning or risk mitigation, the risk of disconnection could also incentive these systems to modernise and offer attractive services to reduce consumers' willingness to disconnect.

The efficiency of labelling and disclosure to final customers, to promote the increase of energy performance of the DHC and the switch to renewable will depend on the ability of the MSs to raise awareness and effectively influence the willingness and interest of customers to envisage disconnecting. This could only happen if the renewable alternatives are effectively available and are competitive. But in any case, disconnection will remain difficult for a consumer and would be a last resort solution.

This variant extends the existing provision under article 24(1) regarding information to final consumers, by increasing transparency. Hence, it will be a minor amendment.

[476] Aalborg University. (2019). Towards a decarbonised heating and cooling sector in Europe : Unlocking the potential of energy efficiency and district energy. Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

Subsidiarity

Currently, MSs already should ensure that information on the energy performance and the share of renewable energy in their district heating and cooling systems is provided to final consumers in an easily accessible manner, such as on the suppliers' websites, on annual bills or upon request. MSs should ensure that both the information about the renewable share of district heating supply and the efficiency of the systems are communicated to customers. Thus, the most appropriate extension of this option would allow MSs to build on the work already developed under current provisions.

Coherence

The review of the definition of efficient heating and cooling under the EED is an important complement as it provides the conditions for exempting from applying the provisions on disconnection, network access and the indicative annual average RES increase requirement. Furthermore this option should consider coherence with the EBPD.

Administrative burden

This variant could imply additional administrative burden for DHC operators required to disclose additional information regarding the share of renewable and the energy performance of their systems. However, such data would not be complicated to gather and disclose for the most efficient and smart systems, which could also be an incentive to upgrade DHC.

Variant 4 - Energy label (voluntary or mandatory) for DHC systems

Effectiveness

Inviting or obliging district heating and cooling operators to certify their systems would contribute to increased competition on the local heating and cooling markets and provide transparent and comparable data on energy performance of district heating and cooling systems, enabling households and industry to make informed choice on most appropriate energy solutions for their heating and cooling needs. An obligation should be based on standard methodology included in the CEN standard for district heating and cooling energy performance.[477] This European Standard[478] defines the determination of energy indicators of district energy systems. District energy systems may be district heating, district cooling or other district energy carriers (e.g. standalone gas network fuelled with local biomethane produced locally for the only purpose of this network).

Online tools available to cities, urban planners and DHC companies to compare heating and cooling options have been developed in the frame of the EcoHeat4Cities. These include Excel Design tools and accompanying guidelines, and promotion material. For the effective use of such labels, high awareness should be raised, in the DHC sector, and beyond.

[477] CEN/TC 228 standard prEN 15316-4-5 is a European Standard being part of a set of standards on the method for calculation of system energy requirements and system efficiencies.
[478] UNI - Italian Standardization Body. Standard EN 15316-4-5: 2017 on Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-5: District heating and cooling, Module M3-8-5, M4-8-5, M8-8-5, M11-8 -5. Available at: http://store.uni.com/catalogo/en-15316-4-5-2017?josso_back_to=http://store.uni.com/josso-security-check.php&josso_cmd=login_optional&josso_partnerapp_host=store.uni.com

There is no one common solution that fits with all, given the huge discrepancies between country regimes. Solid foundations to roll-out a green-labelling scheme for DHC throughout Europe exist, based on these differences, and on several best practices.

Subsidiarity

District heating networks are usually confined within local/regional/national borders and subject to jurisdiction within the national context and planning usually at city level, thus it would be fitting to allow MSs to implement the labelling. Given that not all MSs have developed district heating networks, EU-level regulation would not be applicable to the majority of MSs. Regardless of the mandatory or voluntary nature of this variants, MSs should be given the led in developing the labels with the EU supporting in the provision of guidelines and standardisation of methodologies, for example using the one developed by the EcoHeat4Cities project.

Coherence

Policy-makers should consider alignment of the label in relation to:

- Calculation methods for environmental performances of heating systems;
- Relationship between energy and building regulations;
- Taxes, support and market chain;
- Planning and evaluation.

There is also need to evaluate the coherence of this measure with the EPBD and EEP.

Administrative burden

Setting up a labelling scheme may be complex and long, especially in the case of a mandatory scheme. If the labelling remains voluntary, the administrative burden could be reduced significantly. Support from EU-funded projects such as EcoHeat4Cities can also decrease the administrative burden by providing capacity building and information.

Synthesis

This section we synthesize the findings from the analysis of the different options for deploying Renewables in Heating & Cooling. These options can be grouped in two groups:

- Group D1: Nature of the RES H&C target (binding/indicative)
- Group D2: Accelerate the share of renewables in District H&C

The findings from the analysis of each option are brought together under the three headlines of economic, social and environmental impacts.

Table 4-1 Impacts considered

Economic	Environmental	Social
Administrative costs	GHG emissions	Distributional effect
Costs to economic operators	Air quality	Political feasibility
Investor certainty	Biodiversity	
Energy security and innovation		

D1 - Nature of the RES H&C target (binding/indicative) & accompanying measures

Four options and four variants (accompanying measures) were evaluated for the nature of the RES H&C target, namely:

- **Option 1** aims at increasing the ambition for the annual average increase, by using an indicative uniform baseline & MS-specific additional increase;
- **Option 2** aims at increasing the ambition for the annual average increase, by using a binding uniform baseline & indicative MS-specific additional increase;
- **Option 3** aims at increasing the ambition for the annual average increase, by using a binding a uniform baseline & MS-specific additional increase;
- **Option 4** aims at fixing an indicative 39% EU H&C target on top of the previous options
- The four variants concern:
  - Planned replacement schemes of heating appliances to facilitate fossil phase-out;
  - Consumer RES heat purchase agreements;
  - Risk mitigation framework for RES heat supply (heat production and related infrastructure) with large upfront investment;
  - Planning and implementation of renewable and waste heat & cold deployment projects and infrastructure in heating and cooling, specifically article 15 (3).

Economic impacts

As a market instrument, the EU ETS results intrinsically in cost-optimal emission reductions. Hence, pushing for emission reductions through specific measures such as binding RES deployment will be less cost-effective as long as the carbon price is not high enough to enable H&C RES to become competitive in the industry. The same applies to the ETD, for the building sector.
In both industry and buildings, without specific measures to increase renewable's competitiveness, the risk remains high that renewables would not be taken up in the H&C sector. The two options would then be

either to increase carbon pricing significantly (which is out of scope), or to enforce the uptake of renewable via specific instruments.

Therefore, a specific target for the H&C remains important and more cost-effective than the existing instruments (from option 0 to option 4), by giving more guarantee that the overall renewable target will be met. Having in mind the full decarbonisation of the sector by 2050, such target also supports overcoming no-economic barriers, such as the basic lack of awareness (e.g. in the industry where renewable is not associated to the core business), the administrative barriers, the lack of information (to final consumers) and public perception and the high upfront investments.

An increased (options 1 to 4) and binding (partially under options 2 & 3, fully under options 3 & 4) target would raise the issue of the freedom of MSs to determine the best global approach to deploy renewables in all sectors (electricity, transport, heating & cooling), considering their national and local influencing factors and at the same time targeting a complete decarbonisation of the H&C sector by 2050.

The calculation method should be inspired from the EU gap filler mechanism for the overall RES target from the Governance Regulation, as detailed in Annex II, and integrate additional objective criteria addressing the purpose of heating and cooling, such as a new criteria specific to heating and cooling infrastructure; focusing on H&C potential, considering all renewable fuels and technologies; adding a criteria related to the H&C demand pattern, integrating the energy performance of the building stocks (and possibly the pace of renovation) and the energy profiles of the industrial sectors (considering the large variety of options to decarbonise).

Without integrating those criteria it would probably remain complicated to reflect MS's specific ability to deploy renewables in the H&C, and the associated costs that cannot be fully captured at macro level.

Option 1 could use the governance regulation calculation method (or formula) based on GDP and global cost-effectiveness, to determine MS indicative additional efforts to the already agreed baseline indicative target set out in RED II article 23. As the target would remain indicative, a simple calculation method seems to be fit for purpose.

Given the important discrepancies between MSs in the NECPs, with completely different reference/current situations, and the fact that 14 MSs do not meet this target in their NECP, the cost-effectiveness of the 1.3% annual share increase can be challenged, probably due to the fact a uniform target does not take into account the national factors. Option 2 would first require to agree that the baseline article 23 target is cost-effective, before it becomes binding.

Binding a MS-specific additional RES share target, under option 3, would require the use of a very specific calculation method, the too simplistic method based on GDP and macro-cost effectiveness would not be precise enough to determine a MS contribution, especially when the target increases and reduces MS's freedom and possibility to determine the global cost-optimum based on national and local factors.

Option 1 would be the most cost-effective, providing to MS a clear direction, while allowing for freedom to select the most cross-sectoral balance and cost-effective option, and also simplifying the process to calculate the MS contribution.

Option 2 would be a little bit less optimal by binding a partial target (existing 1.3% article 23(1) target) uniform for all, without considering national/local factors. On the other hand, with a zero-carbon sector by 2050, increasing by only ~10% the share of renewable in H&C on a 10 year period would be far from enough. Therefore, making it binding would probably be needed.

The cost-effectiveness of options 1 and 2 could be even improved with the deployment of accompanying measures under RED (see variants below), with the mainstreaming of renewables in H&C in the frame of EPBD and EED, and with the reinforcement of market-based instruments (ETS & ETD).

A binding H&C RES target is only slightly beneficial for investor certainty in the case of option 1 (EU level), while options 2 and 3 would have a more positive impact than option 1, as these would be established at MS level.

Theoretically, there would be no additional macro-economic impacts (investments and jobs) than the baseline option, as the three options would not increase the H&C RES ambition, but only make them binding. The only slightly positive impact of all three options comes from the fact that the binding nature of the target increases the likelihood for MSs to reach their target. Therefore options 2 and 3 would be a little bit more secure than option 1 (with a EU target, there is still a short likelihood for the MS to miss their target).

All three options making the EU H&C RSS target binding would have a positive impact on security of supply by creating reduced import dependency, with possibly a slight decrease of this positive impact for MS relying on imported bio-energies (such as pellets).

For less mature technologies, such as in some industrial sectors, especially with high temperature levels, the positive impact of a binding target would be larger. There is no clear difference between the three options regarding the impact on innovation.

Options 1 and 2 can have a better distributional impacts than relying more on carbon pricing and other energy efficiency instruments, unless the adopted programmes are set up to uniformly distribute carbon revenues, leading to an equal impact for both instruments. Option 3 has definitely a negative impact.

Options 1 and 2 would have a strong negative administrative impact, and option 3 would have an even much stronger impact compared to options 1 & 2.

Planned replacement scheme (**variant 1**) would require planning the phasing out of fossil-based systems, based on the renewable potential assessment (art 15(7) RED II), in close coordination with infrastructure planning (deployment, reinforcement, dismantling or conversion of gas infrastructure to hydrogen), and hand in hand with the building renovation addressing energy efficiency, and renewable heating alternatives.

Given the complex task to fully decarbonise the H&C sector, and to deploy renewables in H&C, any reform will require such integrated planning and coordination efforts. The additional cost of variant 1 will be higher compared to no action, but would remain limited if associated with other measures, notably planning.

Planned replacement schemes of heating appliances to facilitate fossil phase-out would support the clear signal of a move to a low-carbon (or even zero-carbon) energy system, which would also benefit other areas lacking such strong signal. A specific provision on planned replacement of fossil fuel systems should at least require to be integrated in the revision of the above-mentioned articles under RED II (planning), EPBD (LTRS, MEPR, EPC, BRP) and EED (Comprehensive Assessment, CA under article 14).

Administrative burden and associated costs will vary per MS depending on the extent of multi-level governance between different levels of government (national, regional, municipal), the choice and level of ambition of the phase-out and the existing administrative framework in place among many other variables.

To conclude, the planned replacement should be complemented by other instruments addressing the energy performance of the buildings, to be tackled in the frame of the EPBD, such as a Minimum Energy Performance of the Buildings Standard (MEPS).

The operating cost of heat purchase agreements (**variant 2**), would be limited for MS to the administrative costs to develop such global framework and the cost of covering (backstopping) pilot or demonstration projects. After a trial/demonstration period, operating costs would be tackled by market actors, such as heat/fuel suppliers, to be integrated directly into their new business models. There is an opportunity associated with this option for consumer empowerment and increased awareness. New business model based on heat purchase agreements could be used to lower the barriers to renewable H&C adoption associated with their high upfront costs, and could increase the attractiveness of renewables, addressing the increasing willingness of households to move to carbon-responsible or green solutions. This would stimulate the market and increase the cost-competitiveness of renewables for all. The design of these instruments would be left to the MS, to comply with the implementation of the market design at national level, and possibly with building codes or requirements (addressing comfort), although inviting MS to develop such schemes would incentivise their development. The "heat as a service" schemes, and renewables heat purchase agreements would also, e.g., require the service provider (like an aggregator) to understand the physics of the building and the corresponding H&C system, in order to maximise the potential for flexibility. Synergies as regards building installations, envelope and H&C system focusing on performance and energy efficiency should be coordinated. A comprehensive carbon pricing (ETD or ETS extension) would also directly have an influence on supporting such heating purchase agreement framework, increasing the attractiveness for renewable H&C, and the interest to develop adequate business models, possibly based on a service concept. Administrative burden and associated costs, and the success of the deployment of HPAs will depend on the existing administrative frameworks in place, and the global policy context to decarbonise the building sector.

Adequate de-risking instruments (**variant 3**) would require some public funds as illustrated in the case of France and its Geodeep fund for covering the natural risk associated with deep geothermal drilling. This

kind of fund, if well designed, should recover automatically as the experience would lead to globally decrease the risk associated and therefore reduce the likelihood to activate the guarantee, which provision would therefore be used for the next investments. Therefore, de-risking instruments would have a negative entry impact, but with the ability to improve the impact over time. Investor's certainty is directly linked to the de-risking instrument, raising investors' confidence to provide capital for the targeted investments such as DHC network, geothermal drilling and changes in industrial processes. Therefore, a risk-mitigation framework will increase the confidence of investors.
Setting up risk-mitigation instruments are no-regret measures and should be adopted in a structured way to frame the decarbonisation of the whole heating and cooling sector, building on existing tools and initiatives. Also innovation could directly benefit from these de-risking instruments.
De-risking instruments decrease the cost of capital, and therefore reduce the cost of renewable H&C technologies, increasing their attractiveness to all. They can be used to reduce upfront investment cost and stimulate market development, and facilitate access to affordable finance.
Action at MS-level would not have been completely sufficient to significantly contribute to deploying renewables in the H&C, as these de-risking instruments are not completely new but still remain not broadly developed and implemented across EU MS. Therefore, by reason of the effects of the variant, EU action would have an added value, at least to incite MS to take the required action.
These instruments require upfront discussion with all concerned parties, such as investors, research and academics, public bodies, financing institutions, engineering, and demand side representatives (industries and building owners/designers). Therefore, some initial efforts are required to set up the instruments and develop them to maturity. Best practice sharing and lessons learned would be very useful. With the increase of maturity in the development stages, the source of financing would progressively move from the public to the private.

Coordinated infrastructure planning (**Variant 4**) with more involvement of local and regional authorities could result in important economic savings and avoid issues of mis-planning, mis-communication, mis-information and lack of understanding of the local particularities, needs and opportunities resulting in inefficiencies. The costs related to administration, coordination and communication are not expected to be significant compared to the savings of avoiding inefficient planning. Heating and cooling goes hand to hand with urban planning. Therefore, the Energy Transition Partnership[479] of the Urban Agenda[480] for the EU is focusing on both planning and H&C in its action plan released in April 2020, while ensuring local needs and interests remain an important concern. Prior to planning, mapping would be recommended, using existing tools and best practices. Managing an integrated planning, in most cases, would require additional skills and human resources. Mapping and quantifying heating and cooling demand and sources is a complex task. In any case, the economic impacts of such integrated planning have demonstrated to be beneficial in almost all case studies, to achieve a structural and long term decarbonization of the heating and cooling sector, at local level. Such planning allowed the cities to estimate the cost optimum integrating both energy efficiency and renewable (or DHC) in their planning. Efficient collaboration between the national and local levels is paramount. . Strategic planning would require the involvement of many different stakeholders,

[479] European Commission. (n.d.). Energy Transition Partnership. Available at: https://ec.europa.eu/futurium/en/system/files/ged/3.orientation_paper_energy_transition.pdf
[480] European Commission. (2019). Urban Agenda for the EU: Energy Transition Partnership Action Plan. Available at: https://ec.europa.eu/futurium/en/system/files/ged/uaetp_final_action_plan.pdf

working at increasing the resilience of the heating and cooling system, with the flexibility to address specific consumer's groups, such as poor households.
Local H&C planning is the most appropriate approach to handle the cost optimum and find a cost-effective balance between energy efficiency and renewable sources and waste heat recovery, considering local conditions and constraints, such as the local climate and weather patterns, the energy density, the kind of buildings and infrastructure surrounding it, the renewable energy resource potential and proximity to sources of waste heat, but also the local skills.
H&C planning should be properly combined with the phasing of carbon pricing schemes (like ETD or ETS extension).
Planning of renewable and waste H&C deployment projects and infrastructure in heating and cooling should ideally be at the core of the NECP section on the deployment of renewables in the H&C sector. Given the high dependency of the different energy infrastructures (in the frame of energy system integration, moving e.g. partially from gas networks to electricity and/or DHC). The LTRS should also address, at least partially, the issue of planning, as the deployment of renewable heating systems and the increase of energy efficiency in buildings should go hand in hand.

Environmental impacts

The displacement of fossil fuel consumption and thereby the reduction of GHG emissions, is directly linked to the ambition level and its binding nature. A binding target can lead to additional H&C renewables than a higher non-binding target which is not providing any guarantee. Hence, a binding H&C RES target will have a positive contribution to GHG emission reductions as it is expected the target will be met. As a result, all three options have a more favourable emission reduction impact than the baseline option 0.

A potential environmental impact due to the rapid deployment of all renewables in buildings is linked to biomass deployment, as this is probably one of the most competitive options without any incentive scheme and could possibly take the lead in deploying the various renewable technologies in buildings. Depending on the heating system used, biomass can have adverse impacts, such as on air quality or biodiversity reduction, that should be considered vis-a-vis the benefits in terms of renewable energy deployment and GHG reduction. Moreover, bioenergy is not a completely emissions-free process as some emissions associated with the cultivation are not avoidable. RED II currently establishes rules for calculating the GHG impact of bioenergy sources under annex V and annex VI. Depending on the pathways, great care should be taken when considering biomass sustainability including expanding the scope to small-scale systems.

The environmental impacts are almost the same for all variants, accelerating RES H&C deployment. However, de-risking instruments (variant 3) may have an additional positive effect by directing the RES H&C deployment towards locally available resources, and more capital intensive investments such as solar heat, geothermal heat, district heating, heat pumps (large and small-scale) instead of more fuel and operating expense intensive technologies (mainly bio-based, but also possibly RFNBOs). This would increase the share of these capex intensive technologies, and possibly decrease the share of the opex and fuel-cost driven technologies.

Building on the success of past experiences, projects and toolboxes, many cities and regions are currently preparing ambitious climate and energy strategies and action plans (variant 4), committing to net-zero carbon by 2050.

Social impacts

Regarding the political feasibility, option 2 would have an important negative impact, while option 1 would require a less hard-binding formula and leave some room for simplifications and common agreement. Option 3, given all these elements to consider, and the fact only nine MSs already meet the target under article 23, would probably become an immediate 'no go' from those MSs not complying with article 23.

With a share of renewable in H&C above 60%, one MS (SE) is not subject to the renewable increase requirement (article 23(2)(b) of RED II), while 3 MS with a share above 50% (and below 60%) have to achieve only half of the renewable increase requirement (article 23(2)(c) of RED II). Hence, on the total nine MSs meet the target of article 23(4) of RED II, only 5 are effectively meeting the target of 1.3%-point annual increase of renewables in the H&C sector of article 23(4) of RED II, while 18 MSs are not meeting the requirement at all. Therefore, it seems unrealistic to make it binding for all MSs, which is the aim of option 2, when the gap remains so important, especially for 13 MSs. It should also be pointed out that a common target for all MS does not take into account national renewable resources, nor current market dynamics, or existing situation.

Heating and cooling planning (variant 4) at city level helps to keep control of energy installations on the territory while ensuring the local energy transition has the common interest at its centre.

Concluding remarks for D1

Option 2 would have an important economic negative impact, while option 1 would require a less hard-binding formula and leave some room for simplifications and common agreement. Option 3, given all elements to consider, and the fact only nine MSs already meet the target under RED II article 23, would probably become an immediate 'no go' from those MSs not complying with article 23.

Variant 4 is seen as a necessary measure, as planning of renewable and waste H&C deployment projects and infrastructure in heating and cooling should ideally be at the core of the NECP, given the high dependency of the different energy infrastructures (in the frame of energy system integration, moving e.g. partially from gas networks to electricity and/or DHC). The LTRS should also ensure appropriate local planning, as the deployment of renewable heating systems and the increase of energy efficiency in buildings should go hand in hand. The costs related to administration, coordination and communication are not expected to be significant compared to the savings of avoiding inefficient planning. Heating and cooling goes hand to hand with urban planning.

The planned replacement schemes of heating appliances, variant 1, could be associated with variant 4, as the additional cost of will be higher compared to no action, but would remain limited if associated with other measures, especially planning. The planned replacement schemes should be complemented by other instruments addressing the energy performance of the buildings, to be addressed in the frame of the EPBD, such as a Minimum Energy Performance of the Buildings Standard (MEPS), or the LTRS. Generally, this replacement should be considered as a part of variant 4.

New business model based on heat purchase agreements (variant 2) could be used to lower the barriers to renewable H&C adoption associated with their high upfront costs, increase the attractiveness of renewables. The administrative burden and associated costs, and the success of the deployment of HPAs will depend on the existing administrative frameworks in place, and the global policy context to decarbonise the building sector.

A risk-mitigation framework (variant 3) will increase the confidence of investors, and facilitate the access to financing. De-risking instruments would have a negative entry impact, but with the ability to improve the impact over time. Well-designed national schemes could also be an important pillar of the H&C planning, based on a long term vision.

1.2 D2 - Accelerate the share of renewables in District H&C & accompanying measures

Three options and three variants (accompanying measures) were evaluated to accelerate the share of renewables in District H&C & accompanying measures, namely:

- **Option 1** aims at including an additional EU renewable target (indicative) for renewables' share in DHC; increase the indicative 1%-point increase target;
- **Option 2** aims at including a national renewable target (indicative) for renewables' share in DHC; increase the indicative 1.1%-point increase target ;
- **Option 3** aims at increasing the 1%-point increase target and leave it voluntary;
- The four variants concern:
    - Enhanced coordination and common market operation of DHC systems with electricity distribution system operators
    - Enhanced coordination and common market operation of DHC systems with gas distribution system operators, hydrogen and other energy networks - in addition to with electricity operators
    - Requirement to include specific RES share and a numerical energy performance number (PEF) in the information district heating/cooling systems provide to consumer
    - Energy label (voluntary or mandatory) for DHC systems.

Economic impacts

The currently limited uptake of renewables to support the DHC to reduce their emissions can be linked to the low competitive advantage of renewable fuels (due to the current low carbon price level, and to the other more cost effective solutions such as fuel switch – from coal/oil and natural gas), and to the lack of knowledge and risk management compared to individual fossil based appliances. With an increasing carbon price, renewables may become more attractive and deploy without any further intervention or policy action than the ETD (or even ETS).

Without specific measures to increase renewables' competitiveness, the risk remains high that renewables would not be taken up in the DHC. The two options would then be either to increase carbon pricing significantly (which is out of scope), or to enforce the uptake of renewables via specific instruments. In the first, accompanying measures would be necessary to guide the integration of renewable in all DHC.

From several case studies, it seems clear how important technical guidance (option 0) is to help the upgrade (EE & RES) of existing DHC, even when the business cases are very attractive. In all cases, an external guidance (via the Upgrade DH project) was necessary to initiate, support the identification of upgrading measures, and coordinate all works.

A increased target under options 1 to 3 would give a clear signal to accelerate the uptake of RES in DHC, while improving their performance. A specific target for the H&C in DHC (from option 1 to 3) remains important and would complement existing instruments (ETS or ETD) and market stimuli, by providing the needed trend to fully decarbonise DHC. Having in mind the full decarbonisation of the DHC by 2050, such target also supports overcoming non-economic barriers, such as the basic lack of awareness (e.g. in the industry where renewable is not associated to the core business), the administrative barriers, the lack of information (to final consumers) and public perception, the high upfront investments. However, a DHC RES target without a strong policy framework setting up a real level playing for renewable would lead to disproportionate costs and loss of value, putting the existing assets at risk.

Binding the target would be a complex task, given the huge differences between MS (e.g. comparison of Germany and Lithuania), regarding the current share of RES, the total heat delivered via DHC, but also the available options to significantly increase the production of renewables. It would also compromise the freedom of MS to increase their share of renewables in the most cost effective way. As making the target binding would require a precise calculation method adapted to national contexts (cost of upgrading DHC, cost and available RES, competitiveness of DHC compared to individual supply), while only addressing 12% of the supply of H&C, remaining with an indicative target seems therefore more appropriate.

Increasing the target (options 1 to 3) should also consider seriously the competition with individual heating systems, especially with natural gas- based ones, given that natural gas is cheaper across Europe. It is therefore essential to address the deployment of renewable in DHC in combination with other instruments such as the ETS, but mainly the ETD regarding the building sector.

Increasing the 1%-point RES share increase target (options 1 to 3), to reach the CTP ambition (39% H&C RES in 2030), would give the concerned MS the needed push to achieve the global RES target by 2030.
Option 1 would give all MS an appropriate EU target to meet, highlighting the importance to accelerate the uptake of renewables in existing DHC, where it usually makes sense (scale effect) if combined with efficiency improvements.

By eliminating the exceptions and making access to networks mandatory for renewables and other carbon-neutral sources (waste heat), including from prosumers, in large DHC networks, option 3 would slightly increase the efficiency of option 1.

Option 3 would be the most cost-effective, providing to MS a clear direction, while allowing them to have the freedom to select the most cost-effective option, and also simplifying the process to calculate the MS contribution.

The cost-effectiveness of all options could be improved with the deployment of accompanying measures under REDII (see variants below), by mainstreaming renewables in DHC in the frame of EED, and with the reinforcement of market-based instruments (ETS & ETD).

An indicative target set at EU level has little impact on investor's certainty, but as increased targets (options 1 to 3) would probably lead to increased actions at national level, at least in some MS, the investor's confidence would come from these national frameworks, and possibly increase slightly

For the existing DHC to uptake renewables, the three options would theoretically have the same macroeconomic impact as the level of the target would be identical.

All three options increasing the RES target in DHC would have a positive impact on security of supply by reducing import dependency, with possibly a slight decrease of this positive impact for MS relying on imports of bio-energy (such as pellets), which is however currently the first renewable source in DHC.

There is no clear difference between the three options regarding the impact on innovation.

The burden of option 2 could increase, requiring MS target calculations, and therefore administrative follow up and gap filling calculations, in addition to the overall target requirement. Upfront, the calculation formula would require to assess those factors that are essential in determining the national potentials, resources and needs to mainstream them in a common formula fitting for all MS.
Therefore, option 2 would have a strong negative impact, while option 1 and 3 would have almost no impact, compared to the baseline.

A major potential for flexibility in the heat sector generally and especially in DHC comes from the low cost of storing heat, providing an opportunity to shift electricity demand, or even supply.
In addition, the combination of an increasing deployment of variable RES-E production with the building space heat electrification via heat pumps poses two challenges for the electricity system: coincidence of weather events stressing the power system and increased net load demand requiring backup capacity, unless it is possible to partially decouple heat and electricity through flexibility. In order to make the distribution networks more flexible and resilient towards demand profiles with rapid variations, one of the solutions for a DSO is to use flexibility provided by the consumers, producers or network's components, among which DHC and all its capacities to provide flexibility services.
Given the challenges of sector integration and the expected role DHC may play, coordinated planning (**variant 1**) is needed to gather the required expertise and anticipate the future demand and generation on both heat and electricity side, and develop on the most cost-effective options, considering all local influencing factors.

Such planning is costly and may be compromised by the lack of human and financial resources or the administrative burden for the DSO and DHC operators. It could therefore be guided from the EU level, but its design should be left to MS, complying with the national rules and regulations.
Coordinated planning between DSOs and DHC operators is the most appropriate approach to find a cost-effective way to take advantage of flexibility services provided by DHC, hence increasing revenues in electricity markets.

Electricity network development plans are not always necessary and would result in onerous costs and administrative burden of little additional value, overlapping with current regulations ensuring quality of supply. Therefore, requiring to coordinate with DHC operators may also become an administrative burden and should be addressed in the most efficient way, to avoid such onerous efforts. Therefore, planning at the side of the DHC (e.g. a new boiler installation) could also become the trigger for coordination between both planning processes. Adequate guidelines may be used to avoid useless efforts.

Coordination between gas DSOs and DHC operators (**variant 2**) is the most appropriate approach to tackle the complementarity and scale effect of individual gas supply and DHC.
Building refurbishment programmes, electricity, telecommunication, water, or gas network investments and works are rarely implemented considering new DHC systems. Sustainable energy programmes targeting the decarbonisation and energy efficiency of buildings and the heating and cooling supply are often overlooked during the urban planning and design phase.

Enhanced coordination of DHC systems with all energy infrastructure would support cost effective decarbonisation of the H&C, especially in the case of gas networks that may either supply DHC (renewable gases such as biomethane or renewable hydrogen), or compete by extending their scope, and hence jeopardising DHC and/or becoming potential stranded assets. Therefore, any natural gas DSOs should consult energy planners & DHC operators to determine the most appropriate option for the long term decarbonisation of the H&C sector. Natural gas is mainly used for heating (space heating, warm water, process heat). therefore, natural gas and DHC could be competitors in many cases.
In order to promote all types of energy utilisation and supply (all renewable sources), interaction between supply and demand as well as efficient operation, a new generation of energy systems which treat the district heating network as the centre piece is emerging. Unlike traditional energy systems, the DH network, electricity and gas networks in the new generation of energy systems are closely linked through CHP units, HP and other electricity and/or gas-driven heating systems and influence each other. Therefore, to ensure the safe operation of the future DH network and gas & electricity networks, the integrated framework for generation and infrastructure planning need to be carried out.

Given the double challenge of sector integration with renewable gases supplying DHC and of the potential shift (in some places) from individual gas supply to other renewable carriers (to avoid stranded assets), coordinated planning is needed to gather the required expertise and anticipate the future demand and generation on both heat and gas side, and develop on the most cost-effective options, considering the whole strategy for heat decarbonisation.

Coordination between gas network development plans & DHC plans would result in onerous costs and administrative burden, possibly with limited additional value. Therefore, requiring to coordinate with DHC operators should be addressed in the most efficient way, to avoid such onerous efforts. Upfront clarity on the pathway for H&C decarbonisation and appropriate guidance would support finding the most balanced approach.

Usually, in supply-driven systems, billing is often based on lump sums and hence the system is frequently seen as unfair and outdated. By evolving to more demand-driven systems thanks to disclosure (**variant 3**), consumers would adjust their energy consumption to their needs. Therefore, if consumption-based billing is paired to metering, consumers would also have an incentive to more rationale energy use, which in turn, would pave the way to increasing energy efficiency. The importance of metering in a demand-driven system reaches far beyond a proper billing of the energy consumed, since the deeper knowledge of the consumer patterns and conditions may enable the detection of faults in the consumer installations or demand-side management.[481]

All these are mainly driven by efficiency purposes, but by providing information on the renewable and carbon content of the heat consumed, consumers would also more deeply follow the logic behind price formation and the energy sources used to produce heat. This variant could imply additional administrative burden for DHC operators required to disclose additional information regarding the share of renewable and the energy performance of their systems. However, such data would not be complicated to gather and disclose for the most efficient and smart systems, which could also be an incentive to upgrade DHC.

Inviting or obliging DHC operators to certify their systems (**variant 4**) would contribute to increased competition on the local heating and cooling markets and provide transparent and comparable data on energy performance of district heating and cooling systems, enabling households and industry to make informed choice on most appropriate energy solutions for their heating and cooling needs. MSs should be given the lead in developing the labels with the EU supporting in the provision of guidelines and standardisation of methodologies. Setting up a labelling scheme may be complex and long, especially in the case of a mandatory scheme. If the labelling remains voluntary, the administrative burden could be reduced significantly. Support from EU-funded projects such as EcoHeat4Cities can also decrease the administrative burden by providing capacity building and information.

Environmental impacts

Among the other potentially significant environmental impact is the effect of measures targeted at using sustainable biomass deployment, where large scale systems would lead to decreased impacts, if sustainability criteria for bio-energies are enforced (cf. options under sustainability of biomass). Geothermal and solar thermal do not emit GHGs. Regarding biomass burning, large scale plants minimise emissions of air pollutants and also improve the overall efficiency of the system. Waste heat recovery also avoids using other potential emitting energy sources, while avoiding wasting energy.

[481] Aalborg University. (2019). Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy. Available at: https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

The current share of RES in DHC is pulled by solid bioenergy. While the deployment of all other renewable alternatives will accelerate, more than solid bioenergy, the later may remain the most important renewable source in the coming two decades. Therefore, great care about biomass sustainability should be taken, expanding the scope to small-scale systems.

Social impacts

Including a national renewable target (option 2) would require a calculation method, which should be inspired from the EU gap filler mechanism for the overall RES target from the Governance Regulation, as detailed in Annex II. However, the Governance Regulation criteria may not allow to capture the national heating and cooling specificities of DHC (as those criteria are more addressing the electricity sector). Therefore, an alternative could take into account other objective criteria addressing the purpose of heating and cooling: a new criteria specific to H&C infrastructure & not considering interconnection, including electricity distribution grid, district heating and cooling, gas infrastructure; a criteria on H&C potential, considering all renewable fuels and technologies, including the availability of local resources such as waste heat; adding a criteria related to the H&C demand pattern, integrating the energy performance of the building stocks (and possibly the pace of renovation), the density of heat demand, the possibility to upgrade the DHC. Without integrating those criteria it would probably remain complicated to reflect MS's specific ability to deploy renewables in the DHC, and the associated costs that cannot be fully captured at macro level. Therefore option 2 would probably remain less efficient than option 1.

An increased target (options 1 to 3) could increase awareness at the level of decision makers, planners, and local authorities, to support leveraging local existing potentials, and would engage potential suppliers of heat and consumers together, provide them with relevant information to make informed decision, or even increase pressure on their DHC operators to support higher share of renewable energy in the DHC system.

All options would enable consumers at building level to make a choice between efficient and renewable DHC system connection or producing their own renewable heat at building level.
The deployment of RES in DHC leads to an increased level of education and training. More local professionals are concerned (planners, designers, installers, renewable energy supplier, heat suppliers, DHC operators, and local authorities) and would be trained with all three options.

The main concern regarding potential distributional impacts will be the effect of the options on DHC operators of small-and medium-scale DHC, on small and medium-size heat suppliers, on customers and the overall cost-efficiency and business case for district heating investments. Increased targets would increase the need for adequate implementation guidance, for roles and responsibilities clarification, for the identification of the remaining barriers. Increased targets would affect local DHC suppliers and DHC system operators, and customers through the conversion to new RES generation, leading to technical adaptation costs, switching to new business cases and upgrading existing DHC.

A more active role of consumers (**variant 3**) in promoting high shares of renewable energy in district heating and cooling through the disclosure of district heating and cooling energy performance certificates, to be compared with building level energy performance certificates, would be supportive to make the adequate choice. This variant increases competitiveness, and therefore economic impacts.

Concluding remarks for D2

A DHC RES target without a strong policy framework setting up a real level playing for renewable would lead to disproportionate costs and loss of value, putting the existing assets at risk.
Option 3 would be the most cost-effective, providing to MS a clear direction, while allowing them freedom to select the most cost-effective option, and also simplifying the process to calculate the MS contribution.

Coordinated planning between DSOs and DHC operators (**variant 1**) is the most appropriate approach to find a cost-effective way to take advantage of flexibility services provided by DHC, hence increasing revenues in electricity markets. However, electricity network development plans are not always necessary and would result in onerous costs and administrative burden of little additional value. Therefore, requiring to coordinate with DHC operators may also become an administrative burden and should be addressed in the most efficient way, to avoid such onerous efforts. Hence, planning on the side of the DHC (e.g. a new boiler installation) could also become the trigger for coordination between both planning processes. Adequate guidelines may be used to avoid useless efforts.

Enhanced coordination of DHC systems with all energy infrastructure (**variant 2**) would support cost effective decarbonisation of the H&C, especially in the case of gas networks that may either supply DHC (renewable gases such as biomethane or renewable hydrogen), either compete by extending their scope, and hence jeopardising DHC and/or becoming potential stranded assets. Therefore, any natural gas DSOs should consult energy planners & DHC operators to determine the most appropriate option for the long term decarbonisation of the H&C sector. However, coordination between gas network development plans & DHC plans would result in burdensome costs and administrative burden, possibly with limited additional value. Therefore, requiring to coordinate with DHC operators should be addressed in the most efficient way, and upfront clarity on the pathway for H&C decarbonisation and appropriate guidance would support finding the most balanced approach.

Requiring to include specific RES share and an energy efficiency in the information district heating/cooling systems provided to consumer (**variant 3**) could imply additional administrative burden for DHC operators required to disclose additional information. However, such data would not be complicated to gather and disclose for the most efficient and smart systems, which could also be an incentive to upgrade DHC. A more active role of consumers is also expected.

Setting up a labelling scheme (**variant 4**) may be complex and long, especially in the case of a mandatory scheme. If the labelling remains voluntary, the administrative burden could be reduced significantly. Support from EU-funded projects such as EcoHeat4Cities can also decrease the administrative burden by providing capacity building and information.

Annex E - Accelerate renewable share in buildings

Annex E to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

Acronym	Full name
BRP	Building Renovation Passport
CTP	Climate Target Plan
CSP	Concentrated Solar Power
DHC	District Heating and Cooling
DSO	Distribution System Operators
EE	Energy Efficiency
EED	Energy Efficiency Directive
ETS	Emissions Trading Scheme
ETD	Energy Taxation Directive
EPC	Energy Performance Certificate
FTE	Full-Time Equivalents
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GO	Guarantee of Origin
GSHP	Ground Source Heat Pump
H&C	Heating and Cooling
HP	Heat Pump
HPA	Heat Purchase Agreement
HVAC	Heating, Ventilation and Air Conditioning
IRR	Internal Rate of Return
JRC	Joint Research Centre
LTRS	Long Term Renovation Strategy
LTS	Long Term Strategy
MS	Member State
MEPR	Minimum Energy Performance Requirements
MEPBS	Minimum Energy Performance of the Buildings Standard
NECP	National Energy and Climate Plan
NREAP	National Renewable Energy Action Plan
NZEB	Nearly Zero Energy Building
PCI	Project of Common Interest
PPA	Power Purchase Agreement
PV	Photovoltaic
RED	Renewable Energy Directive
RES	Renewable Energy Sources
RHC	Renewable Heating & Cooling
RFNBO	Renewable Fuels of Non Biological Origin
RD&I	Research Development and Innovation
SME	Small and Medium Enterprises
TEN-E	Trans-European Networks for Energy
TSO	Transmission System Operator
WACC	Weighted Average Cost of Capital

Background

The building sector, currently responsible for 40% of final energy and 36% of greenhouse gas emissions in the EU, has a large cost-effective potential to reduce emissions. Today, 75% of the EU's building stock is energy inefficient[482]. Many homes are still heated with outdated systems that use polluting fossil fuels such as coal and oil. Fully tapping into this potential for improvement would require the renovation rate, which is around 1%/yr today, to at least triple in the period up to 2030. In particular, deep renovations addressing building shells, smart digitalisation and the integration of renewable energy together need to increase strongly.

According to the Climate Target Plan, in order to reach the 55% greenhouse gas emissions reduction target, and in line with the Renovation Wave, buildings and power generation can provide the largest and most cost-efficient emissions reductions, in the order of 60% and more compared to 2015. Emissions reductions in the building sector can be achieved by combining measures that reduce the energy consumption of the building stock, ensure a switch from fossil fuels to sustainable renewable energy, and improve the efficiency of the entire energy system.

This will require a transformation of the sector, adapting current construction and renovation practices and supporting the combination of strong efficiency measures with a phasing out of fossil fuels and a switch to renewable energy. Renovation practices need to be scaled up to industrial levels. A focus on deep renovation will reduce energy demand in buildings and will replace existing heating systems with more efficient and renewables-based systems. A strategic effort to decarbonise heating and cooling energy supply and to invest in low temperature renewable heat supply infrastructure is needed. Buildings should become "renewable-ready" to switch to renewable heating.

The current deep renovation rate of 0.2%/year needs to grow by at least a factor 10: to 2%/yr and should approach 3%/yr as quickly as possible, to ensure the renovation of the full building stock by mid-century in order to reach the required performance level. This transformation will only be possible with effective policies and support instruments. The Renovation Wave is addressing some of the measures that will transform the building sector, but other policies and support instruments are required to accelerate this transformation in a holistic way.
The use of fossil fuels for heating and hot water in buildings should drastically decrease in the next decade. Considering that the average lifetime of heating equipment is in the range of 15-20 years, policies to discourage installation of new fossil-fuel based systems should be implemented. Some stakeholders are advocating for banning installation of new heating systems based on fossil fuels (gas, liquid or solid) in new construction from 2021 onwards. Any new installation of fossil fuels-based heating systems locks in CO_2 emissions for the next two decades, unless full decarbonisation of the energy carriers (e.g. natural gas being fully replaced by biomethane or hydrogen) is achieved.
The more the transformation is delayed, the higher the effort in increasing renovation rate and depth will have to be in the next two decades.

EU Member States need to increase the speed and effectiveness of national policies and should launch effective action by involving citizens, local authorities, investors and the construction value chain.

[482] New buildings today consume only half as much as typical buildings from the 1980s. About 35% of the EU's buildings are over 50 years old .

This Annex is closely linked to the Annex D - Heating and Cooling, with a specific focus on the building sector. Some overlap and cross references may appear.

Design

Problem Definition

The sustainable energy transition in the building sector is currently lagging, and decarbonisation goals are unlikely to be met by 2030. Reducing emissions from the current level of 130 million tons of CO2 to between 70 and 72 million tons in the next 10 years will require ramping up all available technologies in a coherent way. Technologies to be deployed include building envelope, heat pumps and renewable electricity, heat networks, decentralized renewable energy such as solar thermal and geothermal heat, and renewable gases incl. infrastructure und CHP/boiler technologies. Cherry-picking the various building technologies is no longer an option because of past shortcomings.[483]

The main specific problems identified are:

- The slow uptake of renewable energy technologies and fuels in the building sector, due to a lack of a level playing field and mass market for renewables, despite the fact that most of them are mature;
- The lack of the required skills and trained workforce to significantly accelerate the rate of renovation and the renewable systems deployment, while improving the quality of buildings and their heating systems;
- The lack of a combined and integrated strategy to decarbonise the heating and cooling sector addressing at the same time the deployment of renewable technologies and energy efficiency.

- *Problem 1: Slow uptake of RES in buildings due to a lack of a level playing field*

In order to reach full decarbonisation of European buildings, districts, cities and industries, renewable systems should be deployed in buildings, mainly for heating and cooling purposes, but also for electricity production, via solar PV, or CHP including micro-CHP.

At the EU level, renewables made up almost one fifth of all gross final energy consumed for heating and cooling (19.5 % in 2017; 19.8 % in 2018, according to EEA estimates[484]). The sector grew by 5% each year, on average, over the period 2005-2017, as depicted in Figure 2-1 for the residential sector only. This growth rate allowed EU to reach its 20% RES target by 2020, but will remain too short to achieve the new target set in the Climate Target Plan (CTP), which means doubling the share of RES-H&C in 10 years. Hence, the pace of RES deployment in the H&C should almost double in average (energy efficiency would require less supply).

The generally slow progress seen at national levels to increase this share remains an important concern, considering the huge discrepancies among Member States, as illustrated by figure 2-2. In 16 Member States, RES-H&C represented over half of the national gross final consumption of renewables in 2017.[485] Solid biomass-based

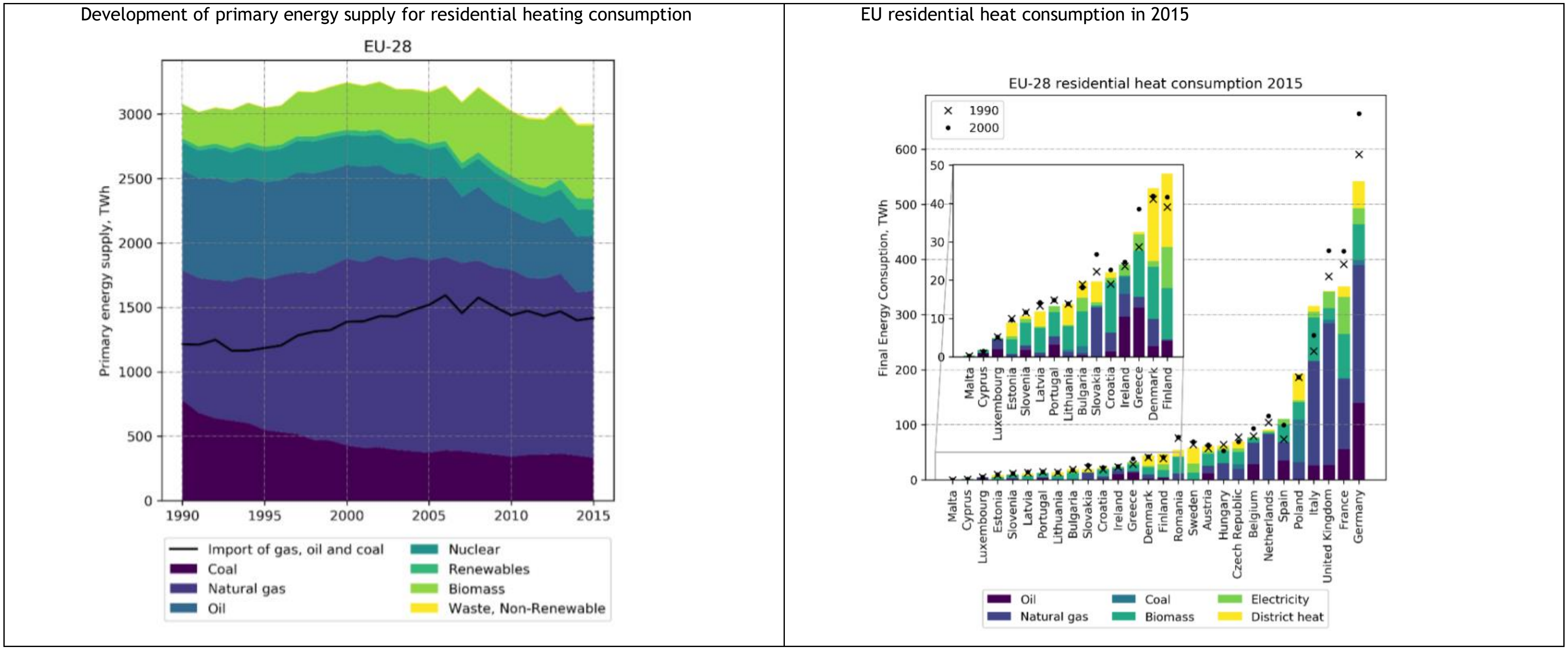
[483] ifeu, Fraunhofer IEE and Consentec. (2018). Building sector Efficiency: A crucial Component of the Energy Transition. A study commissioned by Agora Energiewende. Available at: https://www.agora-energiewende.de/fileadmin2/Projekte/2017/Heat_System_Benefit/163_Building-Sector-Efficiency_EN_WEB.pdf

[484] European Environment Agency. (2019). Share of renewable energy in gross final energy consumption in Europe. Available at: https://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-4/assessment-4

[485] Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Romania, Slovenia

technologies prevailed in the heat market (~83%), followed by heat pumps (~10%), and then by all other renewable heat production from all other renewables (biogas, solar thermal, geothermal and bioliquids).

Figure 0-1 Development of primary energy supply for residential heating consumption (left) and EU residential heat consumption in 2015 (right)



Source : EU-28 Residential Heat Supply and Consumption: Historical Development and Status[486]

[486] Bertelsen, N. and Mathiesen, B. V. (2020). EU-28 Residential Heat Supply and Consumption: Historical Development and Status. Department of Planning, Aalborg University. Available at: https://www.mdpi.com/1996-1073/13/8/1894/pdf

Carbon neutrality of buildings by 2050, driven by energy-efficient and renewable heating and cooling, can be achieved by increasing the annual renovation rate to more than 2%/yr by 2030 on the one hand, and by accelerating the deployment of renewable-sourced systems on the other hand. The decarbonisation of energy carriers should also be ensured in parallel to the deployment of on-site renewable production, and the deployment of district heating and cooling[487] (DHC). Several important drivers and developments in technologies are, however, still missing, or are at least weakly mainstreamed, such as:

- Developing affordable, compact, highly efficient, easy to install, and intelligent renovation kits for replacement of traditional fossil oil- and gas-fired heaters, allowing ease of control, operation and maintenance. E.g. hybrid combinations like high temperature geothermal heat pumps or clean and efficient wood burning stoves may help to make new heating equipment smaller, allowing for cost reductions. Innovative energy storage should also be included;
- Pushing development efforts to achieve economic breakeven for grouping renovation of buildings (i.e. renovating many similar buildings at once), through efficient prefabrication of elements and advanced HVAC capabilities;
- Empowering heat pump technologies regarding their capability for simultaneous heating & cooling, increasing their efficiency – including via well trained and skilled installers, adapting to dynamic electricity tariffs;
- Optimising the system architecture for combination with new renewable sources allowing for tri-generation[488] of low-temperature heat, cold and electricity, while considering the multi-level cost of electricity, heat and cold and the overall renovation cost, rather than just investment cost for the refurbishment of the H&C equipment. Coupling with new intelligent storage concepts becomes key;
- Exploring and demonstrating new renewable concepts and applications, which can act as heat source for more efficient sole-based heat pumps. The renewable heat source should be more efficient, more environmental-friendly.

- *Problem 2: Lack of the required skills and trained workforce*

At the time of writing, not all MSs have transposed article 18 on Information and Training of the Renewable Energy Directive recast (RED II), although the transposition deadline is June 2021. They are generally facing some difficulties translating the provisions into their national frameworks, or simply left their existing training and certification schemes as they were. Several countries have well-functioning training and certification schemes in place, but these are not related to RED II art. 18. Therefore, the intention of art. 18 (3) to have mutually recognized schemes in the different MSs has not been successful.

Generally, even when certification schemes are available, they are not used if there is no reward (“carrot”) linked to the scheme in the form of, for example, subsidies (as e.g. provided in Nordic countries).

Discrepancies are huge among countries:

- For some, the quality of installations is an important issue, while for others it is not (as long as heating systems are delivering, efficiency is not a concern);

[487] DHC are addressed under Annex D on heating and cooling
[488] Via gas-based CHP (internal combustion engines), fuel cell CHP

- Some are obligating all installers to be certified, while others have established costly certification schemes, which are, however, not used at all (as there is no subsidy, there is also no interest at all to use the scheme);
- Some MSs only certify installers (people), others certify companies, and others certify both;
- Some countries require both training and an exam, others only an exam.

Given the many new concepts and technologies arising, requiring more design capacity to integrate the "simple" installation of H&C systems into building, there is currently a lack of well-trained craftsperson and installers.

The assessment of missing skills should consider, among others:

- The distinction between different types of professionals in Renewable Heating and Cooling (RHC) technologies and in the H&C sectors. For example, geothermal professionals are installers (mainly drillers) and designers (engineers). Designers need regular updates to their educational background about new regulations. Drillers need further training on shallow geothermal because their basic education is often general (e.g. on water drilling). Skills of installers should be addressed in the framework of the overall heating system needs, as part of the building. Balancing, maintaining and servicing are key for any heating system to work at its best efficiency level. These tasks should consider the heat generator, heat emitters (radiators, underfloor), control systems, as well as the relation of these components with the building envelope and other technical building systems (insulation, windows, ventilation, etc.);
- A Curriculum for designers and drillers of shallow geothermal systems (prepared by the Geo Trainet[489]) comprises the fundamentals and constraints (incl. feasibility studies), introduction to design (incl. ground heat transfer, design criteria, borehole heat exchangers), integration with the ground (incl. geology, drilling, site investigation), integration within the building (incl. Heat Pump, or HP technology, energy load), ground source heat pump (GSHP) system alternatives (incl. design of borehole heat exchangers, design of horizontal collectors), GSHP installation (incl. installation & grouting, functional & quality control), regulation (European legal situation and standards, national and regional regulations, energy efficiency building codes, environmental issues;
- Heat pump certification guidance is available on the certified installer database, developed by the EUCert programme[490]. The core-training manual addresses relevant aspects of an efficient heat pump installation: - Marketing - Costs of a heat pump system - Environment and ecology - Geology, climate and national regulations - Energy efficient buildings - Operation principle of HPs and technical details of the heat pump circle - Heat distribution systems and hydronic system integration - Determining planning and installation of the heat source - Operation mode and control - Conducting a site assessment - Installing HPs & auxiliary components and performing a system check - Electrical basics - Customer education and Warranty - Maintaining a heat pump system - Fault diagnostic, frequent mistakes and practical experiences;[491]

[489] GEOTRAINET project. (2015). Curriculum for designers and drillers of shallow geothermal systems, European Federation of Geologists. Available at: http://geotrainet.eu/wp-content/uploads/2015/11/Curriculum-for-Designers-and-Drillers.pdf
[490] EHPA. (n.d.). EHPA EUCERT programme. Available at: https://www.ehpa.org/quality/eucert/
[491]EHPA. (2017). EUCert European Certified Heat Pump Installer Program. Available at: https://www.ehpa.org/fileadmin/red/04._Quality/EUCERT/20130307_EUCERT_overview.pdf

    - Each training course consists of maximum 36 hours manufacturer independent education, including 8 hours of hands-on, practical training. The training can be complemented by manufacturer training. It is completed by an exam. Participants successfully passing the exam can then opt for a certification (valid for 3 years).
- For solar thermal it is difficult to define common EU needs. The markets are different, and the typologies of houses and heating systems also vary considerably. For example, in Greece most systems installed are thermosiphon systems for domestic hot water, which are rather simple to install. In contrast, in Germany most of the systems installed are combi (space heating and water heating) and that is an essential skill for an installer to be able to integrate with the heating system in place. The systems installed and used in different member states, due to different weather or building design can vary considerably, requiring different competencies. Hence, there is a preference that the Annex is not too prescriptive in terms of skills or curricula. Focusing rather in having a proper certification and qualification system in place and the national needs properly addressed;
- For other technologies, improved skills and knowledge are also required, such as for internal combustion engine micro-CHP, micro fuel cells, biomass boilers, ventilation, etc.

Information strategies, at EU or MS levels, with the aim to inform installers, architects, end-users, manufacturers, suppliers etc. of the benefits of working with renewable technologies are also missing widely, while these could be considered as key success factors to make training systems attractive along the whole chain, and mainly to the end-consumer.
Schemes and certification for renewable installers are quite heterogeneous in the different Member States. Overall, there is no meaningful collaboration among EU countries in this field, although training and certification schemes remain a key tool for the deployment of all renewables. The lack or poor quality of current training is a barrier to the further development of the sector in certain countries: installers who lack proper knowledge and skills to deliver efficient, high quality projects are creating a bad reputation of the sector. Therefore, skill levels in the installer base need to be addressed.

However, as training is clearly required, in-depth national assessments should be carried out to define whether certification may be an enabler for increasing interest in renewable installers and consumers.

- ***Problem 3: Lack of integrated approach to deploy renewable technologies and energy efficiency***

It is more and more recognised that the deployment of renewables in H&C and the increase of energy efficiency or performance should go hand in hand, especially in the building sector where an energy performant building will be more adapted to the use of renewables. However, this is not the case in practice. Very few examples demonstrate a real integration of both efficiency and renewable energy in a coherent set of policy instruments, and planning.

This problem is partially addressed by looking at the coherence between the concerned Directives (namely the Energy Efficiency Directive (EED) and the Energy Performance of Buildings Directive (EPBD)), while this main problem would have required a drastic change by integrating all these aspects in one legislative framework. Planning the deployment of renewable infrastructure separately from planning the renovation of the building stock no longer makes sense. The issue of planning is addressed under paper D on H&C.

Development of policy options

The purpose of the measures proposed below is to accelerate H&C renewable share in the buildings.

Table 0-1 List of options considered

Options	Description
Option 0 (baseline)	Leave Article 15(4)-(6) as it is
Option 1 (non-regulatory)	Guidance on best practices related to the application of Article 15(4)-(6), on information to be given under Article 18(2), (4) and (5), and on requirements for installers etc. under Article 18(3)
Option 2	RES target for national building stock (a general numerical level of minimum RES use in national building stocks)
Option 3	Update qualification and certification requirements for installers of heating and cooling systems
Option 4	Obligation on technology providers to train and assist certification of one installer ~300 marketed appliances to ensure sufficient availability of qualified professionals

- ***Option 0: No updates – Baseline scenario***

The baseline scenario (Option 0) does not consider any additional measure, relying on the existing framework, comprising the provisions of RED addressing the buildings (under articles 15 & 18), the deployment of decentralised electricity generation (mainly small-scale PV on building roofs, and possibly biomass-fuelled CHP), and the revision of the EPBD and EED. Requirements with regard to renewable heating and cooling in the building, including building codes, information, training and certification are included in RED II and continue after 2020. The provisions of revised EED and EPDB concerning renewables are currently being implemented, therefore renewable energy technologies in buildings are indirectly promoted through legal requirements on building energy performance, including nearly zero energy buildings, technical building system, methodologies for calculating the energy performance of buildings, information and training measures, calculation of the primary energy factors for the purpose of calculating the energy performance of buildings, comprehensive assessment of national heating and cooling potentials, and building renovation and energy efficiency measures are included in the Energy Efficiency Directive and the Energy Performance of Buildings Directive.

Specific policies to support RES-H&C technologies that were present in 2020 at national level will continue to be in place, and reinforced according to the National Energy and Climate Plans (NECPs) to reach the 2030 RES target. Renewable energy technologies will need to compete with low level fossil fuel prices and distortive subsidies for fossil fuels with no corrections through carbon pricing, or equivalent measures restoring a level playing field.

- ***Option 1: guidance on best practices***

Option 1 would only consider non-regulatory measures, supporting the implementation of the existing provisions addressing buildings under RED II, namely:

- Art. 15(4) on the introduction of appropriate measures in building regulations and codes to increase the share of all kinds of energy from renewable sources in the building sector, by requiring the use of minimum levels of energy from renewable sources in new buildings and in major renovations, and reflecting the results of the cost-optimal calculation (under EPBD);
- Art. 15(5) on ensuring that new public buildings and major renovations fulfil an exemplary role, such as by complying with nearly zero-energy building provisions (EPBD);
- Art. 15(6) the promotion of renewable heating and cooling systems and equipment that achieve a significant reduction of energy consumption (eco-labels or appropriate certificates or standards), ensuring adequate information and advice on renewable, highly energy efficient alternatives as well as eventual financial instruments and incentives available in the case of replacement (to promote an increased replacement rate of old heating systems and the switch to renewable solutions);
- Art. 18(2) on ensuring that suppliers of the equipment or the competent authorities inform on the net benefits, cost and energy efficiency of equipment for the use of renewable sources;
- Art. 18(3) on certification schemes or equivalent qualification schemes to be available for installers of small-scale systems (based on the criteria laid down in Annex IV);
- Art. 18(4) on making information on certification schemes or equivalent qualification schemes available to the public, possibly with the list of installers;
- Art. 18(5) on ensuring that guidance is made available to all relevant actors, in particular to planners and architects.

Option 1 concerns the development of specific guidelines to support the relevant authorities to implement these provisions related to renewables in the buildings.

- ***Option 2: indicative level of minimum RES use in national building stock***

Option 2 defines an indicative general numerical level of minimum RES use in the national building stocks as a percentage of the overall energy use, in complementarity with the EPBD. MS would decide on the most appropriate approach to reach the required share of renewables in their entire building stocks, by focusing on a certain building category:

- Service: hospital, commercial & market, sport, offices;
- Residential: single family house, multi-apartments block;
- Public or private;
- New or retrofit;
- Type of heating and cooling system (e.g., focus first on heating oil replacement);
- Age of the heating and cooling appliance (to address the oldest and less efficient systems in priority);
- Individual systems or district heating and cooling (a special target for the buildings supplied through a DHC could be foreseen, replacing or complementing article 24(4)).

To determine the required minimum level of RES share in the building sector to reach a cost-effective global target of 40-45% renewables by 2030, the following considerations should be used:

- The building sector is at the core of the Green Deal and decarbonisation pathways, given the untapped potential to increase energy efficiency (which also increases the share of renewable by diminishing the building energy use) and its important share in the final energy consumption of EU;
- Most of the energy used in buildings is used for H&C (heating in residential, both heating and cooling in the service);
- The deployment of renewables in the building is currently limited, with bio-energies as the main source;
- The different renewable technologies are adapted to the local and building circumstances that should be clearly established in such schemes, through constraints for the installation (e.g. increase efficiency requirements (or even forbid) for pellet boilers in urban areas; heat pumps only for a label D building);
- Hybrid systems (using at least 2 energy carriers, usually 1 fossil and 1 renewable fuels) could also be part of the eligible technologies. This would require appropriate design and operation (and monitoring).

Option 2 would require to

- Add a new article, such as article 25 determining a target for the transport sector[492], to increase the share of renewable energy within the final consumption of energy in the building sector to an indicative 40-45% by 2030;
- Mirror or adapt article 9 (1.b) of the EPBD, where Member States must draw up national plans for increasing the number of nearly zero-energy buildings. These plans may include targets differentiated according to the category of the buildings. Currently these plans (article 9(3.c)) have to include information on the measures concerning the use of energy from renewable sources in new buildings and existing buildings undergoing major renovation. It would make sense to align the categorisation of the buildings with the existing frame under the EPBD and ensure Member States have a coherent approach to define these categories (even if the priorities may not be the same).

No adaptation of article 7 is required, as this option is considering the overall energy use, and separating the consumption of the building (electricity & heating and cooling) would not add to the global target, and would complicate the accounting rules.

To comply with the minimum level of RES to be used in the buildings in Member States (being indicative under option 2), building owners, occupiers or operators would have the following possibilities:

- physical installation of a highly efficient renewable heating and cooling systems in the building, including bioenergy, geothermal heat, solar thermal, heat pumps, and waste heat recovery as an energy source for heating and cooling;
- physical installation of a renewable electricity generation unit, such as PV, micro-CHP;
- connection to renewably fuelled district heating and cooling system;
- switching fossil fuelled DHC to renewable fuels;

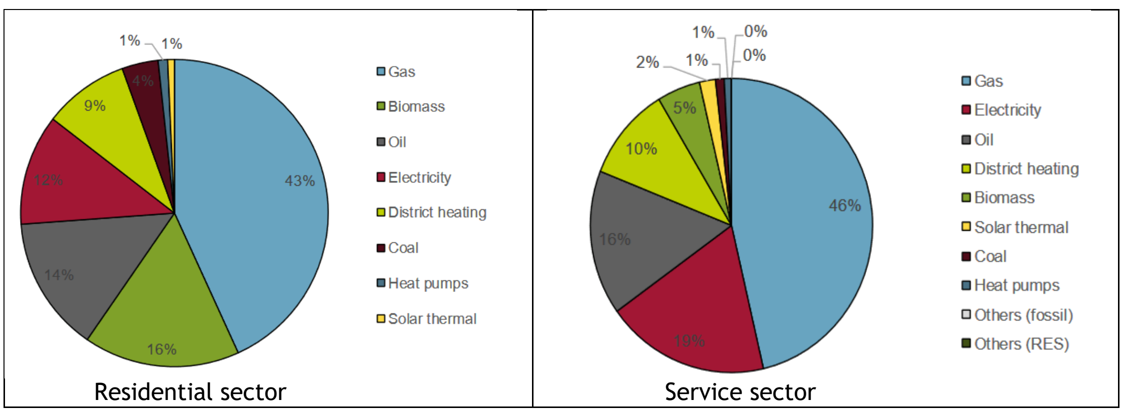
[492] Article 23 RED could also be considered as reference, but seems less appropriate as it works with an annual average, increasing the share of renewable energy in the H&C sector by an indicative 1,3% as an annual average

- physical installation of any type of conventional boiler (gas, liquid or solid-based), directly fuelled with renewable fuels (e.g., bio-propane), proven by tradable certificates, or through the purchase of a tradable certificate (provided by another renewable fuel producer);
- physical installation of a highly efficient hybrid heating and cooling systems in the building, designed to supply almost all H&C demand by the renewable source (e.g., heat pump, complemented by gas boiler, to supply the peak demand);
- other alternatives may be considered.

Increasing the energy performance of the building beyond the minimum legally required threshold could also be considered as an alternative to the use of renewable energy sources (e.g., renovating to a label A++, when the minimum legal requirements ask for a B label). Monitoring would be required regarding the installation of the systems, and regarding their operation and the fuel consumed and produced.

With natural gas representing about 45% of the total EU heating and cooling supply in 2015 (see figures below), the minimum level would probably lead to develop biomethane and tradable certificates (or GOs) as an easy way to comply with the requirements, with limited changes in the building infrastructure. This would allow gas suppliers to gradually increase their share of biomethane injected into the network and tackle the untapped potential of the sector.

Figure 0-2 Heating and cooling demand profile 2015. Fraunhofer (2017)[493]



For the physical installation possibility, the connection to a renewable DHC and the increasing share of a DHC, a methodology is required to calculate the amount of heat and cold a RES-H&C installation is delivering to the building and is recognised for accounting purpose. The mechanism applied must ensure that the calculated or metered output of a RES-H&C installation is accurate, replicable, and not open to abuse. This will be vital for protecting the scheme from gaming and fraud.

Such obligation could also try to maximise the delivery of renewable H&C, and therefore conflict with any measure aiming to decrease the energy use of the building, leading to avoid energy efficiency investment, especially under the three first possibilities. A way to avoid such conflicting situation could be to set up

[493] Fraunhofer ISI, TEP Energy GmbH, University Utrecht & ARMINES. (2017). Profile of heating and cooling demand in 2015. Heat Roadmap Europe, A low-carbon heating and cooling strategy. Available at: https://heatroadmap.eu/wp-content/uploads/2018/11/HRE4_D3.1.pdf

additional conditions imposing to reach a defined level of building performance, based on the EPC as defined under EPBD. A common metric to count the energy savings and the renewable energy supplied is the savings of carbon emissions, or the amount of fossil energy consumption for H&C per inhabitable m^3.

In addition, accelerating building energy efficiency will also play a role in increasing the share of renewables in heating and cooling by lowering the overall demand, especially with regards to non-renewable heating, while the overall consumption of renewables in final heat would increase. Therefore, additional measures will be needed to ensure that renewables will gradually replace fossil fuels in heating and cooling of buildings, address the untapped potential in terms of electrification and heat pumps deployment, and district heating and cooling deployment or conversion to renewable energy. These additional measures are addressed under option 4.

- ***Option 3: update qualification and certification requirements for installers of heating and cooling systems***

This option would revise article 18(3) of RED II, currently aiming at ensuring that certification schemes or equivalent qualification schemes are available for installers of small-scale renewable heating systems, and information is made available to the public.

The option provides further non-regulatory measures to ensure a stronger implementation, especially focusing on capacity building of installers and building professionals, urgently needed to promote the uptake of renewables in the sector.

An update of article 18(3) and Annex IV of RED II containing requirements for the certification of installers is needed to ensure an accelerated pace of renewable H&C systems deployment and the large-scale replacement of the current fossil based heating systems in buildings by skilled professionals. Such update should ideally address the weaknesses of the current regime of article 18(3) of RED II, summarised as follows:

- There is no rule or obligation to ensure the appropriate use of these schemes, meaning that MS may establish such certification scheme which would then remain unused;
- There is no requirement for a framework on education and training for small-scale renewable heating and cooling appliances;
- End-consumers are not encouraged to make use of certification or qualification schemes;
- There is a lack of policy coordination which would support uptake of renewable H&C skills training and greater certainty around the demand for renewable H&C skills and technologies.

The option will comprise the following elements, amending article 18 of RED II on information and training:

- article 18(1) by adding to the support measure to be made available, information on certification schemes or equivalent qualification schemes;
- article 18(3) by adding all renewable heating systems in the list to be covered by certification schemes or equivalent qualification schemes;

- article 18(3) by mirroring article 16(1) of EED, including, where necessary, suitable training programmes, becoming available or already being available for providers of energy services, energy audits, energy managers and installers;
- article 18(3) by obliging the use of certification schemes or equivalent qualification schemes in certain circumstances (e.g. in case a technology is supported by public finance, through support schemes, etc.);
- article 18(4), by putting an obligation on member states to make the list of installers available to the public;
- articles 18(5) & 18(6), where guidance/information is made public, this should be notified to the Commission;
- Amending annex IV on certification of installers, by adapting the criteria, and enlarging the scope to all renewable heat/cold technologies.

- ***Option 4: Obligation on technology providers to train and assist certification of one installer ~300 marketed appliances***

This option would add an obligation on MSs to ensure technology providers:

- provide training to installers;
- assist the certification/qualification of installers to ensure there is at least one certified (or qualified) installer for every ~300 appliances sold on the national market on a yearly basis.

Mapping of potential impacts

- **Direction:** Positive or negative;
- **Magnitude:** limited or significant;
- **Horizon:** Short to long term;
- **Affected parties:** following categorization indicated below.

Table 0-2 Mapping of impacts per option

Option X - impacts map	economic	environmental	social
Option 0 (baseline)	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A
Option 1 (non-regulatory)	D: positive M: limited H: short term A: energy suppliers and operators, installers, consumers	D: positive M: medium H: short term A: national/regional and local authorities, installers, consumers, RES suppliers	D: positive M: medium H: short term A: national/regional and local authorities, installers, consumers, RES suppliers
Option 2 (RES target)	D: negative M: limited H: middle term A: energy suppliers and operators, installers, consumers	D: positive M: medium H: middle term A: national/regional and local authorities, installers, consumers, RES suppliers	D: positive M: medium H: middle term A: national/regional and local authorities, installers, consumers, RES suppliers
Option 3 (certification)	D: negative M: significant H: middle term A: energy suppliers and operators, installers, consumers	D: positive M: significant H: middle term A: national/regional and local authorities, installers, consumers, RES suppliers	D: positive M: significant H: middle term A: national/regional and local authorities, installers, consumers, RES suppliers
Option 4 (certification from technology providers)	D: negative M: significant H: middle term A: energy suppliers and operators, installers, consumers	D: positive M: significant H: middle term A: national/regional and local authorities, installers, consumers, RES suppliers	D: positive M: significant H: middle term A: national/regional and local authorities, installers, consumers, RES suppliers

Analysis

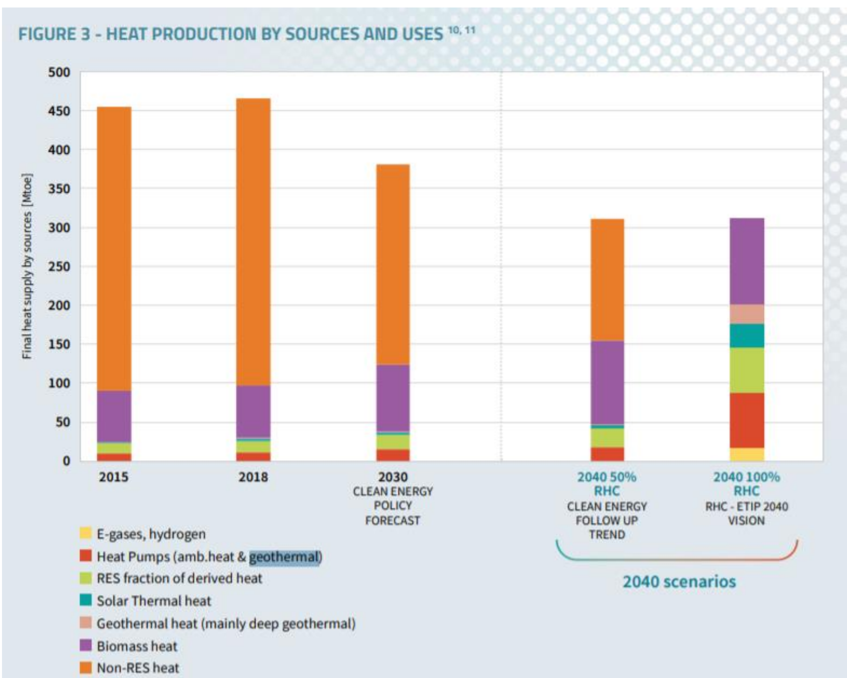
Semi-quantitative and qualitative assessment

Building consumes energy for space heating and cooling, hot water production, lighting, and for all households appliances. A focus is given on space heating and cooling, as it represents more than 80% of the building energy use in EU.

On-site production concerns both electricity generation (through micro-generation units such as PV, or micro-CHP fuelled with renewable gases) and H&C systems, either individual or through district heating and cooling. Today, the most common renewable heating and cooling technologies in buildings are solar thermal, geothermal, biomass boilers and ambient energy.

The current heat production by sources and use is depicted in Figure 0-3.

Figure 0-3 Heat production by sources and uses. RHC-platform (2020)[494]



Reaching a 100% renewable supply for heating and cooling should be feasible if appropriately combined with sharp energy savings, although many different pathways still exist. The main energy sources are described below:

- Geothermal energy is available everywhere in Europe and the extent of geothermal deployment is limited only by the demand for heat. Thanks to the continued technological development, in 2050 Geothermal H&C systems are expected to be available and economically viable everywhere in

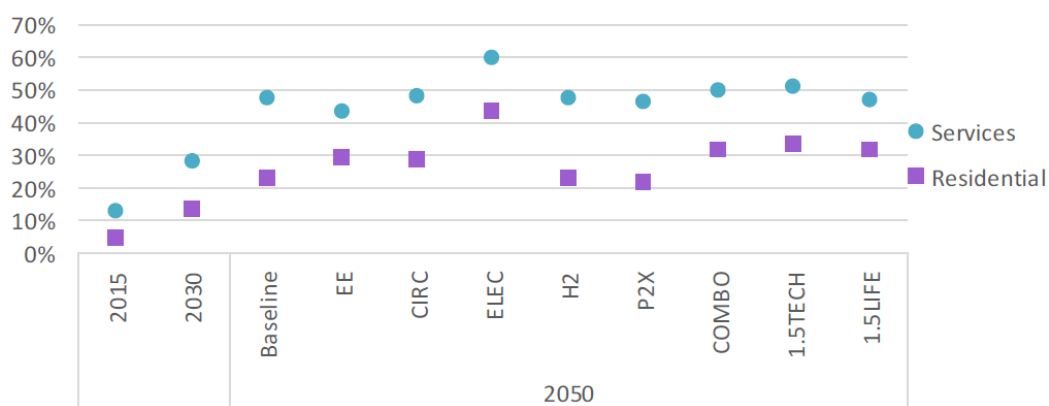
[494] Renewable Heating & Cooling, European Technology and Innovation Platform. (2020). Strategic Research and Innovation Agenda for Climate-Neutral Heating and Cooling in Europe. Available at: https://www.rhc-platform.org/content/uploads/2020/10/RHC-ETIP-SRIA-2020-WEB.pdf

Europe, for both individual buildings and geothermal H&C from enhanced and combined systems for urban areas, industries, and services;

- Solar thermal is a widely used low-cost technology for domestic hot water, mainly in Southern Europe, and solar-heated buildings and solar district heating systems have been successfully demonstrated. According to the RHC-platform[495], solar collectors may cover more than 50% of the final energy demand for heating and cooling in Europe with an average collector area of 8m^2 per European citizen, by 2050;
- High Coefficient of Performance (CoP) heat pumps are key to utilise geothermal and ambient energy (aerothermal and hydrothermal) and have already significant market shares in several countries in Europe. With high CoP systems, a wide deployment of HPs will lead to a reduction of energy demand for heating while having only a small impact towards the maximum load on the electricity grid;
- Biomass is plant- or animal-based material used for energy production, heat production, or in various industrial processes such as raw material for a range of products. Biomass is converted into energy through combustion. Direct combustion is the most common biomass conversion technology. However, the main advantage of pure or converted biomass is its storability in liquid, gaseous or solid forms, that allows for a high degree of flexibility. Existing studies have calculated the domestically available potential for energy generation from biomass in Europe to be between 169 and 737 Mtoe (7 - 30 EJ) a year from 2050 onwards (with the middle range being 406 Mtoe), taking sustainability issues into account (Faaij, 2018).

In the eight scenarios of the LTS, it is obvious that the electrification of space heating (mainly via heat pumps using different energy sources) would become an important driver of the decarbonisation of the building sector, especially in residential buildings.

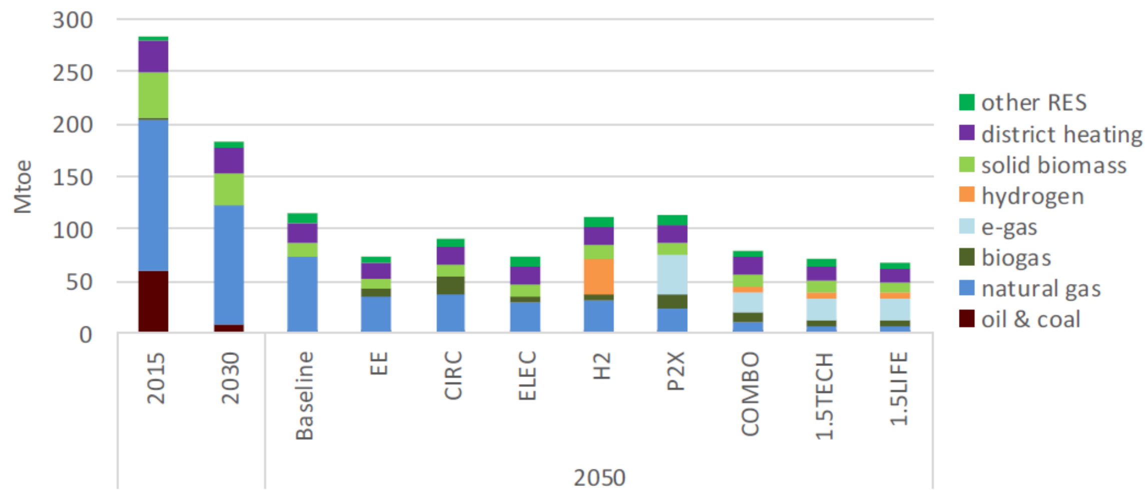
Figure 0-4 Share of electricity in space heating and cooling (LTS[496])



Source: PRIMES.

[495] Renewable Heating & Cooling, European Technology and Innovation Platform. (2019). 2050 vision for 100% renewable heating and cooling in Europe. Renewable Heating and Cooling Platform. Available at: https://www.rhc-platform.org/content/uploads/2019/10/RHC-VISION-2050-WEB.pdf
[496] figure 42 of the LTS (p 103)

Figure 0-5 Non electricity fuel consumption in space heating and cooling (LTS[497])



Source: PRIMES.

Reducing energy used in buildings for space heating, hot water and cooling through energy efficiency measures and covering the remaining energy needs with renewable energy, in power and heating, must be complementary pathways to decarbonise buildings. Therefore, increasing the share of renewable in the building sector should go hand in hand with the renovation of the building stock. The long term renovation strategies (EPBD article 2.a) are a unique opportunity to deploy renewable at scale.

The building sector comprises:

- the residential sector such as single family houses of different types, apartment blocks); and
- the non-residential sector containing a wide range of typologies such as wholesale & retail (28% of the total), offices (23%), educational (17%), hotels & restaurants (11%), hospitals (7%), sport facilities (4%), and other buildings (11%) such as warehousing, transportation and garage buildings, agricultural (farms, greenhouses) buildings, garden buildings.

This extensive set of typologies represents highly complex patterns of energy use within the sector because end-uses vary greatly from one building category to another and from one country to another.

The building stock in the EU Member States is relatively old[498], on average 21.6% of the **building stock** was **built before 1945**, 45.4% was built before 1969 and 75.4% before 1990. A relatively old building stock means that **without significant investments to improve the energy performance, the average level of energy performance of the national stock will remain low.**[499]

[497] figure 43 of the LTS (p 104)
[498] European Construction Sector Observatory. (2019). Improving energy and resource efficiency in the European Construction Sector. Build Up, the European Portal for Energy Efficiency in Buildings. Available at: http://www.buildup.eu/en/practices/publications/improving-energy-and-resource-efficiency-european-construction-sector
[499] Post shared by the Build Up portal. (2019). Overview: Decarbonising the non-residential building stock. Build Up, the European Portal for Energy Efficiency in Buildings. Availablle at: https://www.buildup.eu/en/news/overview-decarbonising-non-residential-building-stock

Option 1: guidance on best practices

Effectiveness

EU guidance & best practices sharing under option 1 would be good to support MSs introducing appropriate measures in building regulations to increase the share of renewables (implementing RED II provisions), promoting renewable heating and cooling systems that achieve a significant reduction of energy consumption, ensuring appropriate information on the benefits/cost and efficiency of equipment for the use of renewable sources, setting up certification schemes, and informing the public about their use. It would represent a one shot cost at EU, and no additional cost for Member States or economic actors involved.

Option 1 would provide technical, economical, but also institutional support, and would therefore ease the process of implementation, reducing the costs for national authorities responsible for the implantation of the provisions, and certainly accelerate the process at regional and local levels, and among economic actors.

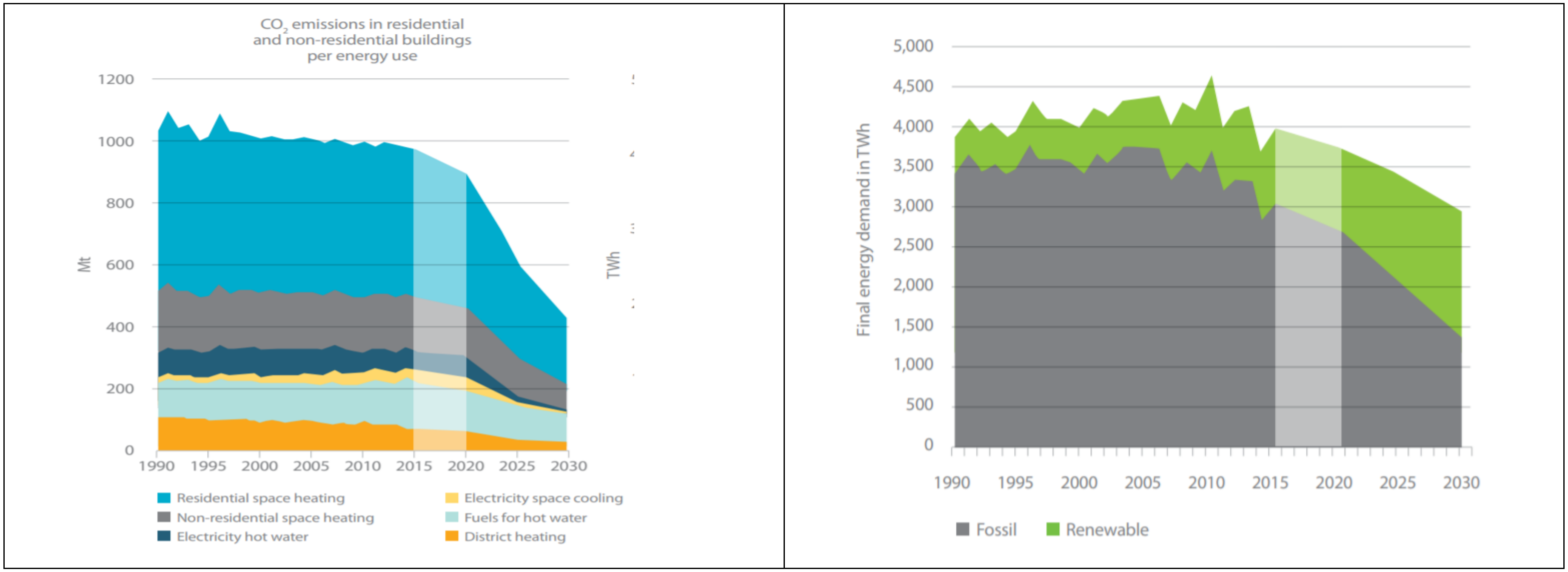
The variations among countries as illustrated by figure 2-2, shows the importance of having national integrated approaches specific to each MS, given each MS has its own context, resource availability, infrastructure, weather condition and baseline. This calls for more guidance to accelerate the process in those MS where renewable is not taking up in the building sector. Meanwhile, the final goal is to ensure the appropriate decarbonisation of the building stock, by massively deploying efficiency and renewable energies in an integrated way. The main national barriers hampering the integrated should be identified and tackled through such guidance.

- *Option 2: indicative RES target for national building stock*

In a recent publication[500], a scenario illustrates how the building sector in the EU can contribute to the EU's 2050 climate neutrality target by achieving in 2030 a CO_2 emissions reduction of 62% compared to 1990 (or 60% compared to 2015), in line with the suggested reduction delivered by the building sector in the Renovation Wave. It supports the achievement of the revised 2030 GHG objective with a proportionate contribution from the building sector. Final energy demand for heating and cooling will decrease by 22.3% compared to 1990, and the additional CO_2 emissions reduction will come from the switch to renewables, as illustrated by Figure 0-6. The share of renewables in H&C would increase from about 18% in 2018 to 53% in 2030 (entire H&C sector), or an equivalent 9.5% yearly average increase, which is almost doubling the growth rate of the past decade (which was around 5%/yr).

[500]Fabbri M., Milne C., Jeffries B. & D'Angiolella R. (2020). On the way to a CLIMATE-NEUTRAL EUROPE, Buildings Performance Institute Europe (BPIE). Available at: https://www.bpie.eu/wp-content/uploads/2020/12/On-the-way-to-a-climate-neutral-Europe-_Final.pdf

Figure 0-6 CO_2 emissions of buildings per energy use (left), and fossil versus renewable final energy demand in buildings (right). BPIE (2020)[501]

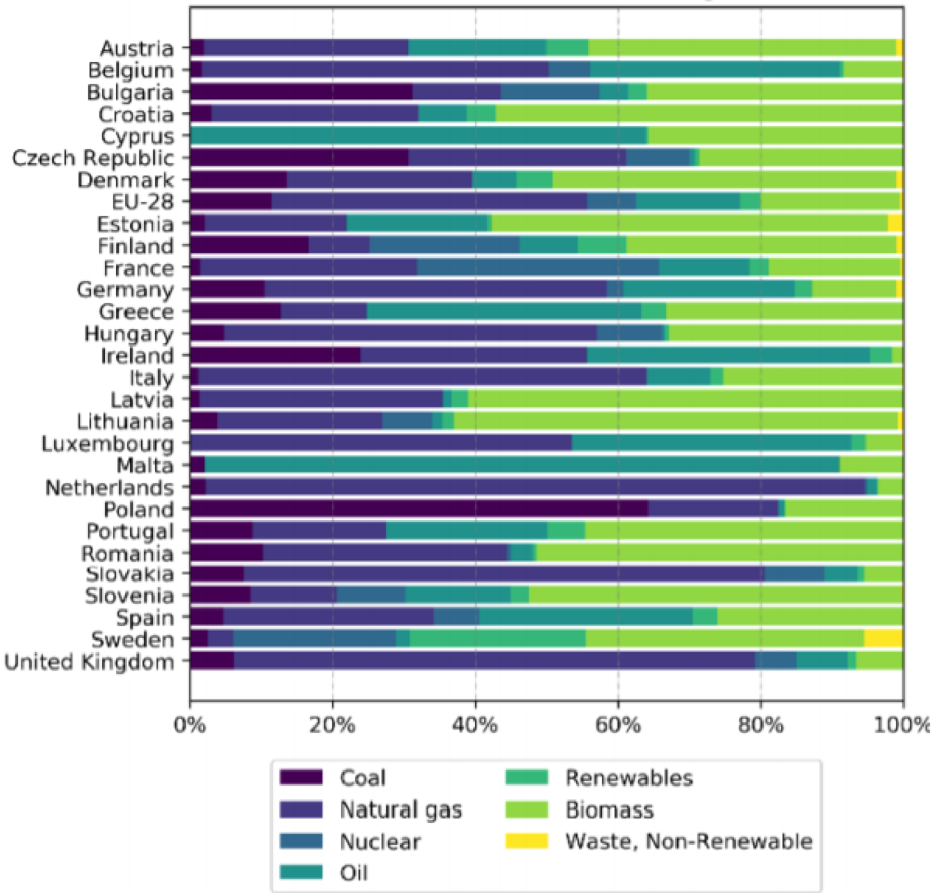


[501] Roscini, A. V., Rapf, O., Dr. Kockat, J. (2020). On the way to Climate-Neutral Europe, Contributions from the Building Sector to a strengthened 2030 Climate Target. Available at: https://www.bpie.eu/wp-content/uploads/2020/12/On-the-way-to-a-climate-neutral-Europe-_Final.pdf

Transposing such rate of 9.5%/yr at Member State level for the building sector alone (excluding industry, but involving local electricity generation) would require handling the current huge disparities between countries, with shares of RES in the residential sector alone varying from around 2-3% in some MSs, up to more than 65% in other MSs, as illustrated in Figure 0-7.

A RES target for the national building stock would therefore necessitate a deep assessment of MSs' abilities to handle the revision of the current H&C RES increase target as defined under article 23(1) of RED II. Increasing the current trend would require setting MS-specific targets, while considering all national potentials and constraints.

Figure 0-7 Primary energy share of EU residential heat supply in 2015. Aalborg University (2020)[502]



This section evaluates the options for making the H&C RES target(s) binding by comparing them to the most relevant alternative policy instruments, by assessing the policy that would best make up for the lack of progress in H&C RES deployment:

1. The potential revision of the **Energy Taxation Directive**, whose aim would be to reduce emissions by putting a price on emissions for the non-ETS sectors (buildings, transport and non-ETS industry, agriculture, waste). A carbon price is expected to re-establish the level playing field for low carbon fuels and technologies, incentivising renewable fuels;

[502] Bertelsen, N. and Mathiesen, B.V. (2020). EU-28 Residential Heat Supply and Consumption: Historical Development and Status. Department of Planning, Aalborg University. Available at: https://www.mdpi.com/1996-1073/13/8/1894/pdf

2. Energy efficiency: instruments that aim to reduce emissions by reducing energy consumption, including the Energy Efficiency Directive, Energy Performance of Buildings Directive:
    a. The **Energy Performance of Buildings Directive**, with the aim to reduce energy consumption and carbon emissions of the building stock, through several instruments like the Long Term Renovation Strategies, the Energy Performance Certificate of buildings or the energy building passports;
    b. The **Energy Efficiency Directive**, with the aim to reduce energy consumption in all sectors, by promoting efficient investments and measures.
3. The **Emission Trading Scheme** intending to reduce emissions by putting a price on emissions in the heavy industries (and possibly extending to buildings and transport). The ETS, as a market instrument, is intended to promote the most cost effective solutions and technologies to support industrial plants to reduce their direct emissions (scope 1 & 2).

Cost-effectiveness

As a market instrument, a fit for purpose ETD (or possibly extension of the EU ETS to the buildings sector) would intrinsically result in cost-optimal emission reductions if there is long term stability and visibility at national level, as it is already the case in some countries with high carbon pricing such as the Nordic countries[503]. An indicative target would provide an additional direction and possibly incentive to concretely mainstream renewable energy in the built environment, by finding the most cost-effective way to decarbonise the building stock.

However, the currently low uptake of renewables to support the buildings in reducing their emissions can be linked to the low competitive advantage of renewable fuels, and to the other more cost effective solutions such as energy efficiency, and to the lack of knowledge and risk management. With an increased integration of externalities, renewables may become more attractive and deploy without any further intervention or policy action than a possible revised ETD. But there is probably no such guarantee without additional intervention in the frame of the RED II.

The building sector has been identified by various studies as a sector that offers considerable potential for the cost-effective reduction of greenhouse gas emissions.[504] Two independent EU-wide assessments[505] indicate that 75%-85% of the technical savings potential in buildings is comprised of cost-effective options, meaning that over the lifetime of these investments, energy savings will more than compensate for the investment costs. Here also, renewable solutions have higher abatement costs than some of the energy efficiency measures, and may face difficulties to compete. It should be reminded that the concerned instruments (EPBD & EED) are not fully addressing renewables, as their main objective is to achieve energy savings.

In buildings, without specific measures to increase renewables' competitiveness, the risk remains high that renewable shares would not increase in space heating and cooling, or in on-site electricity

[503] The success in the Nordic countries is based on long-term predictability of taxes (=economic environment), while the ETS has currently a low predictability of EUA prices, which is a major investment risk, and thus increases the cost of capital.
[504] BPIE. (2010). Cost optimality, Buildings Performance Institute Europe (BPIE). Available at: https://www.bpie.eu/wp-content/uploads/2015/10/BPIE_costoptimality_publication2010.pdf
[505] Fraunhofer-Institute for Systems and Innovation Research (Fraunhofer ISI) and partners. (2009). Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries. Final Report for the European Commission Directorate-General Energy and Transport; Ecofys. (2009). Sectoral Emission Reduction Potentials and Economic Costs for Climate Change (SERPEC-CC) Summary report

generation. The two options would then be to either increase carbon pricing significantly, or to enforce the uptake of renewables via specific instruments in RED II. In the first case, accompanying measures would be necessary to guide the integration of renewables in all low-carbon actions. In the second, accompanying measures will also be necessary (see below under the section on such measures). For the simplification of the assessment, we will not take into account any hypothetical intervention on ETS or ETD, while possible synergies, and amendments to EED and EPBD may still be required and deemed relevant.

Therefore, a specific target for the building sector could become an important lever and be more cost-effective than the existing instruments, by giving a direction to the sector of the expected contribution towards the overall renewable target. Having in mind the full decarbonisation of the sector by 2050, such target also supports overcoming non-economic barriers, such as the basic lack of awareness (e.g. households to compare different options, energy suppliers or construction professionals to advise their customers), the administrative barriers, the lack of information (to final consumers) and public perception (e.g. quality may be weak), the high upfront investments. The past experience has demonstrated how complex it is to deploy renewables in the building sector. Such building target will also support the complex reforms necessary to push RES in H&C, which represents most of the energy use in the buildings[506].

Of course, this would raise the issue of Member State freedom to determine the best approach to deploy renewables in all sectors (electricity, transport, heating & cooling in industry and buildings, etc.), considering their national and local influencing factors and at the same time targeting a complete decarbonisation of the building sector by 2050.

Establishing the level of the national target would require agreeing on the criteria to be used for the calculation formula, and at least integrate a cost-optimum based on national GDP as well as climatic factors and other national differences. The national contributions should be in line with expected contributions of the building sector (H&C and decentralised electricity to a certain extent) to fulfil the CTP ambition (39% H&C RES in 2030). As the target would remain indicative, a very simplistic methodology would the most cost-effective approach.

However, such simple calculation method based only on the cost-effectiveness (at macro level) and the GDP may miss the broad set of factors that influence the real cost of deploying renewables in buildings, although a methodology based on cost-effectiveness and the GDP would remain the most simple and undisputable approach.

An alternative calculation method could be inspired by the EU gap filler mechanism for the overall RES target from the Governance Regulation, as detailed in Annex II, the objective of which is to determine (in the case of a gap), what would be the most appropriate national contribution of each MS. The current criteria set in Annex II of the Governance Regulation (concerning the overall RES target) are:

a. the Member State's national binding target for 2020 as set out in the third column of the table Annex I to Directive (EU) 2018/2001;
b. a flat rate contribution (CFlat);
c. a GDP-per-capita based contribution (CGDP);

[506] E.g., according to the LTS, in Europe's residential building stock, 71% of all energy is used for space heating alone.

d. a potential-based contribution (CPotential);
e. a contribution reflecting the interconnection level of the Member State (CInterco).

But this may not allow to capture the building specificities (as those criteria are more addressing the electricity sector). Therefore, the alternative could take into account other objective criteria addressing the purpose of buildings, especially heating and cooling and decentralised electricity generation, by:

- Replacing criterion (e) by a new criterion specific to heating and cooling infrastructure & not considering interconnection, including electricity distribution grid, district heating and cooling, gas infrastructure;
- Focusing criterion (d) on H&C and decentralised electricity generation potentials, considering all renewable fuels and technologies;
- Adding a criterion related to the H&C demand pattern, integrating the energy performance of the building stocks (and possibly the pace of renovation) and the energy profiles of the industrial sectors (considering the large variety of options to decarbonise).

Without integrating those criteria, it would probably remain difficult to reflect Member State's specific ability to deploy renewables in the building sector.

This option could in principle use the basic calculation formula based on GDP and global cost-effectiveness, to determine MS's indicative RES share targets in their building energy use. As the target would remain indicative, a simple calculation method seems to be fit for purpose.

Balancing RES-E and RES-H&C at building level

Most MSs have set up RES-electricity support schemes which have launched decentralised RES-generation markets, while support schemes are not yet well established for the supply of renewable H&C. This discrepancy between electricity and H&C could possibly lead to a non-level playing field between both electricity on-site generation and renewable H&C supply (via local generation, DHC, or even via the purchase of certified renewable fuel consumed for H&C).

As example, if installing a solar PV system on the roof of a house does provide a simple payback time of 4 or 5 years thanks to a support scheme, while installing a renewable H&C system would have a 10-12 year payback time, the attractiveness of the first solution would jeopardise the needed deployment of renewables in space heating and cooling.

The risk is to limit the deployment of RES to simply installing RES-electricity generation, which could be the most cost-effective and easy way to integrate RES into the building, missing the opportunity for a holistic approach combining electricity and H&C where appropriate.

Other national instruments are required to define specific rules and conditions to avoid such situations, like setting thresholds for on-site electricity generation, and paying attention to possible overlaps and/or conflicts with existing policies and instruments regarding the promotion of renewable electricity production. There would be a need to tackle those when designing the minimum level of RES in buildings.

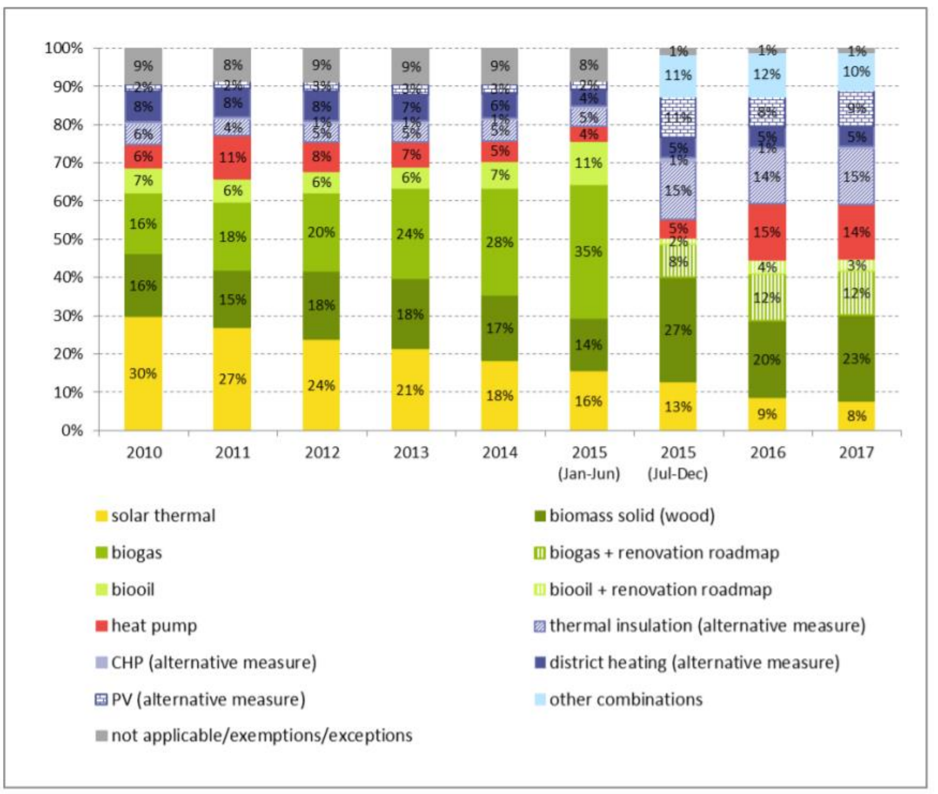
The building RES target would need to be mainstreamed in the more holistic approach of building decarbonisation, to ensure a coherent and integrated building concept leading to effective carbon emissions savings.

The textbox below illustrates how a national schemes (mandatory building requirement) can succeed in deploying different technologies, while targeting a global share of renewables in one single building, where the example of solar PV seems to be considered as an alternative.

Textbox 0-1 Baden Württemberg - mechanism of mandatory building requirements

Germany's third largest state, Baden Württemberg, was the first to mandate the installation of renewable heating technologies in 2008. Owners of a heating system need to employ a minimum share of renewable energy of 15% of the heat demand when the heating system is replaced. Instead of employing a renewable heating system, the building owner can also opt for efficiency measures, including insulation of the building. A part of the obligation can be fulfilled by carrying out an energy audit based on an individual building roadmap.
Figure 3-1-1 illustrates the evolution and the share of technologies.

Figure 3-1-1 Evaluating the renewable heating and efficiency obligation for existing buildings - insights into the mechanisms of mandatory building requirements - building owners compliance.



Source: Öko-Institut (2019)[507]

Purchase of renewable fuels through networks

Renewable gases and liquids are rarely produced locally and consumed "physically" (except in some rural areas where biomethane or renewable gases could be distributed to end-consumers). Unless these

507 Institute for Energy and Environmental Research Heidelberg, Öko-Institut, ECONSULT Lambrecht Jungmann Partnerschaft, IREES. (2019). Evaluating the renewable heating and efficiency obligation for existing buildings – insights into the mechanisms of mandatory building requirements. Available at: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2019/7-make-buildings-policies-great-again/evaluating-the-renewable-heating-and-efficiency-obligation-for-existing-buildings-insights-into-the-mechanisms-of-mandatory-building-requirements/

fuels are not used anymore for space H&C, the purchase of renewable gases via the gas network could be verified through a verification scheme (mass balance or book and claim). Therefore, the purchase of certificates or guarantees of origin (GO) should be allowed to cover the need of a building. The same could apply to renewable liquids, like bio-propane, or hydrogen-based liquids.

However, if this applies to renewable liquids and gases, the same approach could also be considered for renewable electricity, and the purchase of GOs to replace on-site generation. The instrument should clearly define the scope in order to avoid unexpected transposition into national schemes. This would require strong harmonised rules, which would then probably face a number of difficulty in applying this uniformly to all Member States (given all differences between MSs).

Renewable gases production

The option would also possibly support the deployment of renewable biomethane by increasing the demand side via the purchase of tradable certificates (or GOs), and therefore pulling the production side. Allowing to cover the needs of the building sector through such tradable certificates should also be based on the existing potential of a region or a country to effectively produce biomethane in a sustainable way, while also considering other uses like in industry, or transport. This should also bear in mind the importance to prioritise certain fuels, given their specifications (e.g. biomethane is the same molecule as natural gas, which is the most adapted fuel for almost all industries, and has limited renewable alternatives including hydrogen in the case of high temperature processes as example). Clear rules should be set up at national level regarding the sustainable production and adequate use of biomethane depending on the demand profile, before allowing it to cover building energy use by such tradable certificate schemes. The same logic applies to hydrogen-based gases and liquids.

Impact on electricity grid

The renewable energy heating and cooling RES target for the national building stock would provide additional incentives to fuel-switching from fossil to renewable energy. MSs would have the freedom to target the phasing out of fossil fuels, by focusing on specific H&C system types and building categories. It can also accelerate the deployment of heat pumps, and certainly their combination with on-site electricity generation (via PV mainly) to tap the complementarity of both technologies as they would both account for the minimum level of RES in a building. This combination, if properly tackled at distribution level through proper digitalisation and on-site or local storage (e.g. through batteries and/or building inertia), would have a slightly positive impact on the electricity grid by diminishing the need for reinforcement. But if not tackled appropriately, the impact on the grid could be damaging. Therefore, deploying PV or other local electricity generation would be required where heat pumps are being deployed[508], and coordinated planning with the electricity DSO is required, to balance the system and provide seasonal storage.

Skills and qualified workers

The construction sector encompasses on-site renewable energy system installers, as these systems (heating systems or electricity-generation) are fully integrated into the design and operation of a

[508] One should pay attention that heating is required in the winter where solar PV production is significantly lower than during the summer summer. In winter, there are days/weeks without relevant solar PV production, therefore the grid should have sufficient capacity to supply heat pumps with interruption when PV are not producing.

building, touching upon the envelope (e.g. PV installation on roofs), the electric installation, the hydraulic system (e.g. pellet boiler producing hot water to be distributed in the building), and the regulation (e.g. HVAC system equipped with renewable appliances). Therefore, the challenges of skills for the small-scale renewable systems adapted to the building are fully included in the challenges of the whole construction sector.

One important barrier that hampers the development of Nearly Zero Energy Buildings, or NZEB (which encompasses renewables in the building), and effective renovations is the lack of adequate construction skills, both in middle- and senior-level building professionals, as well as the various trade professionals in the area of sustainable energy efficient construction.

Even though most of the building renewable technologies are mature, this lack of competent professionals with the required skills also leads to limited consumer confidence, and hampers efficient systems to be installed.

Nearly 35% of all buildings in the EU are over 50 years old, of which approximately 75% are energy inefficient. Even though renovating existing buildings could substantially reduce energy consumption (by up to 60%), a maximum of 1.2% are renovated each year, of which only 15% are incorporating significant energy-efficiency improvements. This is mainly due to the fact that most of the building sector, including heating, ventilation and air conditioning (HVAC) professionals, lack the necessary skills to perform energy-efficient renovations and retrofits.[509] This option would have a slightly positive effect by supporting MSs with setting up the required framework for the deployment of RES in buildings, and could even be strengthened if a focus is given on training the construction professions in the guidelines (which is covered under option 3).

Investor certainty

While renewables in buildings have shown cost reductions over the past two decades, investments generally still rely on subsidies, especially in the case of capex intensive investments (e.g. geothermal heat, heat pumps, solar PV).

An indicative target for the building sector would provide a signal of the direction to take, in line with an overall binding GHG emissions goal, although a binding target would be stronger and provide more confidence to investors and economic actors.

It is assumed that national authorities will take the required actions and commitments to reach the target, with the accompanying measures to support the development of RES in buildings. The higher the certainty, the more attractive H&C renewables will be for market players, leading to higher competition and lower cost of H&C renewables.

[509] An EU-funded CEN-CE project setting up standard-based qualification and training schemes in energy efficient construction for heating and cooling professionals has been set up, according to CORDIS Results Pack. (2019). Construction skills: Equipping building professionals with new skills to achieve European energy targets. Available at: https://op.europa.eu/en/publication-detail/-/publication/73fde71a-25fb-11ea-af81-01aa75ed71a1/language-en/format-PDF

The perceived risk of adverse policy changes for renewables would be smaller with a target, lowering the cost of capital for renewable energy investments.[510,511]

Overall an indicative building RES target would have a limited positive impact for investors in the building renewables market.

In any case, the most effective way to enhance investor certainty is provided by a stable framework for the long-term, including for support schemes where required. Therefore, if H&C renewables are able to compete without additional incentives (e.g. if the ETS carbon price is high enough and stable, and H&C included in the ETS), these instruments would be more secure for investors than any binding target. If renewables are properly integrated into the EPBD instruments (e.g. LTRS or building passport), and become profitable, investor certainty would be increased.

Macro-economic impacts

The macro-economic impacts depend directly on the uptake of renewables in the building sector. The main impact will be the creation of jobs in the construction sector, with installers, workers, engineering, architects, designers, planners, and in manufacturing, with e.g. heat pumps & pellet boilers or micro-CHP. A market uptake will also increase the skills and knowledge, which could be reinforced via additional measures (addressed in the next option).

Security of supply

The benefit of most renewable energy sources for the building (both for heating and cooling and electricity generation) is that they would create value with locally produced energy, building mainly on the match between demand and supply (geothermal heat, solar heat, PV, heat pumps using a local heat source, bio-energies, including the production/use of biomethane, micro-CHP fuelled with biomethane or hydrogen). It does not mean these sources are only locally based, as, e.g., massive imports of pellets exist, biomethane can be transported via the gas grid, etc. But except for the case of wood-based energy sources (such as pellets) and RFNBOs (to be used in large scale systems, like DHC), these renewables would be produced intra EU, as opposed to fossil fuels, for which the EU relies heavily and increasingly on imports. Therefore, renewable deployment in the building sector reduces import dependency and thereby enhances security of supply.

The indicative RES target for the national building stock would have a positive impact on security of supply by creating reduced import dependency, with possibly a slight decrease of this positive impact for MSs relying on imported bio-energies (such as pellets).

Innovation

Along with enhanced renewables in buildings, deep renovation and innovation in solar buildings skins (incl. BIPV[512]), the interaction of buildings with related areas, such as storage, e-Mobility and Internet of Things, digitalisation and the combination of all components to reach Nearly Zero Energy Buildings by 2050 are important issues to address in the RD&I agenda.

[510] Diacore. (2016). The impact of risks in renewable energy investments and the role of smart policies
[511] Trinomics, Cambridge Econometrics and E3M. (forthcoming). Study on the Macroeconomics of the Energy Union, Report on literature review and stakeholder interviews regarding the representation and implications of the financing challenge.
[512] Building Integrated PhotoVoltaics

The contribution to building renewable supply is made by bioenergy, active solar heat, PV and other electricity generation, geothermal, ambient, heat pumps, and CHP based on renewable gases. All these technologies and carriers, even if mature and already commercialised at scale, still rely on progress in RD&I.

New business models providing energy services to building will be proposed by energy service companies, utilities and other service providers, integrating all different markets to take advantage of the most promising and cost-effective solutions. The intermittent nature of electricity production from wind and PV requires demand flexibility which can be provided by active buildings. Support for trials may be required, depending on local heat and energy markets interactions.

One important challenge will be to provide cost-effective and easy/fast to install retrofitting solutions for old buildings, to be combined with the installation of renewables, where additional research and innovation is still required.

An indicative RES target for the national building stock and the resulting secured RES deployment in buildings is relevant for innovation, as those targets would create and enlarge market opportunities for all renewable applications and technologies, and the enabling technologies such as those providing flexibility to the energy system. Most of the H&C and small scale electricity generation technologies are mature, however, further innovation is still expected regarding cost and efficiency improvements. In the building environment, mass market will be the main driver to accelerate the learning-curve, including on the side of installers and operators where increased skills are still required to adequately ensure cost-efficient and quality delivery. The EU value chain actors, starting with the EU manufacturers, would get more confidence and possibly strengthen research. Several technologies, such as heat pump manufacturing[513], are already well represented at EU level, with some of the major global players. An accelerated deployment would support learning and incentive new products commercialisation, and stimulate the improvement of some technology components via further RD&I. The EU industry can benefit from accelerated learning-by-doing and increased economies of scale.[514]

For less mature technologies or business models, such as smart or active buildings or fuel cell-based micro-CHP, the positive impact of a building target would be larger.

Distributional impact

For the deployment of renewables in buildings, support will certainly be required. As in the case of support schemes for renewable electricity, the distribution of the incurred economic impacts could be better managed than simply relying on a carbon pricing, from the ETD e.g., where no distinction is made between consumers. Carbon pricing would simply increase the costs of carbon intensive consumption without any consideration for income levels, while specific support schemes can be financed in a way that does account for a just distribution of costs (e.g. tax payers to bear the cost, or consumers with exoneration for certain consumer categories). The impact assessment carried out for

[513] Heat pump Barometer 2020, available at https://www.eurobserv-er.org/category/all-heat-pumps-barometers/
[514] IRENA (2015), Renewable energy technology innovation policy.
https://www.irena.org/publications/2015/Jan/Renewable-Energy-Technology-Innovation-Policy-A-process-development-guide

the Climate Target Plan confirmed that the scenario relying most on carbon pricing has the highest negative impact on low income households.[515]

However, the distribution could also be managed appropriately with the ETD if the revenues are directly used to support low income consumers to decrease their energy bill, by, e.g., focusing on these target groups with deep renovation programmes, or providing subsidies for the replacement of old and inefficient heating appliances (by renewable-based technologies), or providing lump sum support (possibly linked to the use of renewables). These revenues offer an opportunity to accelerate both energy efficiency and renewables in the buildings. Such programmes should be adapted to overcome the lack of capital and other barriers that may exist.

The distribution of the costs and benefits of a RES target in national building stocks will rely heavily on how the MSs intend to design their framework in order to meet their target. According to a recent report by the Joint Research Centre (JRC) analysing the information provided by member states on how to decarbonise the heating and cooling sector[516], the measures related to renewables and energy savings in heating and cooling are in most cases provided with limited description. It remains therefore hard to evaluate what will be the global impact yet.

Additionally, lower income Member States have a larger share of lower income households which could possibly intensify the distributional issue on low income classes at national level. Therefore, the RES target for national building stocks can have a positive impact on low income MSs if the formula to calculate the MS contribution/target fully considers these incomes. Otherwise, the impact would be negative on these MSs.

Therefore, the option can have better distributional impacts than relying more on carbon pricing and other energy efficiency instruments, unless the adapted programmes are set up to efficiently distribute carbon revenues, leading to an equal impact for both instruments.

The option would positively affect the countries with high renewable potentials (sun for PV or heat, bio-energies, wind or other renewable-based electricity generation, geothermal heat), and possibly lead to require higher building performance in those countries with less potential. Increasing renewable energy import by those countries with less renewable potential, may also become a final option, therefore negatively affecting their trade balance on the long run.

The option would positively affect the resilience of the energy system, certainly increasing energy independence.

Customer empowerment

The availability of transparent and easy to understand market performance indicators of building H&C systems will become increasingly important. Such indicators should allow consumers to be able to compare different technology solutions using various energy carriers being renewable or fossil-based. These indicators may also allow to compare individual systems with district heating and cooling

[515] SWD(2020) 176 final – Impact assessment accompanying the document “Stepping up Europe’s 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people”
[516] JRC (2020) Assessment of heating and cooling related chapters of the National Energy and Climate Plans (NECPs)

connections. The design of any instrument (e.g. support scheme or mandatory building requirement) to deploy renewables in buildings should enable consumers at building level to make adequate choices between efficient and renewable systems, and should therefore ideally be accompanied by an adequate certification / qualification schemes. In addition to indicators, as many buildings, especially small ones, are owned by private persons, and buildings have individual characteristics, independent, trustworthy, competent, and cheap advice is key to customer empowerment.

Affected parties

A RES target for national building stocks would probably have a limited positive effect on energy suppliers and operators, as the pace of RES deployment in the building sector would strongly depend on their ability to expand their portfolio to emerging energy sources and technologies, opening new opportunities for those having the ability to adapt their business model. In any case the market will increase, with added value, more work compared to a fossil based economy, even with the natural gas industry facing declining volumes.

Discrepancies would appear between suppliers and operators if different approaches are implemented depending on building categories (e.g. suppliers to social housing would have a competitive disadvantages and possibly change their market segment, if the sub-sector of social housing becomes the priority to deploy renewables). This would lead to the short-term most cost-effective options to be implemented, to reduce these impacts, and therefore miss the opportunity for an integrated and holistic approach to decarbonise the building (e.g. this could lead to deploy massively technologies such as pellets boilers, which are currently the only competitive direct renewable-based technology, while in most cases such boilers would not be the most appropriate solution). This negative impact could be diminished if a holistic approach is taken at energy system level, setting up appropriate carbon pricing or equivalent adjustment in the building sector to restore a level playing field. Incentive schemes would probably also be required (to be supported by all taxpayers, or by targeted consumers, depending on the scheme design).

Without an appropriate framework, a building landlord would have no incentive to invest in any new heating system (e.g. from fossil fuel to renewable fuel), while the savings would benefit the tenant. This split incentive is still considered as an important barrier, and should be considered in the entire renovation of the building stock.

A RES target for national building stock would have a positive effect on the activity of installers depending on the market uptake of the renewable and smart solutions for building. They would take the higher advantage of an increase of the activity.

Other building professionals than installers (incl. architects and designers, building operators) could be indirectly affected, if they are appropriately involved in developing all solutions, requiring a high level of building integration, also addressing efficiency improvements and smart building.

The indicative character of the option allows MSs to opt for a smooth integration in the entire building performance dynamic, while reducing the administrative workload of building installers, and possibly other professionals (for the design of a renovation, or filling-in of a building passport), and promoting the creativity of each profession to deal with RES integration in buildings (especially architects).

Globally, a RES target for national building stocks would imply a new mindset for all professions across the supply chain, managing the diversity of technologies and concepts, and the need to improve quickly their skills and knowledge, and adapting their business cases. It would indirectly oblige MSs to address all non-economic barriers hampering the deployment of renewable technologies in their building, to reduce the risks and related costs of capital, and increase the mass market effects when deploying certain technologies such as heat pumps.

GHG emissions reduction & other environmental impacts

The displacement of fossil fuel consumption (heating oil, natural gas, LPG, even coal) and thereby the reduction of GHG emissions, is directly linked to the ambition level and the measures MSs will implement to meet the target. Hence, a RES target for national building stocks will have a positive contribution to GHG emission reductions, although bioenergy is inherently emitting and therefore not fully consistent with a net zero emission, assuming the target will be met.

A potential environmental impact due to the rapid deployment of all renewables in buildings is biomass deployment, as this is probably one of the most competitive options without any incentive scheme and could possibly take the lead in deploying the various renewable technologies in buildings. Depending on the heating system used, biomass might have potential adverse impacts, such as on air quality or biodiversity, that would not counterbalance the benefits in terms of renewable energy deployment and GHG reduction. Depending on the pathways, great care about biomass sustainability should be taken, expanding the scope to small-scale systems. Such obligation could apply to the fuel suppliers, rather than on the building occupant/operator.

GHG emissions

Half of the energy consumed in Europe is used for heating and cooling, and 75% of this energy is still coming from fossil fuels. Additionally, much of this energy is wasted due to inefficiencies in the heating and cooling systems. According to the project Replace[517] (and also to other sources, such as EHI), about two thirds of the heating systems installed in Europe, a total 80 million units, are inefficient. The replacement of these inefficient systems should be addressed in a coordinated way with the deployment of renewable in the building while improving the energy performance of the stock.

State-of-the-art, sustainable renewable heating and cooling systems offer a unique opportunity to make significant contributions to decarbonise EU building stock through the efficient distribution of heat and cold from renewable energy sources.[518]

Bioenergy

A potential environmental impact due to the rapid deployment of all renewables in buildings is biomass deployment, as this is probably one of the most competitive options without incentives. Biomass represents already about 83% of the renewables in the heating and cooling sector, and could possibly continue to lead in buildings. Global pellet production continues to expand year after year, amounting

[517] REPLACE, Making heating and cooling for European consumers efficient, economically resilient, clean and climate-friendly, Horizon Europe project. Available at: http://replace-project.eu/
[518] EU Smart Cities Information System. (2020). District Heating and Cooling booklet. Available at: https://www.euroheat.org/wp-content/uploads/2020/03/scis_solution_booklet_district_heating_and_cooling.pdf

to 36.1 million tonnes of pellets produced in 2016[519], with 16.6 million tonnes produced in Europe in 2016. On the demand side, Europe (mainly EU28) remains a massive pellet consumer, accounting for 22.3 million tonnes per year of wood pellet consumption. Europe remains an important importer of pellets; based on 2016 figures, net imports represent 5.7 million tonnes per year, or almost 25% of EU consumption. These imports also rely on long-distance, with the negative impact on GHG due to transport, as for any type of import.

In addition to sustainability issues and resource availability, and depending on the heating system used, biomass might have potential adverse impacts, such as on air quality or biodiversity, that should not counterbalance the benefits in terms of renewable energy deployment and GHG reduction. The design of the national measures (e.g. incentive schemes, mandatory building requirement) should therefore carefully liaise with biomass sustainability provisions, probably expanding the scope to small-scale systems, but also with energy efficiency of pellet heating systems.

Coherence

The EPBD Inception Impact Assessment[520] presented the Minimum Energy Performance Standards (MEPS) per building as a key instrument to be assessed in the frame of the EPBD revision. Stakeholders usually agree that such MEPS are important and should deliver the required level to reach a highly energy-efficient and decarbonized building stock by 2050, and to deliver a 60% GHG emission reduction by 2030. The phased introduction of mandatory MEPS for all building types to secure such ambitious renovation objectives is key, regarding both energy efficiency and renewable energies. Such high level of GHG reduction would leave no choice to MSs than mainstreaming renewables in the building stock, in all new constructions, renovations and beyond. However, this would also require some safeguards to ensure that the energy efficiency first principle is implemented, and that the decarbonization of the building stock does not lead to the easiest technical and economical solution (which is often switching to renewables without improved insulation), with as consequence to lock-in energy efficiency measures (e.g. building insulation). Financial constraints can be a reason to avoid energy efficiency measures, but also the conviction that full decarbonization has been achieved via the lowest effort (it is usually easier to change the heating system than to insulate the building). Therefore, it is key for the EPBD to set up two clear indicators.

[519] Aebiom. (2017). Aebiom Statistical report, European Bioenergy Outlook, Pellet market overview. Available at: https://epc.bioenergyeurope.org/wp-content/uploads/2017/10/FINAL-PELLET-MARKET-OVERVIEW-2017.pdf
[520] The link to the Inception Impact Assessment survey (2021) is available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12910-Revision-of-the-Energy-Performance-of-Buildings-Directive-2010-31-EU

Textbox 0-2 Minimum share of renewables in Baden- Württemberg & support scheme for renewable heat in Ireland

Since 2008 in the **German State of Baden-Wurttemberg**, owners of a heating system need to employ a **minimum share of renewable energy of 15% of the heat demand** when the heating system is replaced. Instead of employing a renewable heating system, the building owner can also opt for efficiency measures, including insulation of the building. According to the evaluation of this renewable heating and efficiency obligation, the influence of the obligation is twofold: on the one hand, it aims at boosting renewable energy heating compared to fossil-fuel fired heating. On the other hand, it aims at reducing energy consumption by promoting energy efficiency measures at the building envelope level. Overall, the obligation provides positive impetus for additional installations of renewable energies, more energy efficiency and advice. This effect results from the sum of different effects: through the explicit requirements, it provides an additional direct incentive to expand renewable energies. Indirectly, it strengthens the involvement with renewable energies both in the consultation process with heating engineers and planners/architects and in the purchase decision of customers. Additional energy consulting is also encouraged. The evaluation also concludes that the obligation's impact is not sufficient to meet long term climate targets. It would, however, be much more effective when combined with significant carbon pricing – which would ensure climate-friendly solutions are also economically attractive.

In Baden-Württemberg is noticeable the large proportion of oil boilers, with significantly fewer gas boilers than the national average. This shows that in addition to energy efficiency improvements in Baden-Württemberg, more energy sources are needed than at the federal level to improve the climate balance of the heat supply.

The **Support Scheme for Renewable Heat in Ireland** will contribute to meeting Ireland's 2020 renewable energy and emission reduction targets. It will focus on heat users in the Non Emissions Trading (non-ETS) sector. The scheme is designed to increase the energy generation from renewable sources in the heat sector by approximately three percentage points. It is designed to financially support the adoption of renewable heating systems by commercial, industrial, agricultural, district heating and other non-domestic heat users at sites not covered by the emissions trading system. It aims to bridge the gap (using operating-aid) between the installation and operating costs of renewable heating systems and the conventional fossil fuel alternatives. The Terms & Conditions for operational support will include the requirements that buildings and heat using processes must adhere to (and continue, during period of support, to adhere to) verified energy efficiency criteria.

Both cases (Baden-Wurttemberg & Ireland) illustrate the combination of renewable heat and efficiency measures.

Of course, an indicative general numerical level of minimum RES use in national building stocks as a percentage of the overall energy use would give an additional impetus to MSs to set up such scheme, to reach the overall target.

For many stakeholders, the phased introduction of EU-wide mandatory MEPS would be effective in overcoming barriers to renovation if combined with proper funding & guidance. Such guidance could be based on a mid- and long-term target, providing a clear direction for renewables in buildings (especially for H&C renewable).

For the majority of the stakeholders, EU-wide mandatory MEPS should also leave sufficient flexibility to MS to adapt to national or local particularities of their building stock, which is also at the core of the deployment of renewable H&C, and therefore depends on local resources, infrastructure, demand profile (incl. building performance), behaviours, etc. The calculation of the level of RES in buildings should also be aligned with the phasing of MEPS.

Administrative burden

The administrative burden and associated costs will depend on the governance process at EU level, the level of ambition, the methodology to define the national contributions and the existing available data, among many other variables. The higher the ambition, the more precise the national contribution should be calculated to avoid over burden to some MSs, and too light target for other ones. Minimum administrative requirements foreseeable would include defining a methodology to calculate the national contributions, which could be based at least on the following parameters (inspired from the Effort Sharing Regulation), to capture also national building stock specificities:

- GDP-per-capita;
- The current RES share in H&C supply;
- The national potential (existing renewable resources), considering centralised and decentralised H&C generation potentials, addressing all renewable fuels and technologies;
- Existing and potential to develop heating and cooling infrastructure, including electricity distribution grid, district heating and cooling, gas infrastructure;
- H&C building demand pattern (also influenced by the weather conditions), integrating the energy performance of the building stocks (and possibly the pace of renovation), and the energy savings expectation for the coming decade.

Applying the calculation methodology to all MSs to determine their expected share of renewables in the building sector by 2030, starting from the current share (cf. figure 2-1 above on the fuel share of EU residential heating in 2015) and the national commitment (measures and objectives of NECPs) would probably require several iterations between the Commission and the MSs.

Upfront, the calculation methodology to determine each national target and/or monitor progress could require to assess those factors that are essential in determining the national potentials, resources and needs before being able to mainstream them in a common formula fitting for all MSs.

Calculating a national contribution with a one size fits all formula will not be an easy task, given the many differences between MSs, regarding: resources, demand profiles, infrastructure, buildings performance, financing means, type of fossil fuels, capacity to deploy new infrastructure, etc. This should also be integrated into the broader context of the EPBD, as the deployment of renewables is closely linked to the increase of energy efficiency.

At national level, two aspects should be considered:

- The design and implementation of a set of instruments to support the deployment of renewable heat in the building sector (e.g. support scheme, building code, obligation scheme, ban of fossil systems, fiscal incentive, financial instruments, …). It should be recalled that the Effort Sharing Regulation imposes on the MSs a GHG emission reduction target in the non-ETS sectors, with the building sector counting for almost half of the emissions, while the sector would probably count for more than half of the efforts (given the other important sector is transport, which is usually harder to decarbonise). Hence, all MSs to reach the GHG target have already addressed in their NECP and LTRS the required instruments to increase energy efficiency and deploy renewables in the building sector. It does not mean these policies are sufficient to reach the new target, but it means there is already a baseline policy, on which to build;
- Any additional target requires additional administrative burden to comply with, while reducing the freedom of MSs to select and possibly adapt their own decarbonisation pathway. This could be helpful for following up closely the sector concerned by the target, and support the

adaptation of the policies and instruments to more granular indicators. But at the same time, it requires to elaborate new monitoring, and impose an overall target where regional and local specificities would be left aside and possibly forgotten.

To conclude, the additional administrative costs for MSs would then come from the central authority to manage and follow up achievements to reach such new target. The most important cost would probably come from the calculation of the national contributions at EU level, and setting a gap filler mechanism. The bulk of the administrative cost at MS level would come from the set of instruments to be implemented, while their adaptation to increase the ambition will not be costly, unless the MS has not yet planned the appropriate measures.

If the national target is set appropriately (i.e. cost-effectively), compliance costs would depend directly on the ambition level, on the potential technologies (available in national territory), and the state of the building stock (the more performant the stock, the easier it is to deploy heat pumps, for example).

Political feasibility

When fixing a target, the higher the level of granularity, the more it limits the freedom of the responsible parties (EU & MS) to reach the overall target to deploy renewables, as well as to reduce carbon emissions and to increase security of supply at an affordable cost.

Increasing the share of renewables in the heating and cooling sector requires a systemic approach as it is at the core of the energy system integration. The capacity to increase the electrification of the heat space in the building sector (e.g. through heat pumps, or even by using RFNBOs) will depend on the capacity to produce renewable electricity, and to deploy electrical vehicles.

Textbox 0-3 National choices to deploy renewables & RFNBOs for H&C

As an example, a MS with high RES-E potential could freely chose to deploy EVs and HPs, and even produce RFNBOs (for its own consumption or for exporting), or simply increase its RES-E target to reach its overall RES target. A MS with low RES-E potential should think about importing its electricity, or using more local sustainable biomass resources if available.

Deploying HPs will depend on the needs to increase the energy performance of the buildings and the requirements to strengthen the electricity grid, but also the gas grid (potentially refurbished for hydrogen operation) as potential alternative. Using more solar or geothermal heat depends directly and only on the available resource at local scale, and the capacity to deploy district heating and cooling infrastructure, while bio-energies could also be imported from outside the country or even the EU. Installing PV will depend on the roof space and orientation.

Such freedom should be left to each MS to find its own cost-optimum balance to deploy renewables in the building sector, considering all national and local parameters. It appears more and more clear how important it is to plan at national or even regional or local level, from a bottom-up approach.

At the same time, deploying renewables in H&C remains a complex task, touching upon energy infrastructures, building renovation (incl. skills in the construction sector), industrial decarbonisation pathways, local/renewable resources, local player involvement, providing flexibility services, empowering the consumers (with smart systems), etc. Given this complexity, the risk is still high for the MS to postpone the actions to deploy renewables in this sector. Therefore, a clear signal from the EU level should pave the way for the MSs to accelerate the decarbonisation of the building sector by reducing energy used in buildings for space heating, hot water and cooling through energy efficiency measures and covering the remaining energy needs by renewable energy, both in power and heating. These should be complementary pathways to decarbonise buildings.

The calculation to determine the MS's contributions/targets should also ideally mainstream all these interlinked parameters, and it could be expected from the MSs to request so. Therefore, agreeing on a common EU formula would probably become a complex task to negotiate in order to consider all very specific MS aspects.

In addition, given the many missing elements in most of the NECPs, defining the national contribution would require the MSs to further study the penetration of renewables in the building sector before being able to even discuss the formula. A new formula would include the interlinkages with all the sectors, based on the assessment of the RES and RES-E potentials in buildings, integrating the most relevant of these factors.

Therefore, this option could have an important negative impact.

However, with an indicative target, a less hard-binding formula can be used. Such formula could be simpler to calculate national RES targets for the building stocks, than what would be required to calculate a binding target. This would ease the negotiation process.

To conclude, setting up an indicative RES target for national building stocks, to contribute to the new ambition of the CTP, would give the MSs a clear direction on the way forward, and the actions to take to decarbonise their building stock.

Subsidiarity is ensured through the freedom left to each Member State to define its own framework and set of policies to reach the RES building target. Also, the indicative target leaves it up to the Member State/obligated party to choose the most cost-effective measures in its given context, hence the instrument adapts to specific conditions. The possibility for Member States to choose between a range of incentive measures also allows flexibility at national level and ensures proportionality through the mitigation of impacts on smaller suppliers.

Given the importance of the building heating and cooling sector to reaching the overall EU target for renewable energy, accompanying measures to increase the renewable share in the sector is desirable.

However, one should pay attention to the complexity this option adds to the MSs having to deal with many different targets and sub-targets (transport, H&C, DHC, building, industry, …) where their national context would lead them to prefer one single renewable target for the whole energy system, and thereafter to decide on which sector to put which level of ambition.

- ***Option 3: update qualification and certification requirements for installers of heating and cooling systems***

Effectiveness

Capacity building is considered a cost effective way of supporting the decarbonisation of the building sector. Additional investment in training of workers, development of training courses, investing in teaching resources for disseminating green skills and integration of climate, environment and green energy knowledge in scholarship are measures where the initial costs associated with development and implementation of such efforts is expected to result in broader knowledge dissemination and awareness. Several literature studies highlight the importance of awareness raising and information dissemination in achieving energy efficiency and renewable resources adoption.[521]

Upskilling can be achieved through various types of training at different levels (from school to company workers), but the final step to ensure compliance of workers' abilities to deliver quality and appropriate designs can only be verified through qualification schemes. Such qualification of workers and installation companies are key to develop training needs accordingly. Therefore, this option on installers' training is essential, especially in view of an effective upscaling of building stock renovation (as planned by the Renovation Wave).

Qualified installers or workers would also facilitate the access to finance, by providing demonstrated skills and competence to deliver qualitative work, choosing quality products (e.g. complying with EU energy labels). Training, guidelines and best practices sharing would also support accelerating the spread of technical knowledge.

[521] Pantovic, V. S., et al. (2017), Rising Public Awareness of Energy Efficiency of Buildings Enhanced by »Smart« Controls of the In-door Environment, Thermal Science, 20, 4, pp. 1307-1319
Ouhajjoua, N., et al., Stakeholder-Oriented Energy Planning Support in Cities, Proceedings, International Building Physics Conference, IBPC 2015, Torino, Italy, Vol. 78, 2015, pp. 1841-1846

Regarding the EPBD revision, most market players consider that skills under annex IV (6(c)) are not the main problem in the certification/qualification provisions. The main problem remains the failed national transposition of Article 18 of RED II, which should ideally be tackled by the revision. The F-gas certification[522] is a certification scheme which is working well and is properly implemented in the different Member States, and could provide some good basis. This scheme could be used as a good basis. For most of the concerned EU associations consulted in the frame of this study, there is no need to further expand the current provisions in RED II annex IV paragraph 6 (c), regarding skills and additional aspects to be covered in the theoretical and practical part of the training. The description of what should be included in the training for installers is sufficiently comprehensive in the RED II Annex, although upskilling and additional training remains necessary at MS level.

However, RED II annex IV (para 6 (c)) misses shallow geothermal installers, which could read as follows: "The certification schemes or equivalent qualification schemes referred to in Article 14(3) shall take due account of the following guidelines: (c) The theoretical part of the heat pump **and shallow geothermal** installer training … ".

For some market players, another important aspect is to have “multipurpose installers”, that are qualified to install different solutions, from solar thermal, to gas boilers, to micro-CHP, to biomass boilers, heat pumps, etc. These are more relevant for the market than installers specialised in only one solution, but also for the installation companies to add more solutions to their portfolio. Therefore, one aspect that is of paramount importance is the modularity of training/qualification and the flexibility of the training options. There is a need for more installers being able to provide different solutions rather than installers that are specialized in only one technology.

However, this should not necessarily become a priority. Providing advice to the building owner on the most appropriate technology could be tackled by a third party (like an auditor in charge of the Energy Performance Certificate, and/or the Building Renovation Passport, which is then to be addressed under the revision of the EPBD), and it will not be so straightforward to train craftspersons and other workers on additional disciplines than their current area of expertise.

Cost estimate

Based on the experience gained within the Install+RES project (funded by Intelligent Energy Europe[523]), it can be assumed that the implementation of a training course for small-scale renewable energy systems in buildings, including the modules on solar PV, solar thermal, heat pump and biomass systems, should cost, on average, €16,000, comprising several modules[524]. These costs are VAT excluded and do not include any profit for the training providers and the cost for the laboratory equipment. The cost of the laboratory equipment is up to €20,000 per module and should be added to the cost per each module (estimated to be around €4,000 per given course, including consumable costs). The cost of the equipment has to be added only once, if the equipment is not available in the training centre. The cost for replacement of damaged or outdated training equipment must also be considered by the course

[522] To control emissions from fluorinated greenhouse gases (F-gases), including hydrofluorocarbons (HFCs), the European Union has adopted two legislative acts: the F-gas Regulation and the MAC Directive. European Commission. (n.d.). EU legislation to control F-gases. Avaialble at: https://ec.europa.eu/clima/policies/f-gas/legislation_en
[523] Intelligent Energy Europe Project Database. (n.d.). Available at: https://data.europa.eu/data/datasets/intelligent-energy-europe-project-database?locale=en
[524] Each module costs between €4,000 & €8,800 (depending on the country).

provider. The total cost of a training course can be estimated at €20,000 (€16,000 for the implementation & €4,000 for the laboratory cost, including its replacement and update).

Cost of certification should be added. Based on the assumptions below:

Certifying / qualifying (admin costs, on site verification) → ~€500/worker
Partially paid by installers/workers: ~€250-500/worker?
Multiplied by the number of installers/enterprises to be certified

- Between 170,000 & 340,000 installers to train; average: 255,000 (see below)
- Based on RHC figure above, from 98.7 (2018) to 124.4 (2030), an increase of some 26% leading to ~25% more installers in 2030 than today
- Not all installers have to be certified (some already are, and certification is issued per enterprise) → 30% to be certified
- 20,000 € all inclusive average cost of training and certification per installer (depending on the size, several installers per installation company)
  - ⇨ 255 000 (1+25%) * 30% = ~95 000 installers to train & certify

Total estimated cost: €1,900 million.

This cost should be compared to the risk of badly installed RES H&C systems:

- In 2019, EU27 had 195 million households
- Assuming an additional 20% are equipped with RES systems by 2030
- A badly installed HP delivers a Coefficient of Performance (COP) of 2.5, where it should have provided 3 (loss of 0.5, or 20% efficiency loss)
- Energy bill H&C 1,000 €/yr (conservative) increases by 20%, or 200 €/yr
  - ⇨ Total is estimated €7,800 million, i.e. well above the cost of training and certification.

Textbox 0-4 Certification/ qualification schemes

The European Qualifications Framework (Intelligent Energy Europe funded project, 2013, EQF[525]) aims at making qualifications more readable and understandable across countries and systems, which is important to support cross-border mobility of learners and workers and lifelong learning across Europe. There are 8 common European reference levels, described in terms of learning outcomes: knowledge, skills and competences. Detailed information on how to implement training courses based on the European Qualification Framework (EQF) is available in the report "How to integrate the Install+RES training courses in the European Qualification Framework (EQF)" available for downloading for free from the Install+RES website http://www.resinstaller.eu/

The European classification of Skills, Competences, Qualifications and Occupations (ESCO[526]) is meant to be a reference language for employment and education, to create a shared understanding about skills, learning and occupations across borders and languages. It helps to connect people with jobs, education with employment and to analyse information on skills demand.[527]

[525] European Centre for the Development of Vocational Training (2018), European qualifications framework (EQF). https://www.cedefop.europa.eu/en/events-and-projects/projects/european-qualifications-framework-eqf
[526] The European classification of Skills, Competences, Qualifications and Occupations (2020). ESCO available at https://ec.europa.eu/esco/portal/howtouse/bfe2a816-f9dd-49df-a7d2-ec8fafcfce95
[527] ESCO (2020), example of a geothermal power plant operator skills and competences. https://ec.europa.eu/esco/portal/occupation?uri=http://data.europa.eu/esco/occupation/c3959398-a5d7-4b26-

Investor certainty

Often, replacement of heating and cooling equipment is a result of an emergency (e.g. boiler breakdown), which means a lack of knowledge and information on the part of the installer and consequently the investor strongly relying on the advice of its installer when having to make a swift decision on how to replace a broken installation could result in technology lock-in[528] and significant associated costs. Thus, enhancing the skills and knowledge of installers and therefore removing a possible inclination towards the well-known (fossil based) solutions should increase the extent to which actual substitution opportunities are recognised and taken. Hence, a possible decision-bias towards fossil-based solutions would be reduced and the competitive position of RES compared to fossil-based solutions improved, by significantly increasing investor confidence, and hence certainty. Ensuring installers, but also architects and designers, are able to compare several technologies and recommend the most appropriate is essential and should be one of the main objectives of the revision of article 18. The impact is positive on increasing RES H&C investors certainty, especially for small-scale consumers (households, especially low income) not having the knowledge and capacity to make the appropriate choice or to control the quality of their installation.

Regarding the certainty for installers, to invest in training and certification, the driver would be at two levels. Firstly, it would provide frontrunners a serious commercial advantage compared to non-certified/qualified installers, but only if the appropriate communication is delivered to the concerned investors (including notably households). Secondly, in case the whole market (all installers) is certified, the increase in investor (household) confidence would pull the entire market and support the deployment of RES H&C systems, while requiring less commercial efforts (spending hours to convince the customer about the reliability and economic viability of the H&C RES system).

Therefore, the option globally has an important positive impact on all investors' certainty as well as on installers' certainty.

Macroeconomic impacts

The EU's RES sector employed around 1.4 million Full Time Equivalents (FTEs) considering direct and indirect employment with a turnover of approximately EUR 154.7 billion, in 2017.[529] A rough estimate indicates that nearly half of these jobs (45%, 650,800 FTEs) are attributed to the H&C industry. Increasing the share of renewable energy sources used in heating and cooling would have a positive impact on the EU economy and simultaneously on its citizens and environment.

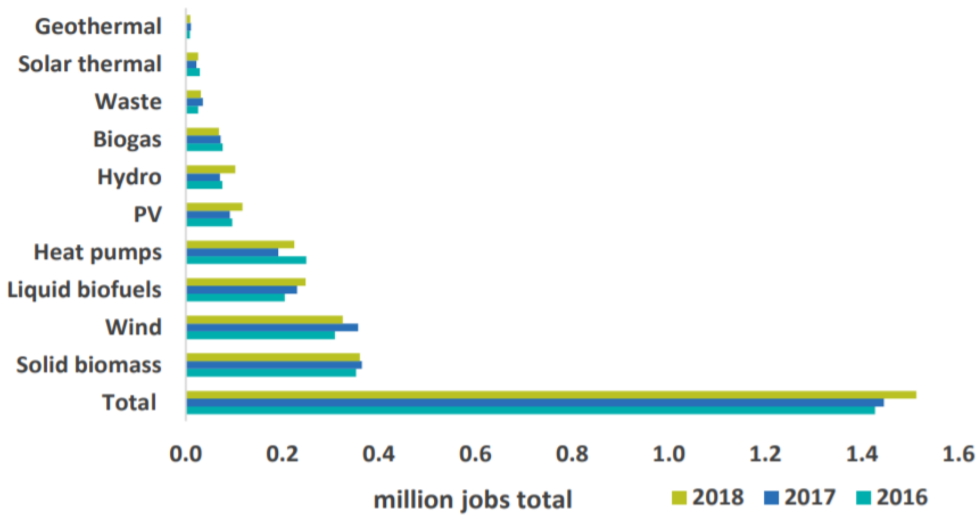
The number of jobs in the EU-28 is illustrated for 2016-2018 in Figure 0-8.

abcf-ef7af87e5822&conceptLanguage=en&full=true#&uri=http://data.europa.eu/esco/occupation/c3959398-a5d7-4b26-abcf-ef7af87e5822

[528] Davis, S. J. et al. (2016). Carbon Lock-In: Types, Causes, and Policy Implications.

[529] European Commission. (2019). Completeness of the heating and cooling industry and services.

Figure 0-8 Employment in the renewable energy industry by sector, EU-28, 2016-2018. JRC (2020) [530]



The estimation of around 650,000 jobs in the renewable heating and cooling related industries in 2017 is based on the following technologies: solid biomass (partially), heat pumps, biogas (partially), solar thermal and geothermal. These jobs are concerning the whole value chain (manufacturing, installation, O&M, decommissioning). Only installation and, to a limited extent, O&M are concerned by training and certification.

The labour intensity of renewable energy is generally higher in all stages of the value chain than that of conventional energy industries. This is not likely to change, as the renewable sector may be less affected by automation, especially in installation, and operation and maintenance work tends to take place in confined, harder to access places (maintenance technicians working in the nacelle of wind turbines, PV panel installers on rooftops, etc.). And these are the jobs requiring training and certification. We could therefore conclude that between 25% and 50% of the current employment are concerned by training and certification, or between 170,000 and 340,000 jobs.[531]

A large part of these jobs is coming from small and medium-sized enterprises, and there will be an increase of economic activity related to deploying training centres and trainers, and using state-of-the art material, certainly in collaboration with manufacturers. Installers are usually local workers, and difficult to delocalise, therefore also increasing the global resilience of the economic activity related to certification/qualification.

Security of supply

More reliable heating and cooling systems will undoubtedly increase security of supply, assuming the deployment of renewable energies for heating and cooling already increases our EU dependency (as developed under option D1 above). However, the import of bioenergy is increasing and could significantly hamper the security of supply.

[530] Czako, V. (2020). Employment in the Energy Sector. JRC Science for Policy Report. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC120302/employment_energy_status_report_2020.pdf

[531] Build Up, the European Portal for Energy Efficiency in Buildings. Available at: https://www.buildup.eu/en/skills

Innovation

Skills are part of the areas requiring improvements, and possibly further RD&I. Increasing the qualification and training of installers would create more experience and sharing of practice that would also benefit the manufacturers, and further RD&I of equipment.

Distributional impacts

More certification would improve the global quality for all consumers, while the risk of low quality would mainly pertain to consumers with less capacity to deal with contractual and verification issues. Therefore, increasing the qualification of installers has a positive general impact on improving the quality.

Affected parties

Consumers (building occupiers, being owners or tenants) would be positively affected, taking advantage of improved skills & quality. However, this could slightly increase upfront costs, for renewable technologies that are already, in most cases, less competitive than fossil-based technologies. Upfront cost remains a barrier, especially in the case of renovation when investors already have to support other material, equipment and installation costs. Therefore, consumers would be slightly positively affected.

Landlords (lending their buildings to tenants) would mainly support the little over cost on the short term and see their building's quality improving in the longer term (increasing the residual value), and therefore not be affected. Energy suppliers and infrastructure operators would not be affected, and would get the opportunity to be voluntarily supporting RES integration in their portfolio, moving from commodity supply to more service, raising awareness and ensuring ambitious communication.

GHG emission reductions and other environmental impacts

Half of the energy consumed in Europe is used for heating and cooling, and 75% of this energy is still coming from fossil fuels. Additionally, much of this energy is wasted due to inefficiencies in the heating and cooling systems. State-of-the-art, sustainable renewable heating and cooling systems offer a unique opportunity to make significant contributions to decarbonising the EU building stock through the efficient supply of heat and cold from renewable energy sources.[532]

The proxy used to measure the potential environmental impact is directly linked to the fossil fuels (heating oil, natural gas, even coal) the renewable fuels (individually or through DHC) would replace.

Better quality would globally improve the efficiency, consume less resources, and lower the emissions of GHGs and any other air pollutants (especially in the case of bioenergies). Quality installations are particularly needed within the heating and cooling sector, especially in the case of heat pumps, the efficiency of which remains sensitive to the quality of the works. Therefore, more qualification will have a positive impact on GHG emissions, and on the environment in general (notably regarding bioenergy-bases appliances).

[532] EU Smart Cities Information System. (2020). District Heating and Cooling booklet. Available at: https://www.euroheat.org/wp-content/uploads/2020/03/scis_solution_booklet_district_heating_and_cooling.pdf

A potential environmental impact related to the rapid deployment of all renewables in buildings is biomass deployment, as this is probably one of the most competitive options without any incentive scheme and could possibly take the lead in the deployment of the various renewable technologies in buildings. Depending on the heating system used, biomass may have potential adverse impacts, such as on air quality. Further negative impacts from biomass on biodiversity are possible if biomass production is not done according to sustainability criteria. According to art. 29, only installations above 20 MW for biomass (and 2 MW for biogas) are required to comply with sustainability criteria. If skill building targets household/small-scale installers, this could lead to an increase in the share of biomass used in installations not subjected to the criteria. The option should therefore carefully liaise with biomass sustainability provisions, expanding the scope to small-scale systems, imposing to bioenergy suppliers to comply with sustainability criteria.

Customers' empowerment

Awareness among small-scale consumers (especially citizens) is currently very limited about alternative RES systems in buildings. Consumers are lacking transparent and comparable data and energy performance indicators of H&C systems and competitive low-carbon alternatives. Therefore, they have limited capacities to orient installers, architects, or even heat suppliers to improve energy performance and switch to renewables. Professionals, such as installers, builders, and architects are not always aware and informed enough to make informed choices on best performing, most suitable and most competitive solutions, which is again highlighting the need to increase skills across the chain.

This option would positively affect the level of education and training outcomes, increase awareness at the level of decision makers, planners, and local authorities, to support leveraging local existing potentials. It would influence the uptake of renewable and would increase the level of education and training outcomes, and the number of jobs (e.g. installers, suppliers, manufacturers).

Subsidiarity

As can be seen on the RES EU installer certification web site[533], MSs do not have the same approach to comply with article 18(3) of RED II. Some MSs have a complete training and certification scheme in place, while others are referring to the common certification of electricians, or to a list of installers. In order to increase the level to ensure high quality of installations in order to take full advantage and efficiency of all small-scale systems across Europe, strengthening of the provisions would be helpful.

Based on the assessment of the existing situation, action at national level would apparently not be sufficient to achieve consistency of training and certification, and to ensure quality and long-term efficiency of renewable systems in buildings across EU. By reason of the effects of additional requirements for installer certification/qualification, an amendment to the existing framework would have an added value, compared to the actions taken by MSs.

The design of the national certification/qualification schemes depends on many national/local parameters, therefore additional requirements to the existing RED II provisions from the EU would probably be counterproductive, although the EU could support the sharing of best practices, and possibly provide some guidance if still required as the RES-EU installer certification database contains the following information for each country listed:

[533] A list of national schemes is available at: https://reseu.eu/schemes

- Contact details for national/regional certification bodies;
- Detailed information on the technologies covered under each scheme, whether the scheme is mandatory or voluntary for each technology and what level of education is required;
- Competencies covered by training;
- Training costs, duration and content;
- Details of any processes established to recognise qualifications issued in another Member State (referred to as "mutual recognition");
- Details of any legislation associated with the certifications/qualification;
- Non-compliance penalties and customer insurances.

The subsidiarity is ensured through the freedom left to each Member State to amend their own certification/qualification scheme. There will be no EU-wide scheme: each MS will have the possibility to (re)design its own scheme where required.

Formal cross-border cooperation programmes are scarce, and it is typically the manufacturers and their distributors who are most active in this field. Hence training tends to be product-specific, rather than focusing on generic good practices. Furthermore, training across the EU is not provided at a uniformly high standard.

According to some market players (EU associations), the issue of the mutual recognition is a very complex one. On one side, there is a need to ensure mobility of professionals in a common market, though the actual mobility of installers is relatively limited. On the other hand, the complexity to address harmonisation is huge. The real urgency, is having the national needs properly covered, ensuring that there are sufficient numbers of qualified installers, also to face the increasing demand, given the expected uptake of renewable-fuelled systems installation. For others, training should be more standardised across the EU, building on the experience of those countries having good training facilities, courses and overall training provision (e.g. Austria, Czechia and Italy, for biomass-based systems) so this should be further developed and harmonised at European level.

Textbox 0-5 Case of France

The number of RES heating installers in France stands today at around 20 000 certified installers, which seems to be in line with installation needs at this stage. This is mainly due to the obligation for installing companies to get a certification in order to obtain public incentives. However, at French like at European level, the number of RES heating installations will increase in the coming years, and this will translate into a need for more certified installers.

Training is a scheme imposed by the public authority with one theoretical part, one practical part, and a final exam to certify the skills. The content covered in these trainings depends on the technology used (heat pumps, solar thermal, etc.). Annex I of the decree "définissant les cahiers des charges des formations relatives à l'efficacité énergétique et à l'installation d'équipements de production d'énergie utilisant une source d'énergie renouvelable", details the architecture and content of the training.

There could be a kind of mutual recognition based on a bottom-up approach with an EU minimum standard such as EQF (see textbox), streamlining quality in the EU. Certification schemes such as Qualisol in France are interesting as they also have the possibility of checking the work of the installers and, doing that, identify the main gaps in the market in terms of training. The share of best practices is key.

Textbox 0-6 Experience of Italy on how training & certification is implemented in different Member States

Training and certification scheme - Italy

Background

EU Directive 2009/28/CE | application in Italy.

The EU Directive has been introduced in the Italian law framework in 2011. The law decree n.28 states that, from August 2013, installers and maintenance workers of biomass boilers, fireplaces and stoves, solar systems in buildings, geothermal systems and heat pumps, must get a specific certification (FER) in order to perform the above-mentioned activities. At that time, it was decided that all the companies with ATECO code related to activity in scope and a technical manager owning the relevant professional knowledge codes, have been qualified to perform the above mentioned activities. From August 2013 onward, the FER certification can only be obtained (this is valid for new companies or existing companies that have decided to expand their business by adding the ATECO code related to the activities in subject) by enrolling the technical manager to the FER qualification training.

FER training course | deployment and contents.

The responsibility for handicraft and vocational education lies with each Italian region that has defined the selection criteria for private companies that would like to perform the two kinds of trainings foreseen:

1/ FER qualification training | 80 hours | 800 euro + VAT (once in a life);

2/ FER update training | 16 hours | 200 euro + VAT (mandatory every 3 years to all the technical managers).

What went well, what could improve and how?

The training system has been implemented, and, according to some concerned stakeholders, it appears to be operational. What has to be improved is the controls system. In case a company does not have a FER qualified technical manager, it has to (only) pay a fine and start the qualification process. Considering that:

1. on average, an HVAC installation company consists of 4 people;
2. private end users believe that installers state that they can install something, they are qualified.

There are some voluntary initiatives aimed at promoting companies that have this FER qualification. One among many is this website **https://registroinstallatorifer.it/**

Is training and certification linked to support or subsidies?

There is no link with subsidies or support, companies have to comply independently, for all installations, mainly because:

1. Subsidies will not last forever. When they will be over, installers should realize that there are still good reasons to follow trainings;
2. Training capacity cannot match with the duration of the incentive, resulting in having companies rushing to get the certification.

Why are manufacturers setting up specific trainings?

Mainly to strengthen commercial relationships with their customers. Installers prefer to install as much as possible the same product of the same brand. It is a matter of confidence and efficiency. Better product knowledge is resulting in faster installation. Saving time results in saving money and higher margin for them.

Do they also deliver a certificate at the end of the training?

Yes, but it has no official value. Some brands have a qualification program for “certified installers” and they advertise members towards end users. Usually, installers included in these schemes have to attend some technical training in order to keep this membership up.

Can these trainings become part of certification/qualification schemes?
No;

What are the costs for the company and for the installer participating?
Difficult to answer. Some companies are giving these trainings free of charge. Others are asking for a few hundred euro.

How can it be ensured that installers/professionals are able to recommend the right technical option for a specific situation, having the expertise to address the technical constraints and the economic calculation?
The Italian scheme is balanced, with mandatory trainings providing theoretical basics and competence on the most common technical solution, and manufacturer training offering the opportunity to become a specialist on some specific products and learn how to explain to end users benefits that can be enjoined by installing them.

Conclusion
Requiring all RES heating installers to be certified takes time to deploy, but it seems it is working well in Italy. One should pay attention as it could potentially slow down the deployment of RES systems, as it requires time to have the appropriate training & certification in place.

Textbox 0-6 on the Italian case illustrates how a mandatory national certification schemes works well. The following textbox illustrates how, on the inverse, the absence of certification can provide positive results nonetheless.

Textbox 0-7 Finland case for Heat Pump

Finland has, in compliance with article 18 of RED II, set up an H&C system installers certification scheme which is not used by installers, due to the lack of demand, although installers are trained. The following depicts the Finish global context and experience.

In Finland, the carbon pricing for all energy sources (in addition to the EU ETS) is driving the entire climate policy, meaning there is no need for additional support to have low carbon options (such as Heat Pump) being competitive. Also, electricity is not expensive (low carbon content based on 43% renewables, 28% nuclear and 18% imports), there is limited gas network across the country, and high standards in building technology. Hence, it has been possible to create a million Heat Pumps market (over 1 million heat pump systems installed for 5,5 million inhabitants), in households across the country since more than 20 years, practically without subsidies. In new small houses, 75% heat pumps penetration has been reached, and the main renovation market has also a good speed.

Traditional market players (manufacturers, installers) had to change their old business models. Behaviours had to adapt, and did succeed (and still do so) thanks to appropriate education & sensitisation systems, rules and norms. Communication and information diffusion was needed to increase awareness and create the favourable market conditions. The purchase & installation of RHC systems with a required level of quality & performance, has been faster than in other member states relying on support schemes, and other accompanying measures.

The market deployment went progressively, with a good level of quality, bringing final clients satisfaction, as main driver to avoid losing market share. Delivering bad quality, in the long-term, leads to losing market share due to bad reputation. However, the successful EUCERT heat pump installer certification system was essential when the market was still at its infancy stage. Around 400 installers did follow the EUCERT trainings and passed the exam, but only about 100 were certified, showing the limited interest and valuation of the certification, while training was considered to be important.

During the last years, there were almost no EUCERT certification trainings. Instead, other heat pump trainings were provided, even in training institutes, although most of the trainings are provided by manufacturers and importers. The Finish heat pump association currently works at finding ways for more heat pump education and training at all education levels, where there is still a lack of integration.

There is currently no scientific evidence to demonstrate that a good level of quality and performance of heat pump installations is achieved in Finland. There are currently no studies on operational data assessing the Seasonal Coefficient of Performance (SCOPs). However, after 2 decades of regular deployment, end-consumer confidence has been built, reaching comfort and consumers expectations, which are continuously requiring competitive solutions.

As illustrated by the different cases, the main issue is the transposition into national contexts to deliver on article 18, much more than describing the required modules for training (in annex IV). This could be inspired by the three national cases:

- Set up a certification scheme, and let the market decide to take it up, like in **Finland**. Without incentives (no need in Nordic countries, as the main driver of the climate policy is the carbon pricing, inducing a level playing field for RES-techs), there is no interest for such certification (workers do not like to lose working days for training). However, the main issue of quality does not seem to be important;

- Making certification mandatory when there is an incentive scheme (fiscal advantage, support, subsidy, ….), like in **France**. This is successful as long as there is an incentive, with the expectation that the level of expertise and skills would be sufficient when the incentive would disappear. Still hard to find evidence on this subject;
- Requiring all RES heating installers to be certified (such as the F-gas regulation), like in **Italy**. This takes time to deploy, but it seems it is working well in Italy. One should pay attention as it could potentially slow down the deployment of RES systems (as it requires time to have the appropriate training & certification in place).

Coherence

Updating certification/qualification requirements of renewable installers should complement other instruments such as:

- Based on article 10(6.a) of EPBD (on financial incentives and market barriers), MSs should link their financial measures for energy efficiency works to be carried out by installers with the relevant level of certification or qualification. However, this criterion is not binding, and only concerns energy efficiency measures. It should become a binding criterion, and be expanded to renewable systems, including heating and cooling appliances;
- With article 16 EED, certification and/or accreditation schemes and/or equivalent qualification schemes for energy-related building elements should only be ensured by Member States if they consider that the national level of technical competence, objectivity and reliability is insufficient. Therefore, these certification and/or accreditation schemes are not compulsory according to the EED. This should also be addressed to encompass all technologies and applications;
- Based on article 17 of EPBD, MSs have to ensure that the inspections of heating systems are carried out in an independent manner by qualified and/or accredited experts. Such inspections could be automatically planned and mainstreamed to the certification/qualification process;
- the revision of the LTRS (article 2.a of EPBD) could address the level of training expected for a large deployment of renewable-based systems;
- heating and cooling decarbonisation planning (cf. Annex D -Heating and Cooling): installers need to update and deepen their knowledge regularly and learn how to work with integrated planning using the most up-to-date solutions. Training should ensure the proper installation of RHC systems, to maximise their efficiency and reduce pollutant emissions (in the case of biomass systems);
- Other relevant areas may be (among others): the exchange of best practices on the follow up maintenance; sensitisation about the impact of wrong installations on air quality (in the case of biomass); level of emissions from different systems (in the case of biomass).

Linking the certification/qualification to providing a support to an H&C renewable installation seems to be essential, as it would influence the quality of installations that are partially paid by public funds. Such requirement to the domestic renewable H&C system to be certified and installed by a certified/qualified installer already exists, as illustrated in the box below.

Textbox 0-8 RHI in UK

Renewable Heat Incentive in UK[534]

Initiated in 2011 and designed to incentivise the uptake of renewable heating alternatives, the Renewable Heat Incentive – the RHI – provides financial payments to homes and businesses swapping to renewable heating.

The Renewable Heat Incentive is available for both domestic and commercial renewable heating applications. The UK government introduced the RHI scheme as part of the wider goal to reduce overall carbon emissions. How much a specific home or business could earn through the Renewable Heat Incentive varies. Payments are calculated against an Energy Performance Certificate (EPC). Payments can be subject to heat demand capping.

To make an application, the following criteria must be met:

A Microgeneration Certification Scheme or MCS-approved system installed by an MCS-approved installer and the relevant MCS commissioning certificate;

An EPC not older than 24 months with no loft insulation or cavity wall recommendations;

Relevant electricity and/or heat metering in place on the system.

Microgeneration Certification Scheme[535]

MCS refers to the Microgeneration Certification Scheme. It is a requirement of the Domestic RHI scheme that all heating systems are certified by MCS. MCS is an internationally recognised quality assurance scheme supported by the Department for Business, Energy & Industrial Strategy (BEIS), formerly known as the Department of Energy and Climate Change (DECC). MCS certifies both products and installation companies to help ensure that Microgeneration products are installed to a high standard.

Links with support schemes

This option would have a positive impact on skills and jobs, as it would support an increase of the economic activity in RES-related sectors. However, special attention should be given to building the required skills at the same time as any support framework is set up.[536] Therefore, if the option creates a boost for RES building technologies, qualification should become a prerequisite.

Upskilling towards energy efficiency

Through the BUILD UP Skills initiative[537], for almost a decade, the EU aims to equip the construction sector workers – from manual labourers to design professionals and senior management – with the skills and knowledge needed to ensure building and renovation projects to meet stringent energy efficiency requirements. The initiative also covers building renewables-related installation. Upskilling towards energy efficiency and sustainable energy should be done throughout the entire value chain of the

[534] The Renewable Heat Incentive (RHI) – subsidy for renewable heating systems. Available at: https://www.greengenuk.com/renewable-incentive/renewable-heat-incentive-rhi/

[535] The Microgeneration Certifications (MCS) scheme. Available at https://www.ofgem.gov.uk/key-term-explained/microgeneration-certification-scheme-mcs

[536] E.g. past experience demonstrated failures with the deployment of small-scale PV with support schemes suddenly accelerating the attractiveness of these systems. Given the pace of deployment, the authorities in charge of training and delivering certification/qualification did not always manage to manage the quality of the installations, by setting up the required training and qualification, and the market to pull. A few installers did install low quality systems, due to a lack of knowledge on both installation practices and product quality. In some cases, qualification schemes arrived too late in the process. The risk is high when the pace has to accelerate quickly, which could be the case if the renovation rate moves from 1.2% to 3&/year.

[537] This initiative aims at increasing the number of qualified trade professionals by developing national qualification platforms and roadmaps, and providing training in the field of energy efficiency and renewable energy in buildings. Build Up. (n.d.) About BUILD UP Skills. Available at: https://www.buildup.eu/en/skills/about-build-skills

buildings sector (including designers, architects, engineers, building managers and operators, technicians, installers and workers). All of these professions across the chain also need to be aware of new and upcoming challenges relating to Nearly Zero-Energy Buildings and an increased integration of renewables in the built environment.[538]

In 2018, partners of the BUILD UP Skills initiative, with the EU-funded ingREeS project have developed training programmes on energy efficiency and using renewable energy in buildings specifically for middle and senior level construction professionals. According to the feedback received from the participants of some trainings, over 60% of the information they learned was completely new, while the rest of the information provided a deeper understanding of concepts they were already familiar with. This shows the importance of continuing to build construction skills, across the entire value chain.

Accelerating the building renovation

These needs for improved skills will sharply increase with the/yr as expected by the Renovation Wave (including renewable integration in buildings). This means that the current level of skilled installers and workers will very shortly need to triple.

Administrative burden

For installers, the administrative burden comes from the process of certification, and therefore the additional communication to customers (that should be part of their marketing), and the immobilisation of workers during training and certification procedures. These are upfront costs, but rapidly recovered by advantageous commercial positioning. There are administrative costs associated with the management of the whole training and certification system, following up, monitoring and verifying the quality of installations. Therefore, this option has slight negative effect on administrative burden.

Textbox 0-9 Examples of national certification schemes

Example of a national certification scheme (https://reseu.eu/schemes/belgium) The scheme, set up under the European Guideline (2009/28/EG), was launched in 2014 and has been harmonised across the three Belgium regions of Flanders, Wallonia and Brussels. After completing formal training and successfully passing an exam at the end of their training, installers can apply to the Renewable Energy Systems Certification Organisation (RESCERT) in Belgium for their certification. In addition to the training, installers are required to have 3 years of professional and 3 years of job specific experience, which RESCERT verifies, before awarding the certification. The certification is valid for 5 years. After this period it can be extended, provided the installers undergo further training. A request for an installer certification costs 250 EUR for (in Wallonia).[539]

- ***Option 4: obligation on technology providers to train and assist certification of one installer/x units of appliances sold on the market***

This option is close to option 3 and therefore all arguments and evidence of the assessment under option 3 can be replicated. To make it easier to read, under option 4 we address only the specificities when obliging manufacturer to train and support the certification.

[538] As developed in the 2018 publication New skills for the construction sector to achieve European energy targets, in the frame of the BUILD UP Skills initiative. Available at: https://op.europa.eu/en/publication-detail/-/publication/11ec9f62-6222-11e8-ab9c-01aa75ed71a1/language-en/format-PDF/source-71672294

[539] RESCERT, the Renewable Energy Systems Certification in Belgium. (n.d.). Available at https://rescert.be/fr

Effectiveness

Cost estimate

With 195 million households and an additional 20% equipped with RES over 10 years, each year about 3.9 million RES appliances would be installed in the EU.

With the target of one certified installer per ~300 appliances installed, the EU would require 13,000 certified installers (which would represent 5% of the 255 000 installers, as determined under option 3).

With a training and certification cost representing about €20 000 €, this would represent a total cost of €260 million to be supported by the manufacturers or the investors.

Each installed appliance would see a cost increase of about €66 (€20,000/ ~300 units). However, the installers do not need training or certification every year. Update training every 5 years seems sufficient. Therefore, the cost increase per installed appliance would be about €13.3. At the same time, compare the option 3 analysis, the yearly savings could be estimated to be around €200, meaning that if the cost of training/certification is passed to the final consumer, the simple pay back would be around one month.

Investor certainty

Involving the manufacturers in delivering training is already a well-established practice[540], and takes advantage of state of the art knowledge and equipment. The training would be driven by efficiency and high quality, with the aim of optimising the installed systems' operation (manufacturers have a great interest to ensure appropriate installations, for their image). This would benefit all stakeholders: the installers which would acquire the best knowledge, the consumer willing to get a well-functioning system, the authorities to increase the global quality at low cost (from public money).
However, the aim of training and certification is also to ensure that installers are able to compare different renewables-based technologies, and to provide appropriate advice according to the available information to their customers (especially regarding the building performance, but also about local market opportunities such as wood pellets or biomethane, etc.). Therefore, some additional general training and coordination efforts will be required from the authorities in charge of setting up training courses and certification processes.

The capacity of the installer to provide ad hoc advice to customers is crucial, even if this implies additional costs for all parties (installers with longer training sessions, manufacturers having to adapt their course, authorities for the additional coordination).

Affected parties

This option would support dissemination, and guidance to identify/address regulatory barriers (e.g. taxes), enforcing the qualification of building professionals, and therefore support national, regional and local policy makers. It would reinforce monitoring and close follow-up, and support the uptake of renewables at cost optimum.

[540] Usually, manufacturers have their own training centers, and own certification, such as
https://www.viessmann.co.uk/professionals/installers,
https://www.buderus.com/be/fr/clients-professionnels/centre-d-information/

Other building professionals than installers (incl. architects and designers, building operators) could be indirectly affected, if they are appropriately involved in setting up the required framework building on the skills of installers, to ensure ad-hoc support to integrate RES, awareness, guidance, and training. The soft character allows for a smooth integration in the entire building performance dynamic, and will reduce the administrative workload of building installers, and possibly other professionals (for the design of a renovation, or filling in a building passport).

The option would slightly improve the mind set to all professions across the supply chain, managing the diversity of technologies and concepts, and the need to improve quickly their skills and knowledge, and adapting their business cases. There is, however, a high risk of concentration of skills, leading to installers specialised in the installation of specific systems, without the knowledge of other solutions. This could be tackled via the design of the certification / qualification regime.

Subsidiarity

This option would ensure the presence and commitment of the concerned manufacturers on all EU27 markets, providing the same level of training to reach the same level of skills and competences.

Coherence

This option could possibly push the market to the most efficient renewable systems, and therefore accelerate the uptake of Ecodesign appliances. The manufacturers would be incentivised to increase the level and push forward their efficient systems, to directly convince the installers to use their systems.

There is a huge risk installers would be specialised in some products, without the knowledge of other systems and even technologies, leading to potentially inadequate technology deployment.

Administrative burden

This option would require additional coordination efforts, compared to option 3, to organise the training with different manufacturers, while ensuring that the certification also covers all technologies and the capacity to advise the consumer on the most appropriate option for their situation.

Imposing on the manufacturers to train a specific number of installers requires defining the metric upfront, determining the scope, the products and brands concerned, the minimum market size to apply the obligation, and defining the responsibility/obligations of the concerned manufacturers. And during the operation of the scheme, a strict follow-up would be required, possibly with penalties in case the manufacturers are not complying with their obligations. This would seriously overburden the administrative load, compared to option 3.

Administrative burden would also be increased for the manufacturers, to manage the training sessions. Obliging manufacturers would be counterproductive, giving the feeling of easy to implement schemes, but with important efforts of coordination to overcome many obstacles. In markets with progressive uptake of RHC, manufacturers are naturally willing to train, in order to ensure high quality and product reputation (obligation would become counterproductive). Therefore, recommending MSs to consider creating synergies between the private (e.g. manufacturers) and public (e.g. training centres) sectors would be an alternative, and benefit from all complementarities between the industry (state-of-the art technologies) & public frameworks (more general aspects not related to specific products).

Synthesis

In this section we synthesize the findings from the analysis of the different options to accelerate renewable share in buildings. The headline findings from the analysis of each option are brought together under the three headlines of economic, social and environmental impacts.

Table 0-3 Impacts considered

Economic	Environmental	Social
Administrative costs	GHG emissions	Distributional effect
Costs to economic operators	Air quality	Political feasibility
Investor certainty	Biodiversity	
Energy security and innovation		

Options to accelerate renewable share in buildings

Four options were evaluated to accelerate the share of renewable energy in buildings, namely:

- Option 1 concerns non-regulatory measures such as Guidance on best practices related to the application of Article 15(4)-(6), on information to be given under Article 18(2), (4) and (5), and on requirements for installers etc. under Article 18(3);
- Option 2 aims to establish a RES target for national building stock (a general numerical level of minimum RES use in national building stocks);
- Option 3 aims to update qualification and certification requirements for installers of heating and cooling systems;
- Option 4 aims to oblige technology providers to train and assist certification of one installer/~300 marketed appliances to ensure sufficient availability of qualified professionals.

Economic impacts

EU guidance & best practices (**option 1**) sharing would provide technical, economical, but also institutional support, and would therefore ease the process of implementation, reducing the costs for national authorities responsible for the implantation of the provisions, and certainly accelerate the process at regional and local levels, and among economic actors. The variation among countries shows the importance of having national integrated approaches specific to each MS, given each MS has its own context, resource availability, infrastructure, weather condition and baseline. This calls for more guidance to accelerate the uptake of renewable in buildings.

As a market instrument, a fit for purpose ETD (or possibly extension of the EU ETS to the buildings sector) would result intrinsically in cost-optimal emission reductions if there is long term stability and visibility, as it is already the case in some countries with high carbon pricing such as the Nordic countries. An indicative target (**option 2**) would provide an additional direction and possibly incentive to concretely mainstream renewable energy in the built environment, by finding the most cost-effective way to decarbonise the building stock.

In buildings, without specific measures to increase renewables' competitiveness, the risk remains high that renewable shares would not increase in space heating and cooling, or in on-site electricity generation. The two options would then be to either increase carbon pricing significantly, or to enforce the uptake of renewables via specific instruments in RED II.

Such target, even indicative, would raise the issue of Member State freedom to determine the best approach to deploy renewables in all sectors (electricity, transport, heating & cooling in industry and buildings, etc.), considering their national and local influencing factors and at the same time targeting a complete decarbonisation of the building sector by 2050. Establishing the level of the national target would require to agree on the criteria to be used for the calculation methodology, and at least integrate a cost-optimum based on national GDP as well as climatic factors and other national differences. As the target would remain indicative, a very simplistic methodology would lead to the most cost-effective approach.

However, a simple calculation method may miss the broad set of factors that influence the real cost of deploying renewables in buildings, although a methodology based on cost-effectiveness and the GDP would remain the most simple and undisputable approach.

The building RES target would need to be mainstreamed in the more holistic approach of building decarbonisation, to ensure a coherent and integrated building concept leading to effective carbon emissions savings.

An indicative target would also possibly support the deployment of renewable biomethane by increasing the demand side via the purchase of tradable certificates (or GOs), and therefore pulling the production side. Clear rules should be set up at national level regarding the sustainable production and adequate use of biomethane depending on the demand profile, before allowing it to cover building energy use. The same logic applies to hydrogen-based gases and liquids.

An indicative target for the building sector would provide a signal of the direction to take, in line with an overall binding GHG emissions goal, although a binding target would be stronger and provide more confidence to investors and economic actors.

The impact on the security of supply, on employment (installers and other building professionals), and the macro-economic impacts will depend directly on the uptake of renewables in the building sector. An indicative RES target for the national building stock and the resulting secured RES deployment in buildings is relevant for innovation, as those targets would create and enlarge market opportunities for all renewable applications and technologies, and the enabling technologies such as those providing flexibility to the energy system.

An indicative target would positively affect the countries with high renewable potentials (sun for PV or heat, bio-energies, wind or other renewable-based electricity generation, geothermal heat), and possibly lead to require higher building performance in those countries with less potential. Increasing renewable energy import by those countries with less renewable potential, may also become a final option, therefore negatively affecting their trade balance on the long run. The target would positively affect the resilience of the energy system, certainly increasing energy independence.
Without an appropriate framework, a building landlord would have no incentive to invest in any new heating system (e.g. from fossil fuel to renewable fuel), while the savings would benefit the tenant. This split incentive is still considered as an important barrier, and should be considered in the entire renovation of the building stock. An indicative target would have a very limited impact on solving this problem.

Globally, a RES target for national building stocks would probably accelerate the deployment of adapted instruments (e.g. training installers, support, standards, building codes,…). It would also imply a new mind set for all professions across the supply chain, managing the diversity of technologies and concepts, and the need to improve quickly their skills and knowledge, and adapting their business cases. It would indirectly oblige MSs to address all non-economic barriers hampering the deployment of renewable technologies in their building, to reduce the risks and related costs of capital, and increase the mass market effects when deploying certain technologies such as heat pumps.

An additional administrative cost for MSs would come from the central authority to manage and follow up achievements to reach such indicative target.

Finally, given the many missing elements in most of the NECPs, defining the level of the target would require MSs to further study the penetration of renewables in the building sector before being able to even discuss the calculation methodology, including the interlinkages with all the sectors, based on the assessment of the RES-H&C and RES-E potentials in buildings, integrating the most relevant of these factors. Therefore, this option could have an important negative impact, counter-balanced by the fact that, as it is an indicative target, a less hard-binding methodology can be used.

To conclude, setting up an indicative RES target for national building stocks, to contribute to the new ambition of the CTP, would give the MSs a clear direction on the way forward, and the actions to take to decarbonise their building stock.

Even though most of the building renewable technologies are mature, there is a lack of competent professionals with the required skills, leading to limited consumer confidence, and hampering efficient systems to be installed. Therefore, installers' training is essential (**option 3**), especially in view of an effective upscaling of building stock renovation (as planned by the Renovation Wave).
The cost of setting up training course is well below the cost savings expected thanks to increased quality and better energy performance of RHC installations.

Globally, updating qualification and certification requirements for installers of heating and cooling systems has an important positive impact on all investors' certainty as well as on installers' certainty. The option would have a positive impact on the employment.

Skills are part of the areas requiring improvements, and possibly further RD&I. Increasing the qualification and training of installers would create more experience and sharing of practice that would also benefit the manufacturers, and further RD&I of equipment.

Finally, this option has a slight negative effect on administrative burden.

The obligation to technology providers to train and assist certification of one installer ~300 marketed appliances (**option 4**) is close to option 3 and therefore all arguments and evidences of the assessment under option 3 can be replicated. In addition, option 4 could possibly push the market to the most efficient renewable systems. The manufacturers would be incentivised to increase the level and push forward their efficient systems, to directly convince the installers to use their products. There is a huge

risk installers would be specialised in some products, without the knowledge of other systems and even technologies, leading to potentially inadequate technology deployment.
Imposing on the manufacturers to train a specific number of installers requires defining the metric upfront, determining the scope, the products and brands concerned, the minimum market size to apply the obligation, and defining the responsibility/obligations of the concerned manufacturers. And during the operation of the scheme, a strict follow-up would be required, possibly with penalties in case the manufacturers are not complying with their obligations. This would seriously overburden the administration, compared to option 3. Administrative burden would also be increased for the manufacturers, to manage the training sessions.

Obliging manufacturers would be counterproductive, giving the feeling of easy to implement schemes, but with important efforts of coordination to overcome many difficulties.

In markets with progressive uptake of RHC, manufacturers are naturally willing to train, in order to ensure high quality and product reputation (obligation would become counterproductive). Therefore, recommending MSs to consider creating synergies between the private (e.g. manufacturers) and public (e.g. training centres) sectors would be an alternative, and benefit from all complementarities between the industry (state-of-the art technologies) & public frameworks (more general aspects not related to specific products).

Environmental impacts

Globally (**for all options**), the proxy used to measure the potential environmental impact is directly linked to the fossil fuels (heating oil, natural gas, even coal) the renewable fuels (individually or through DHC) would replace.

A potential environmental impact due to the rapid deployment of all renewables in buildings, mainly driven by an indicative target (**option 2**), is biomass deployment, as this is probably one of the most competitive options without any incentive scheme and could possibly take the lead in deploying the various renewable technologies in buildings. Depending on the heating system used, biomass might have potential adverse impacts, such as on air quality or biodiversity, that should not counterbalance the benefits in terms of renewable energy deployment and GHG reduction. Depending on the pathways, great care about biomass sustainability should be taken, expanding the scope to small-scale systems. Such obligation could apply to the fuel suppliers, rather than on the building occupant/operator.

Better quality (**option 3**) would globally improve the efficiency, consume less resources, and lower the emissions of GHGs and any other air pollutants (especially in the case of bio-energies). Quality installations are particularly needed within the heating and cooling sector, especially in the case of heat pumps, the efficiency of which remains sensitive to the quality of the installation. Therefore, more qualification will have a positive impact on GHG emissions, and on the environment in general (notably regarding bioenergy-based appliances).

Social impacts

The update of qualification and certification requirements for installers of heating and cooling systems (**option 3**) would positively affect the level of education and training outcomes, increase awareness at the level of decision makers, planners, and local authorities, to support leveraging local existing potentials. It would influence the uptake of renewable and would increase the level of education and training outcomes, and the number of jobs (e.g. installers, suppliers, manufacturers). Consumers (building occupiers, being owners or tenants) would be positively affected, taking advantage of improved skills & quality. This option would have a positive impact on skills and jobs, as it would support an increase of the economic activity in RES-related sectors. However, special attention should be given to building the required skills at the same time as any support framework is set up. Therefore, if the option creates a boost for RES building technologies, training/certification should become a prerequisite.

Concluding remarks

EU guidance & best practices sharing (**option 1**) is key to guide national authorities in planning the full decarbonisation of the buildings. An indicative target (**option 2**) may help giving the direction to MSs, although it should be accompanied by adapted instruments. In any case, the building RES target would need to be mainstreamed in the more holistic approach of building decarbonisation, to ensure a coherent and integrated building concept leading to effective carbon emissions savings. Some update of the certification provisions (**option 3**) would also have a positive impact, while imposing manufacturers to train installers (**option 4**) would be counterproductive and comprises too many risks.

Annex F - Transport

Annex F to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

ludwig bölkow systemtechnik

In association with:

Trinomics

E3Modelling Energy Economy Environment

Artelys

LIST OF ACRONYMS

Acronym	Full name
AFID	Alternative Fuels Infrastructure Directive
A&M	Aviation and Maritime Sector
BEVs	Battery Electric Vehicles
CBAM	Carbon Border Adjustment Mechanism
CCfD	Carbon Contracts for Difference
CCS	Carbon Capture and Storage
CNG	Compressed Natural Gas
CTP	Climate Target Plan
CVD	Clean Vehicles Directive
EC	European Commission
EEA	European Environment Agency
ETS	Emission Trading System
FCEVs	Fuel Cell Electric Vehicles
FAME	Fatty Acid Methyl Ester
FQD	Fuel Quality Directive
GHG	Greenhouse Gas
HBEs	*Hernieuwbare brandstofeendheden*, i.e. renewable energy units
HDV	Heavy-Duty Vehicle
HRS	Hydrogen Refuelling Stations
HVO	Hydrotreated Vegetable Oils
ICE	Internal Combustion Engine
IEA	International Energy Agency
IMO	International Maritime Organisation
LDV	Light-Duty Vehicle
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
MS	Member State
NGOs	Non-Governmental Organisations
OPC	Open Public Consultation
PtL	Power-to-Liquid
RCF	recycled carbon fuels
RED	Renewable Energy Directive
RED II	Renewable Energy Directive recast
REU	Renewable Energy Unit
RES	Renewable Energy Sources
RES-T	Target for Renewable Energy in Transport (RED II, Article 25(1))
RFNBOs	Renewable liquid and gaseous transport fuels of non-biological origin
TCO	Total Cost of Ownership
V2G	Vehicle-to-Grid
ZEVs	Zero Emission Vehicles

Background

The transport sector is the only energy consuming sector in the EU, where greenhouse gas (GHG) emissions have not decreased in recent years. Instead, its GHG emissions have increased compared to 1990 levels, making up for about a quarter of Europeans total GHG emissions in 2019. The European Commission has underlined the significant challenge in its "*Sustainable and Smart Mobility Strategy – putting European transport on track for the future*".[541] It states that "*the success of the European Green Deal depends on our ability to make the transport system as a whole sustainable*".

The historic development of GHG emissions of different transport segments relatively to the 1990 baseline are stated by the European Environment Agency (EEA). While emissions could be reduced in domestic navigation and railway transport, they significantly increased for road, maritime, and aviation with the increase being especially high in aviation. The EEA reported that the transport emission for all EU Member States (MSs) will increase by 32% until 2030, according to projections based on existing policy measures ('with existing measures'/WEM scenario).[542] Additional measures (WAM scenario) planned in national policies, on the contrary, will limit the increase to 17% by 2030.

In contrast to that, the European Green Deal targets a 90% reduction of these emissions by 2050[543]. Achieving the ambitious climate goals that the EU's Green Deal is advocating, substantial changes to the RED II are necessary when it comes to transport. These need to consider that the transport sector is on the one hand in urgent need of advances in climate protection, and on the other hand subject to various processes of fundamental change, notably different modes of transport, digitalisation as well the electrification of road transport and the introduction of other alternative fuels.

In recent years, alternative fuels already gained higher importance in transport. At present, biofuels provide for the largest share, with food and feed crops as major feedstocks to biofuels production. Electrification of transport currently mainly focuses on rail and increasingly on passenger cars, although it's contribution in 2018 has been limited (see Figure 1-1). Nevertheless, it is strongly growing and has a large potential in several applications. The introduction of renewable transport fuels of non-biological origin (RFNBOs), notably hydrogen and synthetic fuels derived from hydrogen are also considered as important elements for the decarbonisation of transport, with application especially in hard-to-electrify segments like heavy-duty transportation, aviation, and maritime sector.

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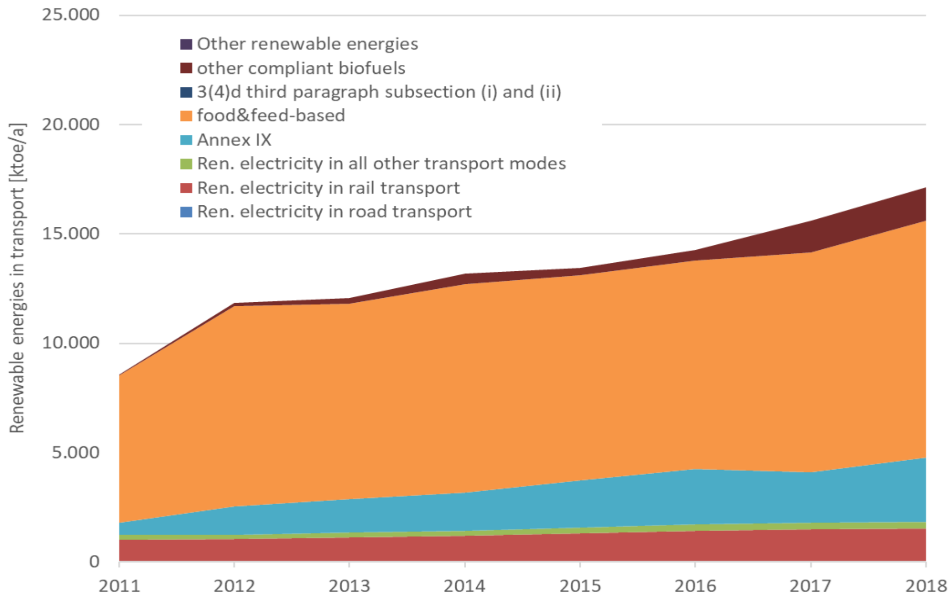
[541] SWD(2020) 331 final.

[542] EEA. (2020). Greenhouse gas emissions from transport in Europe – Indicator assessment. Available at https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases-7/assessment

[543] European Commission. (2021). Sustainable transport. Available at: https://ec.europa.eu/transport/themes/sustainable_en

Figure 1-1: Renewable energy in transport in EU27 by sector[544] (Source: own graph based on SHARES 2019)



The challenge to bring transport on track to a carbon neutral energy system is enormous. Based on the required ramp up of production capacities for alternative fuels as well as new vehicles and infrastructure, the disruptive changes the transport industry is facing within the next decades have to be taken into account today.

[544] Based on data from the EUROSTAT SHARES tool. Available at: https://ec.europa.eu/eurostat/web/energy/data/shares

Design

Problem Definition

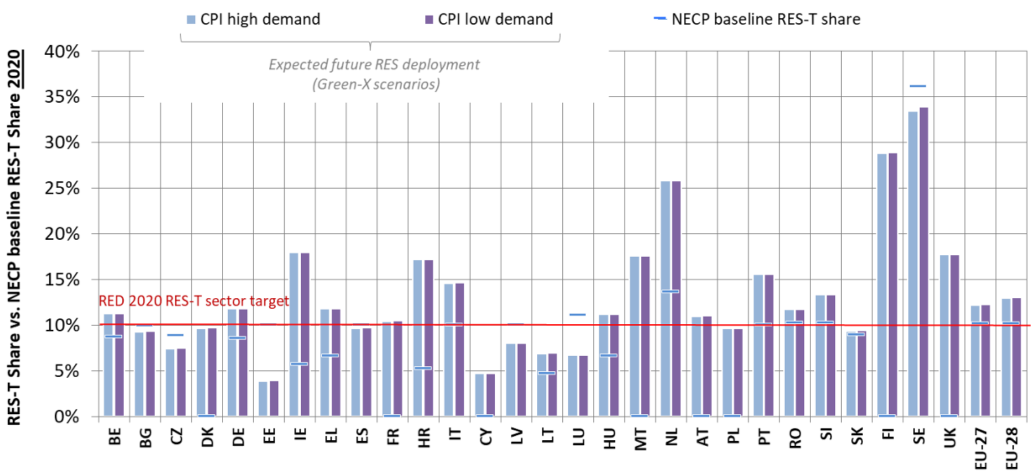
The transport sector faces a significant requirement for GHG emission reduction, which goes in line with new challenges of digitalisation, electrification, and alternative, low carbon fuels. The revised Renewable Energy Directive (RED II) is one of the most important instruments to foster investments in renewable technologies und set a framework for national GHG emission reductions in the different sectors. Main problems identified in current provisions under RED II are presented in the following.

Need to increase the 2030 target share of renewable energy in transport

Whereas the transport target for renewable energy in RED II has been set at 14% by 2030, the Commission expects that it needs to be raised to about 24% by 2030 to reach the overall GHG emission reduction.[545] In fact, the EC's impact assessment on the Climate Target Plan (CTP) reveals that, depending on the scenario, renewable energy shares between 22% and 26% in the transport sector are required to reach the overall GHG emission reduction of 55% by 2030.[546]

The requirement for intensified efforts by several MSs towards introducing renewable energy into the transport sector has also been pointed out by the EC in the latest version of their biannual RES progress report.[547] Based on the projections for 2020, only 16 out of 27 MSs will meet the 2020 RES-T target of 10% (pre-Covid estimations) (see Figure 2-1).

Figure 2-1: Expected RES-T share in 2020 vs. binding national RED RES-T sector target and NECP baseline (%) (Source: COM/2020/952 final based on Navigant)



Shortcomings of existing accounting methodology for RES-T and multipliers

Beside the target value for renewable energy in transport, also the calculation methodology for the 'minimum share' of renewable energy in transport (RED II Art. 27(1)) might be subject to revision. The following list gives some examples of existing inconsistencies:

[545] COM(2020) 562 final.
[546] SWD(2020) 176 final.
[547] COM(2020) 952 final.

- As maritime and aviation are currently excluded from the denominator, naturally, under the current provision, the RES-T targets can be achieved with lower physical shares of renewable energy, which intentionally overstates what has been achieved.
- In addition, Members States can choose to include recycled carbon fuels as renewable energy in the numerator RED II Art. 27(1b), or not, although they are based on non-renewable sources of energy.
- RFNBOs consumed as intermediate product, i.e. especially renewable hydrogen used in refineries for conventional fuel production, are also considered (RED II Art. 25(1)), however, only in the numerator.

To promote certain types of fuels, RED II provides in Art. 27(2) the possibility to apply multipliers for the purpose of demonstrating compliance with both, the minimum share of 14% renewable energy in transport as well as the increasing sub-mandate for advanced biofuels laid out in RED II Art. 25(1). However, existing multipliers grossly overstate the de facto (physical) share of renewable electricity in transport. The task is therefore to properly structure how electricity and RFNBOs are measured in transport (Art. 7 & Art. 27) in a way that is straight forward to implement, able to be verified in real time (e.g., same year) and connected to de facto progress in MSs.

In the current version, all biofuels and biogas from feedstocks in Annex IX (parts A and B) receive a multiplier of two (based on their energy content), whereas renewable electricity shall be considered with multipliers of four (in case of road transport) and 1.5 (in case of rail transport). Fuels supplied to the maritime and aviation sector can be counted with a factor of 1.2, in case they are not produced from food or feed crops. RFNBOs are so far only covered by the multiplier in the maritime and aviation sector, while their consumption in other sectors, e.g., renewable hydrogen in fuel cell vehicles or trains, or as intermediate product in the production of transport fuels, is not supported by this measure.

Whereas multiplier provide an incentive to bring specific fuels to the transport sector, they decrease the actual amount of renewable fuels brought to the system at the same time. Additional propulsion efficiency factors applied to EVs, as is the case in Germany, skew the actual reduction in GHG emissions even further and underscore the distorting effect of the use of multipliers. The current reasoning, namely that it is not possible to account for all electricity supplied for road vehicles in statistics through dedicated metering, such as charging at home, and that therefore multipliers should be used in order to ensure that the positive impacts of electrified renewable energy-based transport are properly accounted for (see RED II recital 87), is potentially invalid, if sound national estimates (e.g. Germany) that closely depict the de facto shares of renewable electricity supplied for road vehicles, are adopted. Furthermore, when all electricity consumed in road transport, including home-charging is estimated on the national level, e.g. foreseen in provisions in Germany, there is a potential risk of double counting when a BEV charges at public charge points but is at the same time accounted for through the domestic fuel supplier.

RED II should accordingly be revised with regard to a more transparent and – to a high extent – harmonised accounting methodology including the overall Union target (Art. 7) as well as the sectoral transport target (Art. 25(1) and Art. 27(1)) and multipliers (Art. 27(2)) should be discussed.

Incomplete sectoral coverage in RES-T (aviation and maritime sectors)

The introduction of renewable energy into the aviation and maritime sectors faces some specific challenges, which do not exist in other transport sectors. These include the highly specific fuel standards in aviation, requiring specifically designed RFNBOs or biofuels. However, biofuel feedstocks suitable for aviation fuel production compete for different uses in the transport sector and are rather limited, while e-fuels are based on abundant renewable electricity resources.[548] In addition, both sectors face strong international competition, an important argument to finely craft and thoroughly justify any individual regulation.

Accordingly, in contrast to promotion activities in other transport segments, low carbon fuels (i.e. fuels based on low carbon hydrogen production like steam methane reforming with carbon capture and storage) might be necessary as alternative fuels in addition to renewable fuels like RFNBOs (at least from the perspective of some stakeholders) (see also Annex B - Energy System Integration, Section B4). Fuels from renewable energy, however, do not play a significant role in both sectors so far. Partially contributing to this are the low costs of fuels in the sectors, owed to minimal taxation. From both a RED II and a perspective of the European Emission Trading System (ETS) concrete obligation for fuels in the sectors therefore seem to be an appropriate instrument. New support schemes should therefore take existing limitations and bottlenecks for alternative fuels into account, i.e. existing competition with food and feed production or limited feedstock potential as in the case of biofuels from feedstocks listed in Annex IX part B.

The international discussion to include the maritime sector in the ETS may significantly increase the demand for low carbon fuels and biofuels. Harmonized obligations on fuel suppliers may impose new challenges on the system: airlines and shipping companies might be incentivized to shift their fuelling activities to non-EU countries to bypass specific fuel requirements. The respective risk of fuel bunkering (maritime) and fuel tankering (aviation) in non-EU countries has further increased with the withdrawal of the United Kingdom (UK) from the EU.

Lack of harmonization

There is a general lack of harmonisation, since current provisions under RED II allow MSs to decide which fuel suppliers and which energy carriers they include when setting the obligations on fuel suppliers. In addition, they can chose how the minimum share of renewable energy in the transport sector in the obligation (i.e. in energy, GHG emissions or volume terms) is expressed or calculated. Secondly, there are no specific obligatory target shares across renewable fuels in place, yet a range of exceptions and options as to how existing targets can be achieved.

The following list shall illustrate that on selected examples:

- MSs “*may take into account recycled carbon fuels*” (Art 25(1) [3b]), or not, and have the freedom to express their obligation on fuel suppliers either through targeting volumes, energy content or greenhouse gas emissions, as long as they demonstrate minimum target compliance.
- Coupled with the use of multipliers, as defined in Art. 27(2), designed to promote certain fuels in certain sectors, these provision not only overstate the overall physical amount of renewables

[548] For an overview of European potentials, see Trinomics, LBST & E3M. (2019). Impact of the use of the biomethane and hydrogen potential on trans-European infrastructure. Available at: https://op.europa.eu/en/publication-detail/-/publication/10e93b15-8b56-11ea-812f-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search

in transport, but fundamentally also inhibit a shared pan-European approach to renewables in the sector, therefore hindering the realisation of economies of scale and more generally a market-friendly environment that encourages continent-wide competition between different national and international fuel suppliers.

The current result is instead a patchwork of national regulations that, due to different obligations and target framing, favours certain fuels over others in different geographies.

Insufficient support for hydrogen and RFNBOs in transport

Provisions under RED II do also include fuel-specific sub-mandates (i.e. for advanced biofuels produced from feedstocks listed in Annex IX part A) (Art. 25(1) RED II), as well as caps for conventional biofuels (i.e. biofuels produced from food or feed crops) (Art. 26(1) RED II). In addition, the contribution of biofuels produced from feedstocks listed in Annex IX part B are only considered up to a certain cap when calculating RES-T (Art. 27(1b) RED II).

During 2020, hydrogen has gained significant attention as a renewable energy carrier for a climate neutral energy system. This important role has also been stressed by the European Commission in their hydrogen strategy.[549] Still, today renewable hydrogen production based on renewable electricity is not competitive to current fossil-based hydrogen production pathways. The transport sector is therefore seen as an important early market for the technology: The introduction of fuel cell electric vehicles would enable significant cost reduction of the technology by mass production of fuel cells combined with a high willingness to pay compared to other hydrogen applications.

Under current provisions of RED II, there are no specific support measures for the consumption of hydrogen as fuel in the transport sector. In the context of RFNBOs, the energy content of hydrogen consumed in rail and road is counted towards RES-T, however, no multipliers or targets are defined for hydrogen.

The European Commission has described their perspective on the role of hydrogen in the transport sector in the three different strategies, published in 2020. Based on the Hydrogen Strategy, in the transport sector, *"[…] hydrogen is also a promising option where electrification is more difficult. In a first phase, early adoption of hydrogen can occur in captive uses such as local city buses, commercial fleets (e.g. taxis) or specific parts of the rail network, where electrification is not feasible."*. This formulation is more open when it comes to possible applications than the formulation in the Energy System Integration Strategy, where renewable hydrogen is described bundled in concept with renewable and low carbon fuels: *"[…] the use of renewable and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification are not feasible, not efficient or have higher costs."* Examples given for the application of biofuels and RFNBOs in the transport sector encompass "*renewable hydrogen in […] heavy-duty road and rail transport, synthetic fuels produced from renewable electricity in aviation and maritime transport*". These slightly differing perspectives have been merged in the Sustainable and Smart Mobility Strategy: *"Manufacturers are also investing into hydrogen fuel-cell vehicles, particularly for use in commercial fleets, buses and heavy duty*

[549] COM(2020) 301 final.

transport.”, supported by the remark that *“energy efficiency shall be a criterion for prioritising future choice of suitable technologies looking at the whole life-cycle.”*

Objective Setting

Based on the problem definition above, the objectives for the revision of RED II in transport are:

1. increased ambition for the 2030 climate target;
2. simplification of the current approach;
3. coverage of all transport sectors including maritime and aviation;
4. stronger harmonisation across the Union; as well as
5. stronger support for hydrogen and RFNBOs.

This section lays out these general objectives of the subsequently developed and analysed options. In doing so, it draws on the general sentiment of stakeholders from the stakeholder workshop in December 2020,[550] survey results from the Open Public Consultation (OPC) questionnaire,[551] latest developments in the transport markets, as well as respective regulation and shortcomings that have been identified in past assessments, and that are identified in the problem definition above.

Note that the graphs presented within this section show results of the stakeholder survey as percentages. For some countries or organisations, there may have only been few representatives of e.g. an organisation type that participated in the survey. The results may therefore not be fully representative and should be viewed with caution. Nevertheless, almost 40,000 responses were recorded, and the results serve as general overview of stakeholders’ sentiments regarding the different objectives presented: Increased ambition, simplification of current approach, coverage of all sectors including maritime and aviation, stronger harmonisation as well as stronger support for hydrogen and RFNBOs.

The consultation results provide indications of possible priorities, design options and focus areas from the perspective of the stakeholders having participated in the consultation related to the five objectives of this revision as defined above.

Increased ambition (targets)

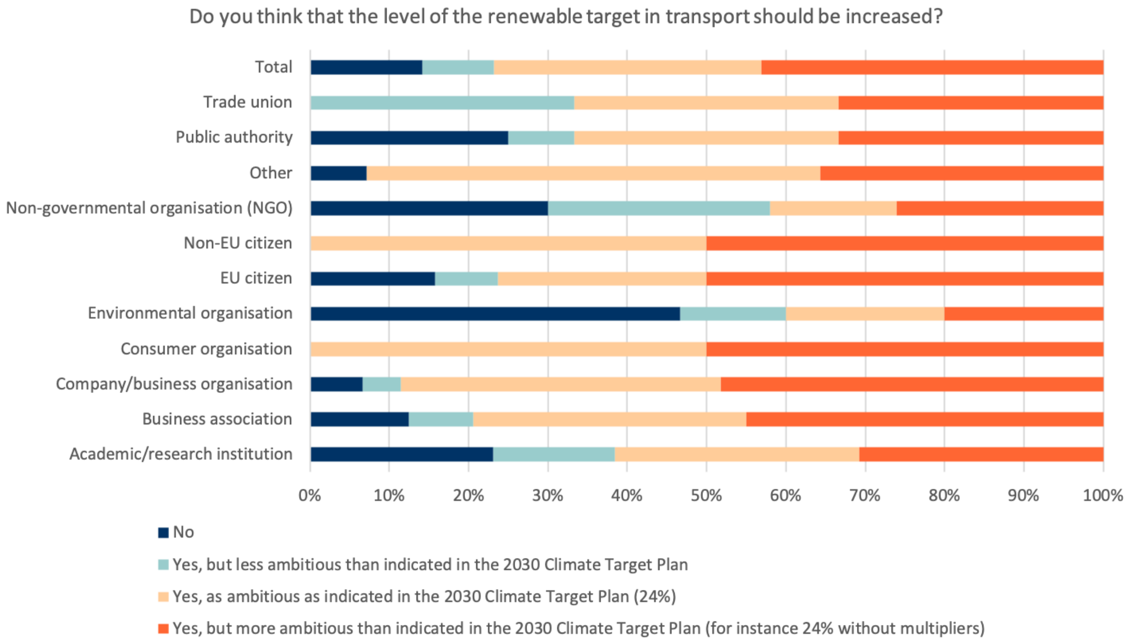
In the reply to the Roadmap, businesses & associations from the biofuels sector called for the increase of the 14% transport target. The same actors from the renewable and low carbon fuel sectors called for the establishment of sub-targets for synthetic fuels in different sectors. Several companies called for the introduction of a minimum target for renewable gas. The EV industry, that represents a minor part of the stakeholders, pleads for an increase of the transport target. At the same time, some actors called for recycled carbon fuels (RCF) to be excluded from the transport target.

[550] On 11 December 2020, the European Commission, DG Energy, held an online workshop in the context of the work to revise Directive 2018/2001 on the promotion of the use of energy from renewable sources. The workshop agenda included 32 external speakers in seven sessions. Some 700 people from over 250 different organisations registered for the workshop, of which approximately 450 actually participated.

[551] A consultation process on the revision of the Directive, was launched on 17 November 2020 and was open until 9 February 2021. The main consultation documents are available online at https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12553-Revision-of-the-Renewable-Energy-Directive-EU-2018-2001/public-consultation

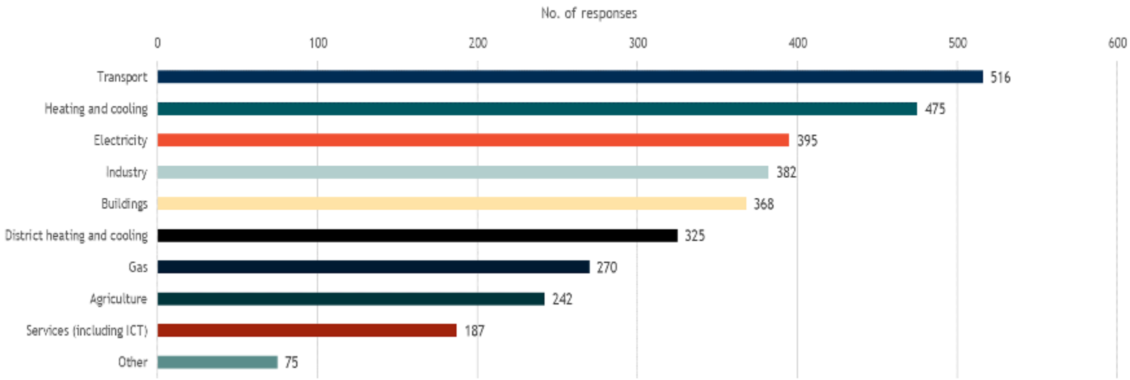
During the stakeholder workshop in December, all the speakers agreed that efforts for promoting renewables in transport should be stepped up. Some panellists agreed that a better harmonisation of policy instruments in RED II is desirable while some others worried about the effect of the review of RED II on policy certainty and investments. Different views were expressed on the importance of biofuels and hydrogen-based fuels for transport decarbonisation and the way electrification of road transport should be promoted. Generally, the proponents for increasing the level of the renewable target in transport are in the majority, with over 80% of all respondents in favour of a target increase (see Figure 2-2). Similarly, when asked what sectors would require additional efforts to achieve a potentially higher renewables target for 2030, stakeholders identified the transport sector as the one where most additional efforts are needed (see Figure 2-3). This underscores not only the need for a more ambitious target but also stakeholders' sentiment, that measures to live up to it need to be stepped up.

Figure 2-2: Stakeholders' opinion whether the level of the renewable target in transport should be increased. Source: LBST based on published OPC results[552]



[552] Contributions to the public consultation are available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12553-Revision-of-the-Renewable-Energy-Directive-EU-2018-2001/public-consultation

Figure 2-3: Which sectors would require additional efforts to achieve a potentially higher renewables target for 2030. Source: Trinomics based on published OPC results[553]



Simplification of current approach (multipliers, target calculation)

Stakeholders during the workshop had a mixed opinion on multipliers and the general sentiment rather seems to be against multipliers, which is also confirmed by the OPC results (see Figure 2-4 and Figure 2-5). However, the sentiment is not consistent across different types of organisations nor MSs, which may reflect worries regarding a reduced RES-share as the national fuel composition benefits from the current calculation methodology, or vice versa. During the stakeholder workshop in November, especially the factor of four for renewable electricity in road (Art. 27(1)) was seen ambiguously. For some stakeholders, it is unclear how it can be justified. Some support it in absence of a better system (although it is a generous mechanism), since the contribution of renewable electricity in transport will be limited until 2030. Removing the multiplier, however, would penalize energy efficiency. In contrast to that, the biofuel industry sees the risk of an inflation of multipliers. Stakeholders' opinion is that for the maritime and aviation sectors existing multipliers should be increased, since the model has worked for electricity in road transport, while the progress in increasing the RES share in maritime and aviation has been limited. In general, however, for fuel suppliers, the rationale behind multipliers is already difficult to understand (which also is mirrored in several questions and comments by the audience during the stakeholder workshop). In summary, the full tapestry of opinions regarding calculation methodology, e.g. multipliers, was expressed during the stakeholder consultations, mirroring the many facets and different rules for target calculation. This supports the notion that the approach needs to be streamlined to a certain degree as to foster understanding, easier execution and hence acceptance by stakeholders.

553 Refer to Annex I – RED II Open Public Consultation.

Figure 2-4: Stakeholders' (by organisation type) opinion whether the multiplication factors for different types of renewable energy should be abolished in order to simplify the legislation and to increase the ambition level (Source LBST based on published OPC results)

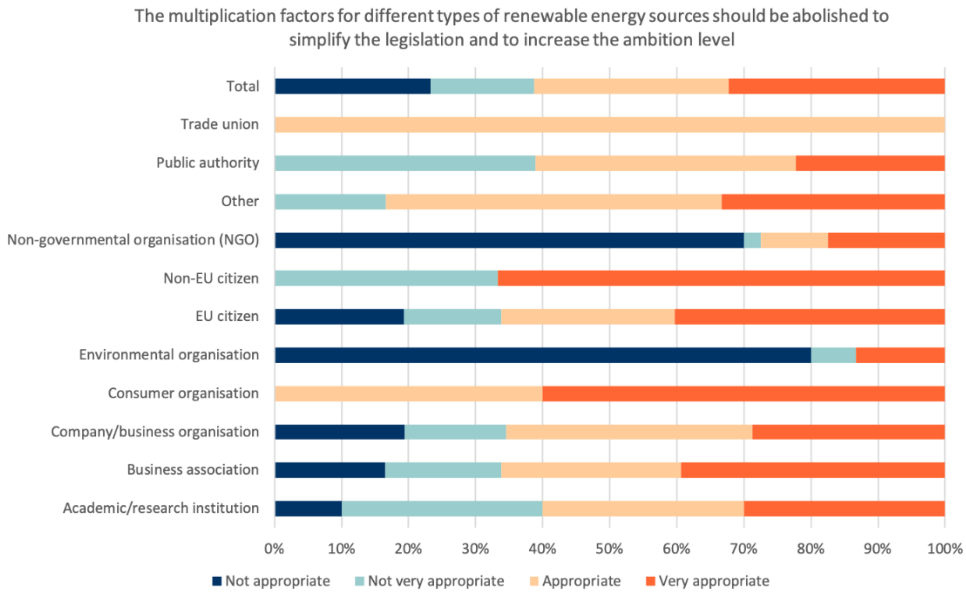
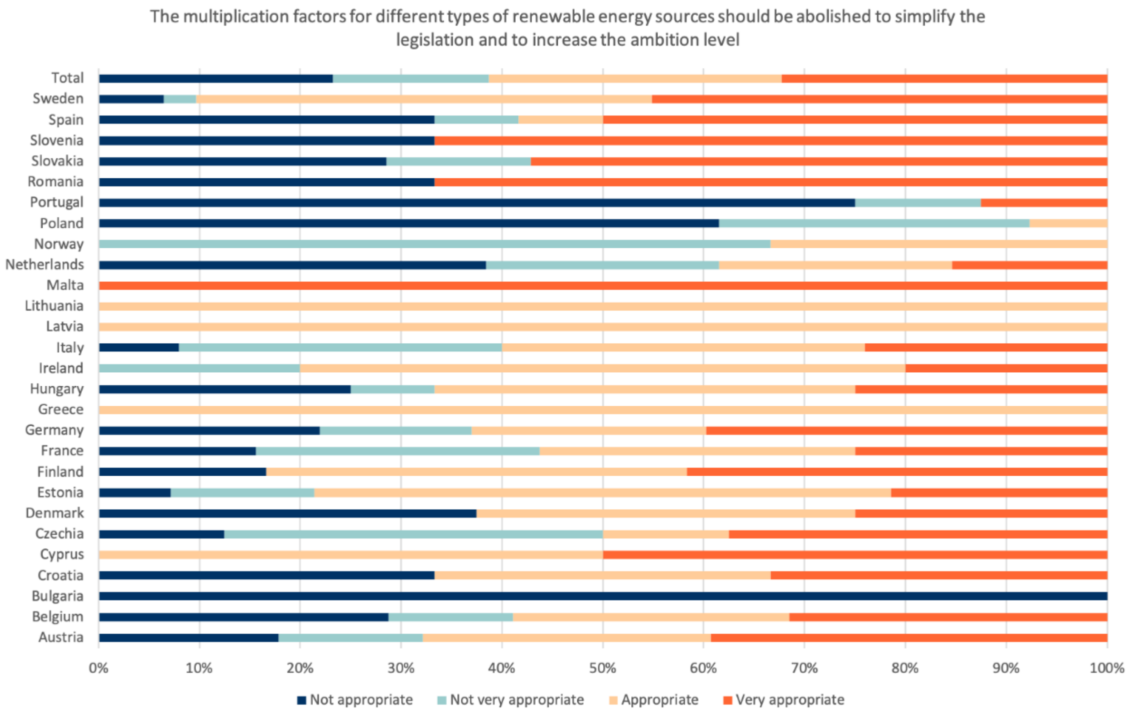


Figure 2-5: Stakeholders' (by Member State) opinion whether the multiplication factors for different types of renewable energy should be abolished to simplify the legislation and to increase the ambition level (Source LBST based on published OPC results)



Coverage of all sectors, including aviation and maritime (calculation methodology)

Some transport sectors, i.e. aviation and maritime, have been particularly challenging to decarbonise. Electrification of transport using renewable electricity will likely be the main option to decarbonise road transport, at least for passenger cars. In sectors that are more difficult to electrify, such as the aviation and maritime sectors, the increased use of renewable and low carbon fuels is expected to be the main option. RED II provides incentives for the MSs to focus particularly on the promotion of renewable and low carbon fuels in the aviation and maritime sectors, but does not fully consider these sectors when setting the renewable energy target for transport. At the same time, electricity in maritime applications has so far not been eligible for a multiplier, which potentially disadvantages the technology in the sector in the first place. The opinion of stakeholders is quite clear on the matter and nearly 80% across organisation types and MSs find it appropriate or very appropriate that specific measures to promote the use of renewable and low carbon fuels in maritime and aviation transport are taken (see Figure 2-6 and Figure 2-7). Hence, provisions to do so are suggested.

Figure 2-6: Stakeholders' (by organisation type) opinion whether measures to promote the use of renewable and low carbon fuels in aviation and maritime transport are appropriate (Source LBST based on published OPC results)

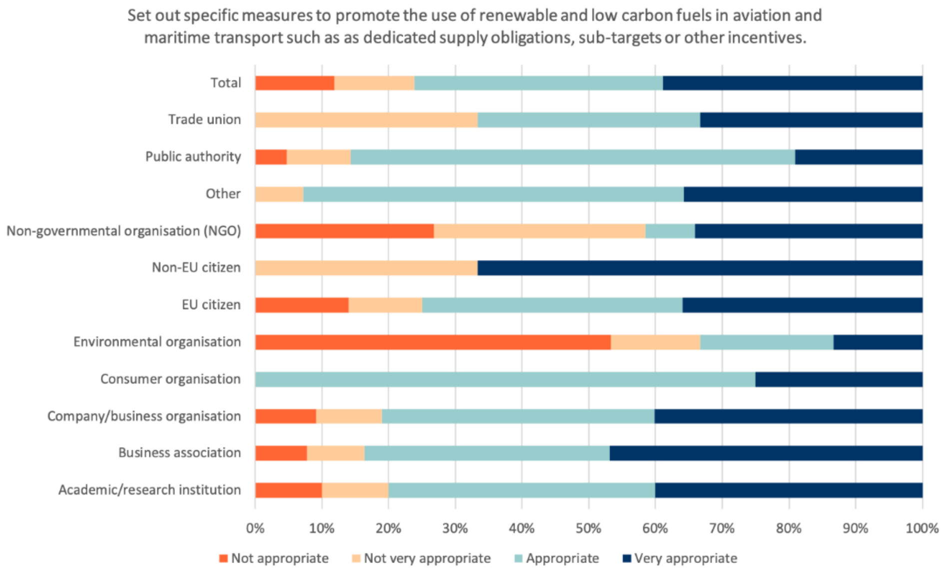
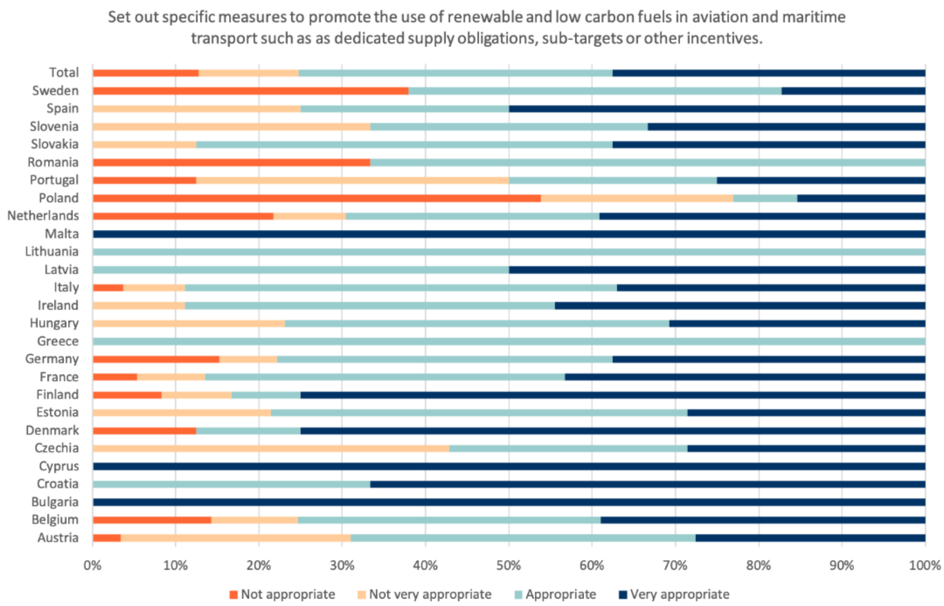


Figure 2-7: Stakeholders' (by Member State) opinion whether measures to promote the use of renewable and low carbon fuels in aviation and maritime transport are appropriate (Source LBST based on published OPC results)



Stronger harmonization (definition of scope, etc.)

Lacking harmonization in terms of target expression and calculation methodology, for example, is a structural barrier to a shared pan-European approach to renewables in the sector, therefore hindering the realisation of economies of scale and more generally a market-friendly environment that encourages continent-wide competition between different national and international fuel suppliers. This is a problem, if one aims to create a level-playing field for all fuels at European level. Either concrete obligations in the current policy architecture are harmonised in a MS-specific, yet dynamic and stringent manner; or a system that ensures a level playing field between renewable electricity, RFNBOs, and (advanced) biofuels across MSs is created in the context of the present, less harmonised policy architecture. The current result is instead a patchwork of national regulations that, due to different obligations and target framing, favours certain fuels over others in different geographies. The sentiment amongst stakeholder evidences this, with nearly 80% of stakeholder saying that they find the suggestion "*The scope of fuels that can be counted should be harmonised to ensure that all fuels that are eligible for counting towards the renewable energy target are supported in all Member States*" appropriate or very appropriate (see Figure 2-9 and Figure 2-10).

Figure 2-8: Stakeholders' (by organisation type) opinion whether the scope of fuels that can be counted should be harmonised (Source LBST based on published OPC results)

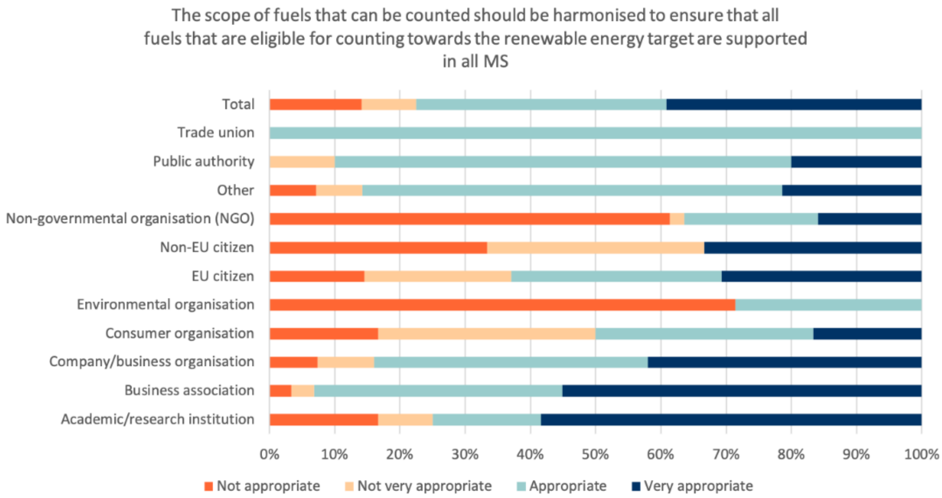
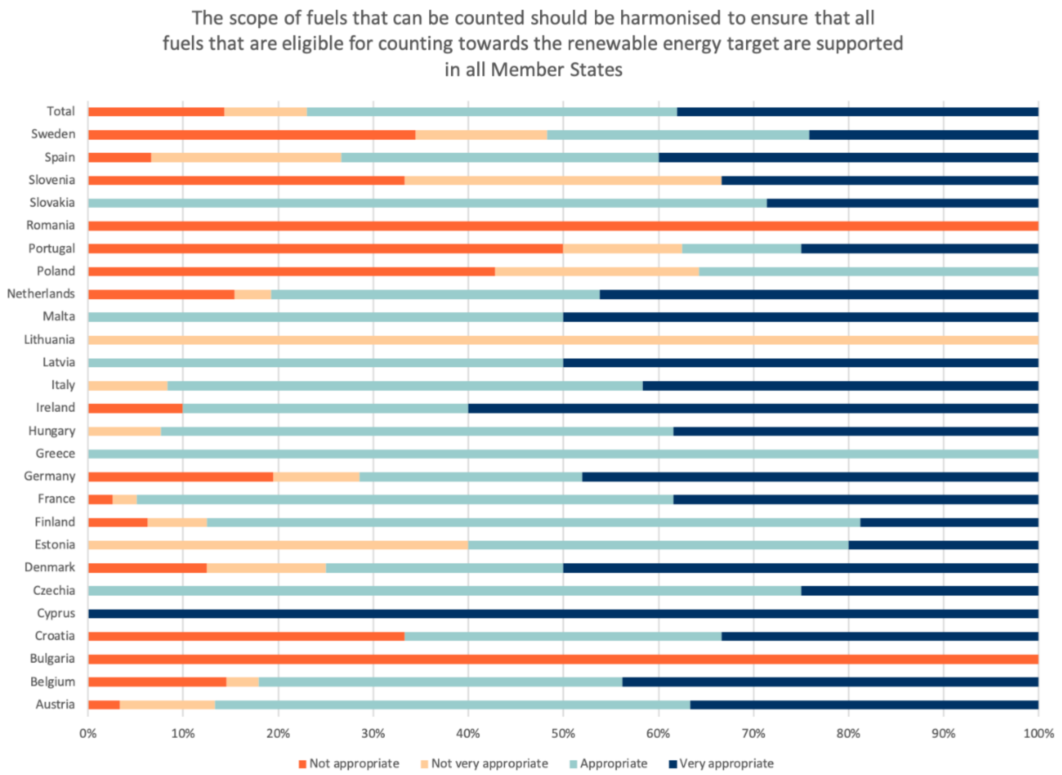


Figure 2-9: Stakeholders' (by Member State) opinion whether the scope of fuels that can be counted should be harmonised (Source LBST based on published OPC results)



Stronger support for hydrogen and RFNBOs in transport (targets, multipliers)

The Renewable Energy Directive recast (RED II) focuses on renewable fuels and renewable electricity only, while other low carbon fuels are not covered except for recycled carbon fuels MSs can opt-in for the transport target. Following the European Commission's assessments described e.g. in the EC's Hydrogen Strategy, low carbon fuels like hydrogen or synthetic fuels / e-fuels from non-renewable sources, however, will be needed in the short- and medium-term to achieve a rapid and cost-efficient greenhouse gas emission reduction in specific, hard to decarbonise areas.

Under current provisions of RED II, there are no specific support measures for the consumption of hydrogen as fuel in the transport sector. In the context of RFNBOs, the energy content of hydrogen consumed in rail and road is counted towards RES-T, however, no multipliers or targets are defined for hydrogen, which is why this assessment looks at options to introduce these, e.g. a multiplier for hydrogen in road transport. Stakeholders' opinions to support measures to promote hydrogen are mixed. While the majority supports encouraging hydrogen production (see Figure 2-10), there is no clear picture among stakeholders on introducing dedicated sub-targets for hydrogen (see Figure 2-11), for example.

Due to a lack of competitiveness compared to fossil-based hydrogen and conventional fuels, further support for renewable hydrogen and RFNBOs will be required to achieve a significant market introduction in the next years. Ramp-up of production capacities and the implementation of the required infrastructure in the next years are key to enable the required widespread application of RFNBOs in hard-to-decarbonise sectors after 2030.

Figure 2-10: Stakeholders' opinion on whether the use of hydrogen and e-fuels produced from hydrogen should be encouraged (multiple answers possible) (Source Trinomics based on published OPC results)

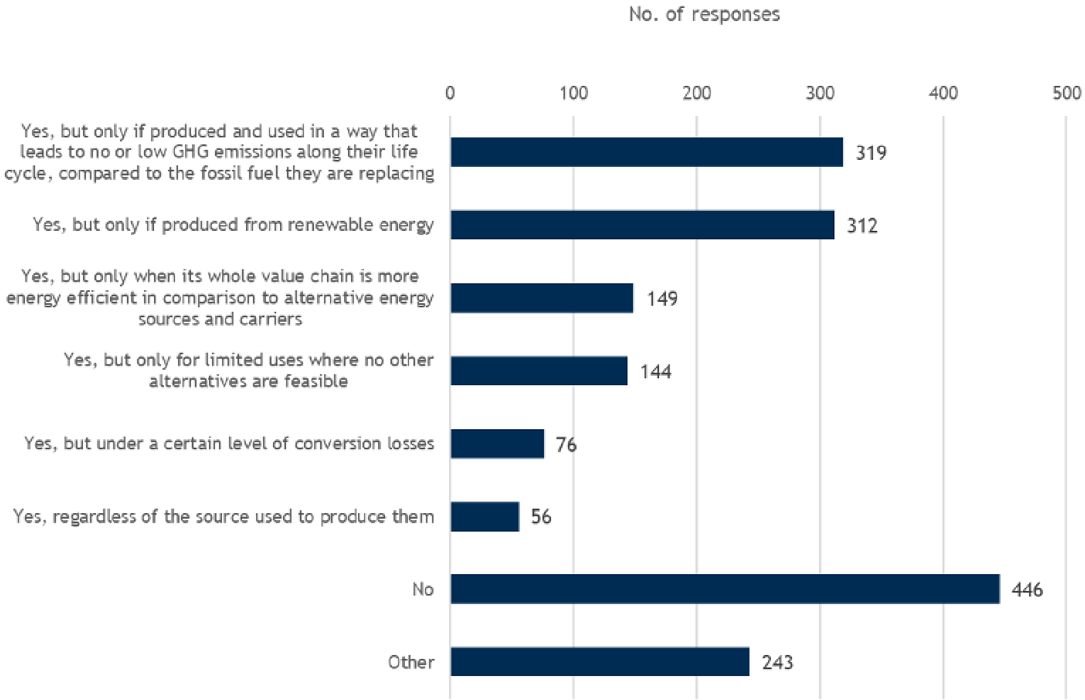
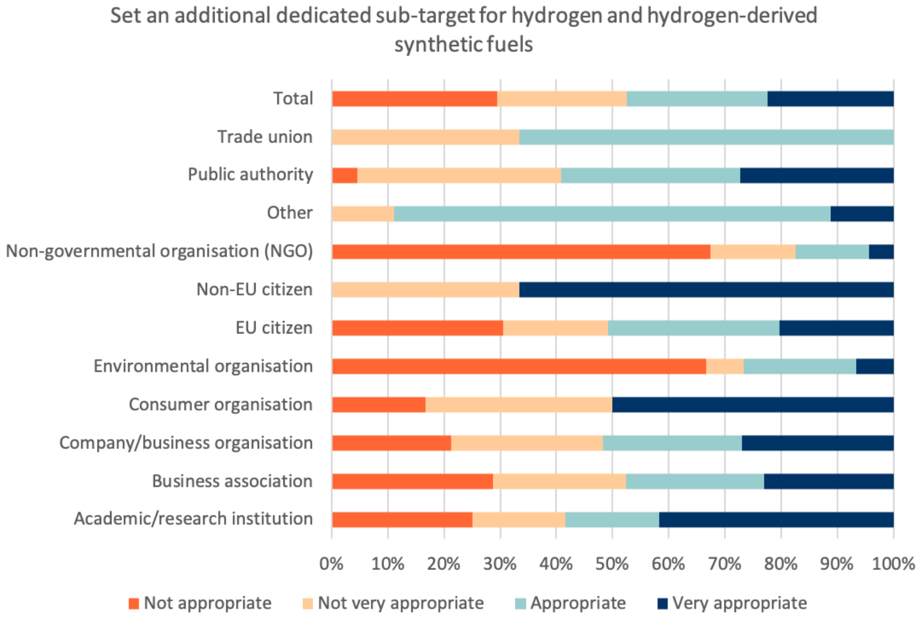


Figure 2-11: Stakeholders' opinion on setting an additional dedicated sub-target for hydrogen and hydrogen-derived synthetic fuels (Source LBST based on published OPC results)



Development of policy options

This section presents a description of different policy options considered for addressing transport sector in the Renewable Energy Directive.

In the following, a table is presented with an overview of the options and sub-options to be analysed, organised by their order of departure from the current approach (e.g. option 0 is the baseline, option 1 are non-regulatory measures, etc.). Below the table, a full description of each option is presented.

Options	Description
Option 0 (baseline)	No change in the current legislation.
Option 1 (non-regulatory)	Promote renewable and low carbon fuels only with non-regulatory measures such as funding of R&D and targeted financial support for renewable and low carbon fuels. This may include: • Market-based instruments • Self-regulation & co-regulation • Information and co-education
Option 2	Incremental improvements (no increased ambition level) More favourable treatment of H_2 in road & rail and electricity in ships: • Introduce a new multiplier (e.g. 2) specifically for renewable hydrogen in road and rail transport • Possibilities to support electricity in maritime applications (e.g. by adapting multiplier) Credit mechanism for all transport energies • Introduce a "*credit mechanism*" covering all fuels and transport sectors (e.g. Dutch system based on 'renewable energy units' called HBEs) allowing fuel suppliers to fulfil the dedicated supply obligations set out for the road, maritime, and aviation sectors in a flexible manner.

Option 3	Option 2 + Increase the ambition level of the transport target (Mix scenario and REG scenario)
	
	Sub-option 3.1: Continue current approach for promotion of renewable energy in the transport sector with increased ambition.
	• Increase of the RES-T target to 24% , including
	  ○ Introduce a sub-target for advanced biofuels in line with CTP;
	  ○ Introduce a sub-target for RFNBOs
	• Dedicated obligation for aviation and maritime fuels (either in RED II or as a separate instrument under Refuel EU);
	• Introduction of new fuels blends in FQD and remove Article 7a target and sustainability and greenhouse gas saving criteria from FQD.
	
	Sub-option 3.2: Broaden the scope of the target to all transport modes with increased ambition
	• Introduction of a RES-T target covering road rail, maritime, and aviation sectors (same ambition as 2% target but adjusted due to larger scope), including
	  ○ Introduce a sub-target for RFNBOs
	  ○ Adapt sub-mandate for advanced biofuels according to CTP and
	• Dedicated obligation for aviation and maritime fuels
	• Introduction of new fuels blends in FQD and remove Article 7a target and sustainability and greenhouse gas saving criteria from FQD.
	
	Sub-option 3.3:
	Sub-Option 3.2 + eliminate or streamline multipliers (adapting the target accordingly)

Options	Description
	Sub-variant a: Discuss possibilities to eliminate multipliers (e.g. adapt new measures to capture amount of renewable electricity in transport) **Sub-variant b:** streamline multipliers • Support of electrification, including exploration of dynamic multipliers tied to MS progress in e.g. RES share or charging infrastructure • Support of "*innovative fuels*" (RFNBOs and biofuels other than food and feed-based biofuels) through changes in existing multipliers for biofuels and introduction of multipliers for RFNBOs and increase in multipliers for fuels in aviation and maritime sectors • Multiplier for renewable H_2 in road & rail
Option 4	Option 3 + Partly harmonise and simplify target and obligation: **Sub-option 4.1:** Further harmonisation of the scope of the supply obligation with regard to fuels, sectors (road and rail) and penalty levels (possibly in a delegated act); voluntary inclusion of conventional biofuels; inclusion of decarbonised fuels including RCF following conclusion in the ESI chapter: • include all sectors in denominator (i.e. aviation and maritime incl. international; to be discussed); include all energies in denominator (LPG etc.); and decarbonised fuels including RCF (following discussion in ESI chapter) in numerator; • partly harmonize scope of supply obligation (eligible fuels, fuel suppliers, and sectors), • partly harmonize penalty levels. **Sub-option 4.2:** Sub-option 4.1 + Define the way the supply obligation is expressed Alternatives: • MSs continue to decide whether to express the obligation in terms of energy, GHG emission savings or volume; • Obligation is expressed in terms of energy; • Obligation is expressed in terms of GHG emission savings;
Option 5	Option 4 + Detailed specification of supply obligation and no targets: • RES-T target is replaced by supply obligation that is specified in detail (scope: eligible fuels, fuel suppliers, and sectors): same ambition level in all MSs and same coverage of fuels i.e. all MSs required to include RCF and decarbonised fuels (following conclusions in ESI chapter) and same penalty system; minimum share for advanced biofuels and RFNBOs; harmonised trajectory up to 2030 • Expression of the obligation in terms of energy, or in terms of GHG emission savings (see sub-option 4.2)

Option 0: Baseline

RED II sets an overall EU target for renewable energy in gross final energy consumption of at least 32% (Art. 3) by 2030. This target, is – in contrast to RED I – a Union target, while there are no binding targets on MS level.

Art. 25 of RED II also includes a transport target (referred to as "*minimum share*" or RES-T), which obliges MSs to "*set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy in the transport sector is at least 14% by 2030*", including at least

3.5%[554] of advanced biofuels and biogases produced from a list of specific raw materials (Annex IX part A) (Art. 25(1) fourth subparagraph). As stated, while renewable fuels consumed in all transport modes as well as electricity for road and rail transport can contribute towards the numerator for achieving these targets (Art. 27(1b)), the denominator is calculated taking only road and rail transport into account (Art. 27(1a)). Accordingly, Kerosene (for the aviation sector) and maritime fuels are not covered by the fuel obligation so far.

The Directive focuses on the promotion of biofuels and renewable electricity and allows MSs to reduce the 14% target, if the contribution of biofuels produced from food and feed crops to the target is set lower than the 7-percentage cap (Art. 26(1)). Further, special incentives are applied e.g. in forms of multipliers to promote 1) the use of specific types of fuels such as biofuels or renewable electricity in road and rail transport and 2) the use of alternative fuels in aviation and maritime sectors, which are particularly difficult to decarbonise (Art. 27(2)). Under these current provision, MSs can apply the following multipliers *"for the purposes of demonstrating compliance with the minimum shares referred to in Article 25(1)":*

- Biofuels and biogas for transport produced from feedstocks listed in Annex IX: 2;
- Renewable electricity for road transport: 4;
- Renewable electricity for rail transport: 1.5;
- Fuels supplied to the aviation and maritime sectors (except of food- or feed-based fuels): 1.2.

Since fuels for aviation and maritime are only considered in the numerator of RES-T in Art. 25(1), their multiplier covers renewable fuels like biofuels but also RFNBOs. In addition to that, there are no further multipliers, e.g. for RFNBOs in road or rail sectors or their use as intermediate product in conventional fuel production. Also, multipliers can only be applied to the calculation of the Union-wide transport target of 14%, but not on the calculation of the overall target defined in Art. 3.

Option 1: Non regulatory measures / Measures outside RED II

Market-based measures

R&D funding programmes likes the European 'Horizon 2020' remain an important pillar of strategic support for the transport sector inter alia including the electrification of transport, respective infrastructure, RFNBOs and low carbon fuels, and integrated mobility. For example, between 2013 and 2020, a total budget of €464 million has been provided for research activities for advanced biofuels and other renewable sources.[555] R&D programmes will especially be tailored to those technologies, whose competitiveness is not foreseen in the near future, while they will be an essential part of a greenhouse gas neutral energy system. Although the volume of R&D programs might decrease with the maturity level of technologies, the support of continuous technology development will remain a fundamental basis for Europe's future economic strength.

A green mobility fund, which could be set up with parts of the proceeds from of a potential credit mechanism, or a newly created pool of funds that MSs commit to supporting, could award projects and incentivise innovation on a competitive basis. Other possible measures for targeted financial support have already been outlined in the EC's Hydrogen Strategy, including national or EU-wide carbon contracts for difference (CCfD), which can be an important element for investors regarding RFNBOs or

[554] After applying the multiplier of 2.
[555] European Union Aviation Safety Agency. (n.d.). Sustainable Aviation Fuels. Available at: https://www.easa.europa.eu/eaer/climate-change/sustainable-aviation-fuels

low carbon technologies. This non-regulatory measure is further described in document B Energy System Integration, subtask B4.

The electrification of transport in particular is a process that can be supported with a tapestry of market-based measures, including reduced vehicle registration fees/taxes for electric vehicles, purchasing subsidies, reduced private or commercial vehicle ownership tax, preferential or free parking or reduced fees on toll roads. Some of these are described further in document B - Energy System Integration, subtask B2.

Self-regulation & co-regulation

Several of the options laid out below, including option 2 on incremental improvements, which covers a European-wide credit mechanism or option 3, on a wider scope of the target, requires substantial convergence of governance and/or national schemes. The EC could play a more active role in guiding the institutional convergence on how to implement some of the suggested measures in an efficient and inclusive way. The EC could also encourage the inclusion of a chapter on regional cooperation in the MSs strategies, which would identify cooperation possibilities and inform further efforts at harmonization.

Self-regulation in form of voluntary agreements is another way to incentivise or support the uptake of the various options laid out below, while allowing for flexibility and limiting the impact on competitiveness between different fuel supplier, which may result from other, harder options. Voluntary agreements are a type of self-regulating measure that can take a variety of different forms. A common type includes a collective commitment of a particular sector to reach a given (in this case renewable energy uptake) objective.

Information and co-education

These instruments intend to change behaviour through the provision of greater information or by changing the distribution of information. This is making information, that may be available to some businesses and consumers, available to others. Examples of these instruments in the context of transport can include information and education campaigns on the importance of green mobility, labelling requirements (e.g. GHG-emissions/km) for fuels, be they of fossil or renewable nature, or other requirements to disclose information to the market. This serves to provide information to consumers and create an environment of competition over transparency and trust between fuel suppliers. Existing practical examples of labelling campaigns include energy efficiency labels on electrical appliances.

Another information instrument could be to organise singular annual events. Existing examples that come to mind include the widely successful and popular Earth Hour, which is an event that is held annually to encourage individuals, communities, and businesses to turn off non-essential electric lights, for one hour. A similar initiative geared towards transport could be launched together with major non-governmental organisations (NGOs) such as the WWF to raise awareness on the importance of reducing fossil emissions in transport. This may be as extensive as the "*No driving day*" (NDD) (or "*Hoy No Circula*") in Mexico or be less prescriptive and include a day or some hours of free public transport in participating cities/utilities or simply consist in encouraging the public to reduce non-essential travel for a day.

Option 2: Incremental improvements

Option 2 covers some incremental improvements, maintaining the general approach in RED II but adds some additional support renewable energy in specific transport segments, like hydrogen in road and rail transport or electricity in maritime, which are not covered under existing RED II provisions so far. Also, the introduction of a credit mechanism for fuel suppliers is discussed to complement RED II.

More favourable treatment of H_2 in road & rail

To support the deployment of fuel cell electric vehicles in road or rail transport, the introduction of a multiplier on the energy content of renewable hydrogen accountable towards the RES-T is seen as option with incremental efforts. The implementation would be similar to those for biofuels and biogas for transport produced from the feedstock listed in Annex IX, which are considered twice their energy content. As laid out in recital (85), RFNBOs are seen as an important option in line with specific biofuels and renewable electricity to decarbonize the transport sector: *"Advanced biofuels and other biofuels and biogas produced from feedstock listed in an annex to this Directive, renewable liquid and gaseous transport fuels of non-biological origin, and renewable electricity in the transport sector can contribute to low carbon emissions, stimulating the decarbonisation of the Union transport sector in a cost-effective manner, and improving, inter alia, energy diversification in the transport sector while promoting innovation, growth and jobs in the Union economy and reducing reliance on energy imports."* In comparison to liquid e-fuels which are consumed in vehicles with internal combustion engine (ICE), the application of hydrogen in fuel cell electric vehicles entails high efficiency advantages, which should be rewarded following the "*Efficiency First*"-principle.

Combining both aspects – supporting hydrogen for the application road application via a multiplier while also considering the higher efficiency compared to other RFNBOs – this option will introduce a multiplier of 2 for renewable hydrogen in road and rail transport in Art. 27(2). Whether there should be a differentiation between its use for passenger cars and heavy-duty vehicles, will be discussed in the analysis section.

Note: Renewable electricity consumed in road and rail transport can also be accounted for RES-T applying multipliers of four and 1.5, respectively (Art. 27(2)). In that case, however, the argument following recital (87) is somehow different: *"Multipliers for renewable electricity supplied for the transport sector should be used for the promotion of renewable electricity […] and in order to reduce the comparative disadvantage in energy statistics"*. This "*comparative disadvantage*" is however not specifically referring to the advantage in efficiency of battery electric vehicles compared to vehicles with internal combustion engine. It is rather justified *"Since it is not possible to account for all electricity supplied for road vehicles in statistics through dedicated metering, such as charging at home […]"*. Attempts to eliminate the existing multipliers due to these inconsistencies in justifying multipliers for RES-T are discussed in sub-option 3.3.

Electricity in ships (Possibilities to support electricity in maritime applications through adoption of a multiplier)

Emissions from ships have been of increasing concern. Currently, shipping produces about 2- 3% of all anthropogenic CO_2 emissions worldwide[556], which is on a similar level to all of Germany's emissions. As the majority of waterborne transport still relies on fossil fuels, the maritime sector offers potential to contribute to the more ambitious targets under the Green Deal.[557] International navigation emissions are presently not included at all in the GHG target scope, not even for movements between two EU MSs. It has to be considered how to include them in the EU target ambition. The International Maritime Organisation (IMO) is discussing further steps to address GHG emissions from maritime navigation to implement its initial Strategy on reduction of GHG emission from ships. The Strategy's current target of at least 50% emission reductions by 2050 falls short of EU ambition. While the Union will advocate for a strengthening of the target as part of the IMO GHG Strategy's revision in 2023, the EU needs to already consider which instruments and policies it will implement to stimulate GHG reductions of this sector. One instrument to do so is to support niche applications and feasible routes in shipping that would benefit from a multiplier for electricity used in maritime.

Currently, under RED II provisions there is a multipliers of 1.2 for all fuels in maritime in place, except for electricity. This is a shortcoming that has not been covered so far and shall be addressed in order to not disadvantage electric propulsion in the sector. Next to seaborne goods that are transported on short routes, ferries, cruise ships, and other smaller vessels, e.g. fishing vessels offer potential for increased electrification, either because their size and use are suitable for alternative means of propulsion, but also because the environmental image is a potential commercial factor, as is the case with cruise ships.

Credit mechanism for all transport energies

The option presented here is similar to the Dutch system wherein companies supplying fuel to transport, must deliver an increasing share of renewable energy annually and do this by means of so called HBEs (Hernieuwbare brandstofeendheden, i.e. renewable energy units). This would be equal to an annual obligation that relates to selected fuels and suppliers subject to an obligation. The option would always be tied to the possibility of introducing sub-objectives, for example for the use of advanced biofuels or a limit on the use of conventual biofuels. Generally, companies that import or produce fossil fuels would be obligated to ensure that renewable fuels make up a defined percentage of the company's total annual supply. Smaller suppliers could be exempt. For this option we assume that all petrol (unleaded light oil or mineral oil) and diesel (gas oil or mineral) suppliers are required to fulfil a quota through means of this credit mechanism.

Within this suggested crediting system, we introduce the renewable energy unit (REU), which is the credit that obligated companies would receive in exchange for supplying renewable fuels to any of the following modes of transport: road, rail, aviation, maritime, non-road mobile machinery, agricultural and forestry tractors. A trading system would allow participants to cooperatively deliver their mandatory share of renewable energy. They could choose whether to deliver and claim delivery of renewable energy themselves thereby creating REUs, or to buy REUs on the trading platform from

[556] In terms of CO_2, shipping is a relatively clean transport mode with CO_2 emissions of up to 60 grams per tonne-kilometre compared to road transport 180 grams per tonne-kilometre.

[557] SWD(2020) 176 final, PART 1/2.

surplus suppliers to comply with their obligations. The trading platform will need to be developed for this purpose. REUs would be generated when a producer produces a unit of renewable fuel. At the end of the of the compliance year REUs can be used by the obligated parties to demonstrate compliance. In a time-window beforehand, REUs can be traded between parties on the trading platform. Excess REUs can be carried over to the next compliance year, as can deficits, which must be made up the following year.

There is a possibility to build on existing sustainability certification schemes for transport fuels under RED/RED II. However, this would need to be jointly assessed with the subtask on certification in this assessment (document B – Energy System Integration, subtask B3) and considering the yet to be developed Union database. For example, companies that have so far used their proofs of sustainability with the national authorities to claim target compliance, could have these transformed into REUs and trade them with companies seeking to comply with their obligation.

Option 3: Option 2 + Increase in ambition level

Sub-option 3.1: Continue current approach for promotion of renewable energy in the transport sector with increased ambition

Increase of the RES-T target to 24% and the sub-target for advanced biofuels in line with CTP (5-8% by 2030)

RED II defines the Union-wide "*minimum share*" of renewable energy in transport to be 14% by 2030 (Art. 25(1)). In addition, the contribution of advanced biofuels and biogas produced from feedstock listed in Part A of Annex IX shall increase from at least 0.2% in 2020 to at least 3.5% in 2030. While MSs shall implement an obligation on fuel suppliers to ensure this target is reached, they can also use different multipliers, e.g. for electricity in road or rail transport or Annex IX biofuels when calculating the minimum share (Art. 27(2)).

As laid out by the EC, an increase in the renewable share of transport to about 24% by 2030 is expected to be necessary to reach the overall GHG emission reduction target of 55%[558]:
"The transport sector had the lowest share of renewable energy in 2015, with only 6%[559]. By 2030, this has to increase to around 24% through further development and deployment of electric vehicles, advanced biofuels and other renewable and low carbon fuels as part of a holistic and integrated approach." This assumption is also based on the EC's impact assessment on the Climate Target Plan (CTP) that projects, depending on the scenario, renewable energy shares in the transport sector of between 22% and 26% in case the 55-percent target is achieved[560].

In line with an increase of the "*minimum share*" in Art. 25(1) to 24%, a revision of the existing sub-target for Annex IX part A biofuels might be necessary (Art. 25(1) fourth subparagraph). On the contrary, an adjustment of the cap for conventional biofuels produced from food or feed crops (Art. 26(1)) (7% or below) seems unlikely.

Whereas the 24% target is a Union target, the discussion about this option could also encompass the question of the introduction of a target on MS level. Due to the vague formulation of Art. 25(1),

558 COM (2020) 562 final
559 Calculated according to the methodology as set out in Directive 2018/2001/EC.
560 SWD (2020) 176 final

requiring MSs to "*set an obligation on fuel suppliers to ensure*" that the minimum share is reached, the provision leaves scope of interpretation, what RES-T share individual MSs shall achieve. In case of an introduction of national transport targets, however, it needs to be decided whether this target should be harmonised across all MSs or whether individual targets should be formulated. The latter might especially be preferred, given the high differences existing differences between MSs in RES-T and the fact, that those differences will potentially increase in case of high market penetration of BEVs and the high multiplier for renewable electricity in road transport.

Note: Further adaption of the absolute value for RES-T (Art. 25(1) first subparagraph) as well as the target for advanced biofuels (Art. 25(1) fourth subparagraph) might be required, depending on modelling results. These results, however, were not available at the time of this report.

Introduce a sub-target for RFNBOs in line with CTP

While Art. 25(1) fourth subparagraph defines a target for the contribution of advanced biofuels and biogas (Annex IX part A) to the "*minimum share*", there is no such target for other innovative and renewable fuels, such as especially renewable transport fuels from non-biological origin (RFNBO). Since both fuel categories will need to contribute significantly to the future fuel mix in transport – also driven by the phase out of conventional biofuels until 2030 (Art. 26(1)) – the introduction of a dedicated target for RFNBOs (hydrogen and e-fuels) shall be discussed.

The analysis will take into account the issues of potential demand and scale-up, since both fuel categories are only accounting for a minor share in EU's transport fuel mix today. In addition, differences in direct hydrogen usage in transport will be discussed compared to less efficient e-fuels.

Dedicated obligation for aviation and maritime fuels

A dedicated obligation for renewable energy in the aviation and maritime sector is currently subject to concrete discussions within other initiatives like ReFuelEU Aviation or FuelEU Maritime. It is expected that future provisions will be implemented by directives or regulations, however not via the Renewable Energy Directive.

Instead, the analysis in this project will focus on the question, whether to include the domestic and international maritime and aviation sectors into the calculation of the RES-T target, as the current provision (Art. 27(1)) does not take these sector into account (in the denominator of RES-T). The detailed discussion follow in sub-option 3.2 (broaden the scope of the target to all transport modes).

The question of specific quota for RFNBOs in aviation and maritime will be discussed in document B – Energy System Integration, subtask B4.

FQD: Introduction of new fuels blends in FQD & Removal of the Article 7a target/supplier obligation and sustainability and greenhouse gas saving criteria from the FQD

The Fuel Quality Directive (FQD) includes provisions on blends of conventional fuels with biofuels. The FQD sets, in respect of road vehicles, and non-road mobile machinery (including inland waterway vessels when not at sea), agricultural and forestry tractors, and recreational craft when not at sea, technical specifications on health and environmental grounds for fuels to be used, with positive ignition and compression-ignition engines, taking account of the technical requirements of those engines and a target for the reduction of life cycle GHG emissions.

MSs shall ensure that providers of electricity for use in road vehicles may choose to become a contributor to the reduction obligation (see below) laid down in FQD Art. 7a(2) if they can demonstrate that they can adequately measure and monitor electricity supplied for use in those vehicles. MSs may permit suppliers of biofuels for use in aviation to choose to become contributors to the reduction obligation (see below) laid down in FQD Art. 7a(2), provided that those biofuels comply with the sustainability criteria set out in the FQD Art. 7b.

Council Directive (EU) 2015/652[561] lays down calculation methods and reporting requirements related to the FQD.

RED II has a somewhat different scope than FQD in including also rail and for some aspects also further transport sectors. Some elements of the RED II scope are subject to the options assessed in this study.

For petrol, FQD Art. 3 defines: *"Member States shall require suppliers to ensure the placing on the market of petrol with a maximum oxygen content of 2,7 % and a maximum ethanol content of 5 % until 2013 and may require the placing on the market of such petrol for a longer period if they consider it necessary."* According to FQD Annex I, petrol may contain a maximum of $10\%_{vol}$ of ethanol (stabilising agents may be necessary). A 5% ethanol blend to petrol ("*E5*") is suitable for all vehicles on the road today. Higher blends up to 10% ("*E10*") are suitable for most modern vehicles, however, is not compatible with some older models (see ACEA list[562]). So-called flex-fuel vehicles are required for use with high ethanol blends, up to 85%. Widespread use of high blends is limited by cold weather properties.

For diesel, FQD Annex II defines a maximum fatty acid methyl ester (FAME) content of $7\%_{vol}$ ("*B7*"). According to FQD Art. 4, however, MSs are allowed to permit the placing on the market of diesel with a FAME content beyond 7%.

While all vehicles on the road are compatible with B7, the compatibility of higher blends with exhaust treatment in cars and cold weather properties is limited, and the lower energy content of FAME compared to diesel and reduced storage stability are critical as well.

"The FQD does not explicitly set maximum blending limits for drop-in biofuels such as pure diesel-like hydrocarbons made from biomass using the Fischer-Tropsch process (BTL, Biomass to Liquid) or hydro-treated vegetable oil (HVO)."[563] The same holds for drop-in RFNBOs (also called PTL, Power to Liquid). *"However, as the scope of the FQD is defined as petrol, diesel and gas oil containing at least 70% by*

[561] Council Directive (EU) 2015/652 of 20 April 2015 laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels (OJ L 107, 25.4.2015, p. 26).
[562] ACEA. (2018). List of ACEA member company petrol vehicles compatible with using 'E10' petrol. Available at: https://www.acea.be/uploads/publications/ACEA_E10_compatibility.pdf
[563] ICF et al. (2015). Impact of higher levels of bio components in transport fuels in the context of the Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998, relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC.

weight of petroleum oils and of oils obtained from bituminous minerals, their share must remain below 30% by weight."[564]

Also, in practice HVO blends are limited by the current diesel specification EN 590, which sets limits for the density of diesel fuels that HVO and other paraffinic fuels do not meet. A new standard EN 15940 has been made for such paraffinic fuels. Not all, but many, vehicle manufacturers have approved the use of EN 15940 fuels in their diesel vehicles without modifications.

The FQD requires MSs to ensure the provision of appropriate information to consumers concerning the biofuel content of fuels.

This aspect of option 2 analyses the impact of introducing higher fuel blends into the revision of RED II.

According to RED II, MSs have the freedom to express their obligation on fuel suppliers either through targeting volumes, energy content, or greenhouse gas emissions as long as they demonstrate minimum target compliance (Art. 25(1)). See option 4 below for a discussion of the expression of the obligation.

As long as volumes are specified for each renewable fuel separately, volume targets can be easily translated into an energy target. Thus, expressing the obligation on fuel suppliers in terms of volumes or in terms[565]. However, expressing the obligation in terms of GHG reduction is structurally different from an energy/volume approach. RED II (Art. 29 (10) for biofuels), among others, defines GHG reduction values eligible renewable transport fuels need to fulfil. These reductions thresholds lie, depending on the fuel and other factors, between 50% and 70%. In the energy perspective, fuels with a 70% GHG reduction provide for the same contribution to the obligation as fuels with a 100% GHG reduction. In the GHG perspective, however, these two fuels provide for obvious differences.

In addition to RED II defining a minimum share based on energy for 2030, the Fuel Quality Directive (FQD) defines a GHG reduction target. The FQD in Art. 7a requires a reduction of the greenhouse gas intensity of transport fuels by a minimum of 6% by 2020. MSs are obliged to ensure that suppliers respect the target of 6% also after the year 2020. This target can be achieved through both renewable and non-renewable fuels.

As a consequence, there is currently a renewable fuel target for 2030 through RED II, and a GHG reduction target for 2020 and thereafter through FQD, which both need to be achieved through MSs putting an obligation on fuel suppliers. This has led to the situation that MSs have established different types of obligations on fuel suppliers: in terms of volumes, in terms of energy, or in terms of GHG reduction.

The FQD also sets monitoring and reporting obligations of life cycle greenhouse gas emissions per unit of energy supplied to transport. These also remain applicable after 2020. Furthermore, FQD sets minimum GHG emissions savings requirements for biofuels to be counted towards the obligation; these

[564] Ibid.

[565] Art. 27(1c) defines which values regarding the energy content of transport fuels are to be used for converting volumes into energy.

were in line with RED. However, RED II strengthened these requirements so that the approaches in RED II and FQD are not identical any more.

Both the Renewable Energy Directive (RED; 2009/28/EC) and the FQD regulated the sustainability of biofuels in a consistent way. Recital 3 of Directive (EU) 2015/1513 of 9 September 2015, amending Directive 98/70/EC (FQD) and amending Directive 2009/28/EC (RED), emphasizes: "*Directive 2009/28/EC sets out sustainability criteria with which biofuels and bioliquids need to comply in order to be counted towards the targets in that Directive and to qualify for inclusion in public support schemes. The criteria include requirements on the minimum greenhouse gas emission savings that biofuels and bioliquids need to achieve compared to fossil fuels. Identical sustainability criteria for biofuels are set out in Directive 98/70/EC.*" RED II, however, strengthened criteria for ensuring bioenergy sustainability, so that the approaches in RED II and FQD are not identical any more.

This option analyses the impact of removing the Art. 7a target/supplier obligation and the sustainability and greenhouse gas savings criteria from the FQD as well as of introducing higher fuel blends into the revision of RED II.

Sub-option 3.2: Broaden the scope of the target to all transport modes

Introduction of a RES-T target covering road rail, maritime and aviation sectors

The incomplete coverage of all transport sectors in the "*minimum share*" overestimates the actual share of renewable energies in transport. Whereas fuels from renewable sources supplied to all transport sectors, including renewable electricity for road and rail transport, are considered for the calculation of the numerator (Art. 27(1b)), the denominator only includes the energy content of fuel and electricity supplied for road and rail sectors. In addition, RFNBOs as intermediate product, e.g. in conventional fuel production in refineries, are not considered in the denominator at all.

To overcome the deviations between RES-T and the actual renewable energy share in transport, especially maritime and aviation sectors should be included in the calculation of the denominator. Beside the explanations on an increased ambition level described in sub-option 3.1, due to the consequently decreasing value of RES-T, the targeted "*minimum share*" for 2030 (for an increased ambition level) needs to be corrected appropriately, to take the effect of the changed calculation methodology into account. The same would apply for sub-targets for RFNBOs or advanced biofuels.

There are, however, different options, whether to include only domestic shipping and aviation or to which degree also international transport activities in those sectors should be considered. Airlines and shipping companies might be incentivized to shift their fuelling activities to non-EU countries, to bypass the fuel obligations for fuel supplier. The respective risk of fuel bunkering (maritime) and fuel tankering (aviation) shall be considered.

Dedicated obligation for aviation and maritime fuels

See description sub-option 3.1

Sub-option 3.3: Option 3.2 + eliminate or streamline multipliers (adapting the target accordingly)

To promote certain types of fuels, the RED II provides the possibility to apply multipliers for the purpose of demonstrating compliance with both, the minimum share of 14% renewable energy in transport as well as the increasing sub-mandate for advanced biofuels (see Article 27(2)). Both renewable energy targets aim at MSs, which “*shall set an obligation on fuel suppliers*” to ensure that those targets are achieved (Art. 25(1)). These multipliers have already been subject to changes between RED I and RED II. In the current version, all biofuels and biogas from feedstocks in Annex IX (part A and B) receive a multiplier of two (based on their energy content), whereas renewable electricity shall be considered with multipliers of four (in case of road transport) and 1.5 (in case of rail transport). Fuels supplied to the maritime and aviation sector can be counted with a factor of 1.2, in case they are not produced from food or feed crops. Since there are no specifications in Article 27(2), whether to apply the multipliers only to the numerator of the minimum shares defined in Article 25(1), they shall be applied to both, numerator and denominator.

A general problem with the usage of multipliers however exists: Whereas they provide an incentive to bring specific fuels to the transport sector, they decrease the actual amount of renewable fuels brought to the system, since targets and sub-mandates can be fulfilled with a lower volume of these fuels. Subsequently, two variants will be evaluated, namely Sub-variant A, which discusses possibilities to eliminate multipliers, and Sub-variant B, which evaluates to what extent existing multipliers can be streamlined.

Stakeholders during the workshop had mixed opinions and the general sentiment seem to be against multipliers, which is also confirmed by the OPC results, as laid out in section *Objectives*. Especially the factor of four for renewable electricity in road (Art. 27(1)) is seen ambiguously. For some, it is unclear how they are being justified. Some support it in absence of a better system (although it is a generous mechanism), since the contribution of renewable electricity in transport will be limited until 2030. Removing the multiplier would penalize energy efficiency. In contrast to that, the biofuel industry sees the risk of an inflation of multipliers. Stakeholders’ opinion is that for the maritime and aviation sector existing multipliers should be increased, since the model has worked for electricity in road transport, while the progress in increasing the RES share in maritime and aviation has been limited. Nonetheless, in general for fuel suppliers the rationale behind multipliers is already difficult to understand (mirrored in several questions and comments from the audience during the stakeholder workshop).

Sub-variant A: Eliminate

The current reasoning, namely that it is not possible to account for all electricity supplied for road vehicles in statistics through dedicated metering, such as charging at home, and that therefore multipliers should be used in order to ensure that the positive impacts of electrified renewable energy-based transport are properly accounted for (see RED II recital 87), is potentially invalid if sound national estimates (e.g. as available in Germany), that closely depict the de facto shares of renewable electricity supplied for road vehicles, are adopted. As mentioned in the problem definition, there is a potential risk of double counting when a BEV charges at public charge points but is at the same time accounted for through the domestic fuel supplier. Next to eliminating the multipliers for electricity – for example, through the adaption of new measures to capture the amount of renewable electricity in transport, or through introducing a central database and standardized submission and accounting protocols obligatory for all EV and charging points – this sub-variant also removes all other multipliers and adapts the target to the de facto renewable share in transport.

Sub-variant *B: Streamline*

While multipliers, inter alia, "*water up*" the *actual* renewable fuels in transport (i.e. the physical consumption of renewable energy), they do reflect the comparatively higher efficiency of direct electrification in transport, for example.[566] This is rooted in the "*efficiency-first*" principle, as battery-electric vehicles (BEV) have a higher well-to-wheel efficiency from RES-E as e.g. biofuels (because of the highly inefficient internal combustion engine) or hydrogen (because of the conversion losses to produce hydrogen and then in the fuel cell to produce electricity onboard the vehicle) and much more so compared to PtL fuels synthesised from RES-H_2 (because they are used in highly inefficient internal combustion engines). However, the high efficiency of BEV will be more and more compromised through quick charging (requiring buffer batteries in the recharging) and developing storage requirements in the grids caused by demand peaks when users charge.

Furthermore, multipliers can, to a certain extent, ensure that the varying degrees of maturity and the cost of different technologies across MSs are accounted for (compare Art 25(1) subparagraph 2).

This sub-variant serves to strike a balance between maintaining a certain incentive for different technologies, reflecting the evolving comparative efficiency of different fuels, and to simplify and streamline the use of multipliers. The streamlined multipliers are a result of close communication with the European Commission's Directorate-General for Energy, reassessing the existing literature, i.e. past assessments, policy briefs and commentaries, as well as several rounds of general consultation on the topic with stakeholders from various sectors. For example, currently, there is no reason to not equip electricity for marine applications with the same multiplier (1.2) used for other fuels supplied in the sector. On the contrary, the exclusion of electricity may disadvantage certain (niche) applications. Similarly introducing a multiplier for RFNBOs would create a more level playing field for innovation and eventual commercial viability of some RFNBOs, including hydrogen in road. Table 2-1 summarizes the changes to be assessed.

[566] Renewable electricity in battery-electric vehicles has significantly higher efficiencies from "well-to-wheel" than conventional vehicles using fossil fuels or biofuels in internal combustion engines. Hydrogen fuel cell-electric vehicles take an intermediate position as hydrogen production from renewable electricity has certain losses, and reconversion of hydrogen in fuel cells on-board the vehicle into electricity has losses, which are, however, much lower than the energy losses in internal combustion engines. Also, systemic effects such as hydrogen production supporting the integration of increasing shares of fluctuating renewables into the electricity system need to be taken into account. Or the increasing need for load management through electric vehicle charging, notably fast charging, may reduce the efficiency of battery-electric vehicles; this could at least partly be mitigated by smart charging and vehicle-to-grid solutions (see Annex B Energy System Integration, subtask B2). Furthermore, renewable electricity is not imported into the EU in significant amounts, while renewable hydrogen could be imported tapping substantial solar and wind resources in neighbouring regions.

Table 2-1: Comparison between current multipliers under RED II and the streamlined multipliers

Fuels & Sector	Current multipliers	Streamlined multipliers
Renewable electricity for road transport	4	2.5
Introduce: Renewable hydrogen for road transport	-	2 (see Option 2)
Renewable electricity for rail transport	1.5	-
Biofuels from food- and feed-based feedstocks	-	-
Biofuels and biogas for transport from feedstocks listed in Part Annex IX	2	2
Biofuels and biogas for transport from feedstocks listed in Part B Annex IX	2	-
Renewable fuels supplied to the maritime sector (except of food- or feed-based fuels, except electricity in maritime)	1.2	1.2
Renewable fuels supplied to the aviation sector (except of food- or feed-based fuels, except electricity in maritime)	1.2	-
Introduce: Renewable electricity in maritime	-	1.2/1.5 (see Option 2)
Introduce: RFNBOs in all transport sectors including maritime and aviation	-	1.5
Introduce: RFNBOS used as intermediate product in conventional fuel production, i.e. mainly renewable hydrogen for refineries	-	1.5

Option 4: Option 3 + Partly harmonise and simplify target and obligation

Sub-option 4.1: Further harmonisation of the scope of the supply obligation

Following the provisions in RED II Art. 25(1), "*each Member State shall set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy in the transport sector is at least 14 % by 2030 (minimum share)*". The details of such obligation is to be defined by each MS individually. As explicitly laid out in subparagraph two, "*Member States may exempt, or distinguish between, different fuel suppliers and different energy carries [...]*". As a consequence, obligations differ between MSs as to

- the different fuel suppliers obligated;
- the different energy carriers covered by the obligation;
- the transport sectors covered.

Further non-mandatory provisions for the obligation on fuel suppliers include the application of multipliers (Art. 27(2)), and the possibility to include recycled carbon fuels[567] in the obligation (Art. 25(1) third subparagraph). Also, the cap on conventional biofuels (Art. 26(1)), the cap on the share of high indirect land-use change-risk biofuels (Art. 26(2)), the cap on the share of biofuels and biogas produced from the feedstock listed in Part B of Annex IX, and the minimum shares of advanced biofuels and biogas produced from the feedstock listed in Part A of Annex IX (Art. 25(1)) may be included in the

[567] In addition, Members States can choose to include recycled carbon fuels as renewable energy in the numerator RED II Art. 27(1b)., or not, although they are based on non-renewable sources of energy.

obligation. These latter provisions are mandatory for the calculation of the minimum shares, in contrast, for all MSs[568].

Whereas the rationale behind these provision is to ensure "*varying degrees of maturity and the cost of different technologies*" (Art. 25(1) second subparagraph)), the existence of several national fuel markets supports the development of independent and non-comparable national fuel mixes in the transport sector, where, due to different obligations and target framing, certain fuels are favoured over others in different geographies.

This heterogeneous situation is furthermore supported, since MSs are free to set specific penalties on fuel suppliers for non-compliance, which creates the possibility for obligated parties to optimize obligation fulfilment within different MSs, while creating administrative costs, both for fuel suppliers and MSs.

Penalties to be imposed on fuel suppliers for non-compliance with the obligation are not defined in RED II. However, FQD Art. 9a relates to penalties applying to the obligation as defined in FQD: "*Member States shall determine the penalties applicable to breaches of the national provisions adopted pursuant to this Directive. The penalties determined must be effective, proportionate and dissuasive.*"

Option 4 focuses the impact of further harmonisation of the obligation in the different aspects mentioned above and of the minimum share at MS level. For the calculation of the minimum shares of renewable energy within the final consumption of energy in the transport sector referred to in Art. 25(1), Art. 27 defines the details. Issues related to the calculation of the numerator are listed above. The denominator covers most, but not all, transport fuels consumed in road and rail transport; as an example, Liquified Petroleum Gas (LPG) is not included. Also, the denominator does not include transport fuels consumed in other transport sectors such as aviation or maritime as well as hydrogen as intermediate product (RFNBOs only included in numerator).

Sub-option 4.2: Sub-option 4.1 + Define the way the supply obligation is expressed

According to RED II, MSs have the freedom to express their obligation on fuel suppliers either through targeting volumes, energy content, or greenhouse gas emissions as long as they demonstrate minimum target compliance (Art. 25(1)).

In case volumes are specified for each renewable fuel separately, volume targets can be easily translated into an energy target. Thus, expressing the obligation on fuel suppliers in terms of volumes or in terms of energy can thus be taken as equivalent[569].

However, expressing the obligation in terms of GHG reduction is structurally different from an energy/volume approach (see also the FQD approach as described under option 2 above). RED II (Art. 29(10) for biofuels) among others defines GHG reduction values eligible renewable transport fuels need to fulfil. These reductions are, depending on the fuel and other factors, between 50% and 70%. In

[568] With an exception for Cyprus and Malta relative to the share of biofuels and biogas produced from the feedstock listed in Part B of Annex IX. MSs may, where justified, modify that limit, taking into account the availability of feedstock. Any such modification shall be subject to approval by the Commission.
[569] Art. 27(1c) defines which values regarding the energy content of transport fuels are to be used for converting volumes into energy.

the energy perspective, fuels with a 70% GHG reduction provide for the same contribution to the obligation as fuels with a 100% GHG reduction. In the GHG perspective, however, these two fuels provide for obvious differences.

This option analyses the impact of continuing with the current approach of RED II to expressing the obligation where MSs can decide whether to express the obligation in terms of energy, GHG emission savings or volume, versus revising this towards a harmonized approach where all MSs express the obligation in terms of energy, or all in terms of GHG emission savings.

Option 5: Option 4 + Detailed specification of supply obligation and no targets

This option builds on option 4 above. It analyses the impact of a full harmonization of the obligation on fuel suppliers at EU level (scope: eligible fuels, fuel suppliers, and sectors) combined with a harmonized approach where all MSs express the obligation in terms of energy, or all in terms of GHG emission savings. The obligation will include a minimum share to be achieved through the obligation in each MS individually; the definition and calculation of a national target will thus not be needed in this option.

Mapping of potential impacts

This section presents an overview of the potential economic, environmental, and social impacts identified for the different policy options to be assessed, summarising the following criteria as follows:

- **Direction: Positive or negative;**
- **Magnitude: limited or significant;**
- **Horizon: Short to long term;**
- **Affected parties: following categorization indicated below.**

Option 0: Baseline

The baseline option focusses the promotion of renewable energies in transport on renewable electricity in road and rail as well as biofuels, especially those from Annex IX part A (advanced biofuels). Since MSs have a high degree of freedom in setting the obligation on fuel suppliers (in terms of scope, sectors, penalties, etc.), the national implementations of RED II will result in a heterogenous regulatory framework in EU27. It can be expected that based on the existing provisions, the RES-T target of 14% in transport will be achieved, especially in case of a significant ramp up of battery electric vehicles in several MSs. The actual share of renewable energy in all transport sectors will, however, be lower, since the current calculation methodology takes multipliers into account and does not cover the maritime and aviation sectors.

Table 2.2 Impacts mapping for Option 0

Option 0 - impacts map	economic	environmental	social
Direction: Positive or negative	Positive (renewable electricity, advanced biofuels) Negative (administrative burden)	Positive	Positive (Job creation)
Magnitude: limited or significant	Medium	Limited (RES-T = 14%)	Medium
Horizon: Short to long term	Short to mid term	Mid term	Short to mid term
Affected parties	Fuel suppliers / RES electricity suppliers	Transport sector; National governments	BEV supply chain

Option 1: Non-regulatory measures

Option 1 covers different non-regulatory measures, including

- market-based instruments (like R&D funding programmes);
- self-regulation & co-regulation (voluntary agreements); or
- information and co-education (labelling or events).

Table 2.3 Impacts mapping for Option 1

Option 1 - impacts map	economic	environmental	social
Direction: Positive or negative	Market-based: positive Self/Co-regulation: positive Educational: positive	Market-based: positive Self/Co-regulation: positive Educational: positive	Market-based: positive Self/Co-regulation: positive Educational: positive
Magnitude: limited or significant	Market-based: significant Self/Co-regulation: significant Educational: limited	Market-based: significant Self/Co-regulation: significant Educational: significant	Market-based: limited Self/Co-regulation: limited Educational: limited
Horizon: Short to long term	Market-based: short-term Self/Co-regulation: long-term Educational: long-term	Market-based: long-term Self/Co-regulation: long-term Educational: long-term	Market-based: long-term Self/Co-regulation: long-term Educational: long-term
Affected parties	Market-based: transport sector (Fuel producers, suppliers, OEMs), public Self/Co-regulation: Fuel producers, suppliers, OEMs, administration Educational: Public administration	Market-based: transport sector Self/Co-regulation: public, administration Educational: public, administration	Market-based: transport sector, administration, public Self/Co-regulation: transport sector, admin. Educational: public, administration,

Option 2: Incremental Improvements

Option 2 covers different incremental elements, including support for hydrogen in road and rail as well as renewable electricity in maritime applications. For the latter, the effect of the measures is expected to be limited, as major burdens around taxation, upfront investments as well as technological feasibility and security concerns remain. In addition, it introduces a credit mechanism to establish a market mechanism allowing fuel suppliers to fulfil the dedicated supply obligations set out for the road, maritime and aviation sectors in a flexible manner. A credit mechanism that allows trading of renewable energy units would optimise the market related to the supply obligation for fuel suppliers at European level, instead of MS-level, and benefit the RES share in the transport sector.

Table 2.4 Impacts mapping for Option 2

Option 2 - impacts map	economic	environmental	social
Direction: Positive or negative	H_2: positive Maritime: positive Credit mechanism: positive	H_2: positive Maritime: positive Credit: positive	H_2: positive (jobs) Maritime: positive Credit: positive
Magnitude: limited or significant	H_2: limited Maritime: limited Credit: significant	H_2: limited Maritime: limited Credit: significant	H_2: limited Maritime: limited Credit: limited
Horizon: Short to long term	H_2: long term Maritime: long term Credit: long-term	H_2: long term Maritime: long-term Credit: long-term	H_2: long term Maritime: long-term Credit: long-term

Affected parties	H_2: fuel suppliers for FCEVs Maritime: vessel operators Credit: transport	H_2: H_2-sector Maritime: vessel operators Credit: transport	H_2: H_2 supply chain Maritime: vessel operators Credit: transport

Option 3: Option 2 + Increase in ambition level

Option 3 encompasses different measures with the overall goal to increase the ambition level as required according to the assessment in the CTP.

Sub-option 3.1: Continue current approach for promotion of renewable energy in the transport sector with increased ambition

Following the existing approach for calculating RES-T, sub-option 3.1 aims at achieving higher shares of renewable energy with an increased target for the transport sector. The option also includes the introduction of a sub-target for RFNBOs and a adaption of the existing target for advanced biofuels (Art. 25(1) fourth subparagraph) in line with the CTP. Both measures with foster the ramp up of these innovative fuels. Consequently, as described for the baseline scenario in option 0, the focus of fuel suppliers will be on increasing the share of renewable electricity as well as biofuels in transport. Via this, they can – due to high multipliers – ensure to achieve the supply obligations building on the increased targets above. Still, shortcomings of the current approach, e.g. like inconsistencies in multipliers, non-harmonised regulation within EU27 or incomplete sector coverage in RES-T, will remain.

Also, the introduction of new fuels blends in FQD and the removal of the target/supplier obligation and sustainability and greenhouse gas saving criteria from the FQD are addressed.

Table 2.5 Impacts mapping for Option 3.1

Option 3.1 - impacts map	economic	environmental	social
Direction: Positive or negative	Ambition level and sub-targets: Positive FQD: positive	Ambition level and sub-targets: Positive FQD: positive	Ambition level and sub-targets: Positive (Job creation) FQD: negative
Magnitude: limited or significant	Ambition level: Medium Adv. biofuels: medium RFNBOs: signficant[1] FQD: limited	Ambition level and sub-targets: Medium (RES-T = 24%) FQD: limited	Ambition level and sub-targets: Medium FQD: limited
Horizon: Short to long term	Ambition level: Short to mid term RFNBOs / adv. biofuels: long term FQD: short-term	Ambition level: Mid term RFNBOs / adv. biofuels: mid- to long term FQD: long-term	Ambition level: Short to mid term RFNBOs / adv. biofuels: mid- to long term FQD: short-term
Affected parties	Fuel suppliers (RFNBOs, adv. Biofuels)/ RES electricity suppliers FQD: fuel suppliers; public administration	Transport sector; National governments FQD: fuel suppliers	BEV, RFNBOS and adv. biofuel supply chain FQD: fuel suppliers, public administration

Sub-option 3.2: Broaden the scope of the target to all transport modes with increased ambition

Sub-option 3.2 builds on the existing methodology for calculating RES-T, but broadens the scope to include also the maritime and aviation sector (A&M) into the calculation of the denominator. While there are several open questions with regard to bunkering and tinkering and how international transport from outside the EU should be handled, one general effect can be expected based on this provision: As a consequence, the achieved shares of renewable energy in the transport sector will decrease in all MSs, forcing governments to implement stronger obligations on fuel suppliers to reach the sectoral target and the sub-mandate for advanced biofuels (and RFNBOs). It seems reasonable to expect that MSs will include suppliers for fuels in the aviation and maritime sector in their overall obligation for fuel suppliers, given that the additional economic burden will otherwise be placed on suppliers in the other transport segments.

Table 2.6 Impacts mapping for Option 3.2

Option 3.2 - impacts map	economic	environmental	social
Direction: Positive or negative	A&M: negative RFNBOs / adv. biofuels: positive	Positive	Negative (costs) Positive (job creation)
Magnitude: limited or significant	A&M: medium RFNBOs: signficant[1] Adv. biofuels: medium	Medium	Medium
Horizon: Short to long term	A&M: short term RFNBOs / adv. biofuels: long term	Medium to long term	Medium to long term
Affected parties	A&M sector RFNBOs producers Producers of adv. biofuels	Transport sector Ports	Freight/Cargo companies, passengers (cost) RFNBO and adv. biofuel industry (jobs)

[1]*depending on the target*

Sub-option 3.3: Option 3.2 + eliminate or streamline multipliers (adapting the target accordingly)

In sub-option 3.3, two variants for dealing with multipliers for RES-T calculation are proposed:

- Variant a: eliminating multipliers;
- Variant b: streamlining multipliers.

Table 2.7 Impacts mapping for Option 3.3 Variant a

Option 3.3- Variant a - impacts map	economic	environmental	social
Direction: Positive or negative	Positive	positive	positive
Magnitude: limited or significant	limited	limited	limited
Horizon: Short to long term	Long-term	Long-term	Long-term
Affected parties	Transport Sectors Fuel Suppliers	Transport sectors	Fuel suppliers, public

Table 2.8 Impacts mapping for Option 3.3 Variant b

Option 3.3- Variant b - impacts map	economic	environmental	social
Direction: Positive or negative	Positive	Positive	Positive
Magnitude: limited or significant	limited	limited	limited
Horizon: Short to long term	Long-term	Long-term	Long-term
Affected parties	Transport Sectors Fuel Suppliers	Transport sectors	Fuel suppliers, public

Option 4: Option 3 + Partly harmonise and simplify target and obligation

Option 4 covers, in addition to the measures of option 3, an increased, but not full, harmonisation of the supply obligation put on fuel suppliers by the MSs. Sub-option 4.1 focuses on the harmonisation of elements of the supply obligation, while sub-option 4.2 adds the harmonisation of the way the supply obligation is expressed (energy, GHG reduction, volume). Main impacts related to efficiency gains in public administrations and for fuel suppliers, which correlate to direct job losses; however, indirectly, efficiency gains may allow for new job creation through the economics benefits and potential for additional business. Environmental benefits mainly link to the integration of the market for renewable energies in transport eliminating possibilities for arbitrage by fuel suppliers between MSs.

Sub-option 4.1: Further harmonisation of the scope of the supply obligation

Table 2.9 Impacts mapping for Option 4.1

Option 4.1 - impacts map	economic	environmental	social
Direction: Positive or negative	positive	positive	negative
Magnitude: limited or significant	significant	significant	limited
Horizon: Short to long term	short-term	long-term	short-term
Affected parties	fuel suppliers; public administration	fuel suppliers	fuel suppliers, public administration

Sub-option 4.2: Sub-option 4.1 + Define the way the supply obligation is expressed

Table 2.10 Impacts mapping for Option 4.2

Option 4.2 - impacts map	economic	environmental	social
Direction: Positive or negative	positive	positive	negative
Magnitude: limited or significant	significant	significant	limited
Horizon: Short to long term	short-term	long-term	short-term
Affected parties	fuel suppliers; public administration	fuel suppliers	fuel suppliers, public administration

Option 5: Option 4 + Detailed specification of supply obligation and no targets

Option 5 builds on option 4, but fully harmonizes at EU level the supply obligation and the way it is expressed. Generally speaking, the impacts are similar to those of option 4. However, some deviations, both positive or negative compared to option 4, are possible as a full harmonization at EU level does not allow for benefitting from national characteristics.

Table 2.11 Impacts mapping for Option 5

Option 5 - impacts map	economic	environmental	social
Direction: Positive or negative	positive	positive	negative
Magnitude: limited or significant	significant	significant	limited
Horizon: Short to long term	short-term	long-term	short-term
Affected parties	fuel suppliers; public administration	fuel suppliers	fuel suppliers, public administration

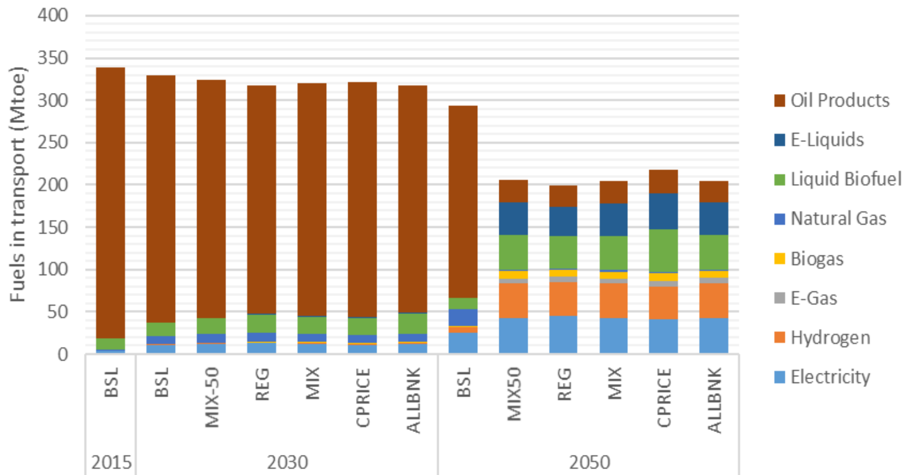
Analysis

Based on the highly heterogenous character of the different options proposed in this section as well as the different aspects to be addressed in each policy option, the semi-quantitative and qualitative assessment in the following is performed for each option separately, focusing on the most important economic, environmental, or social impacts. Where impacts are analysed without focus on a specific option, these are presented subsequently in sections 3.7 to 3.9.

Option 0: Baseline

For an assessment of the baseline scenario, it is referred to the impact assessment of the CTP and the discussed baseline scenario (BSL) there.[570] Figure 3-1 shows contribution of different fuels in the energy demand of transport in transport: for renewable fuels, this will remain limited in the baseline scenario, even by 2050. Accordingly, existing measures will not be sufficient for the transport sector to significantly contribute to the efforts required to meet the ambitious climate reduction targets by 2030 and 2050.

Figure 3-1: Fuels in transport (including aviation and maritime navigation) (Source: SWD(2020) 176 final)



Option 1: Non-regulatory measures

Non-regulatory measures can have important impacts, which, generally speaking, will be limited and most probably not achieve the increased ambition level for 2030. As such, they should be considered as a complement to the other policy options described below, but would not be sufficient to achieve the new 2030 target.

Market-based measures

Market-based measures, including R&D funding programmes like the European 'Horizon 2020', support innovation and global competitiveness of the European economy, but have limited impact on the adoption rates of technologies and solutions in commercial markets.

Funding mechanisms such as a green mobility fund or similar, which award financing to certain green mobility projects based on calls for proposals or auctioning, incentivise innovation on a competitive basis. Their impact, however, largely depends on the funds available.

[570] SWD(2020) 176 final.

Similarly, national or EU-wide carbon contracts for difference (CCfD) as e.g. indicated in the EC's Hydrogen Strategy, are a mechanism to bridge the gap between a market price for green hydrogen and the actual price including any ETS cost, likely based on an auction system. CCfDs may be more applicable to industry applications of hydrogen than for transport, which limit their impact for transport accordingly. Where CCfDs would be awarded to specific sectors separately, e.g. industry or transport, there would be no competition between these sectors, and funds would be distributed between the sectors by policy decision. Where they are not sector-specific, there would be competition between the sectors based on CO_2 reduction costs.

Market-based measures and regulatory measures (see options 2-5 below) are not mutually exclusive.

Supporting transport electrification with a variety of market-based measures (including those mentioned above) has a specifically strong lever compared to other renewable energies in transport, as it may help overcome initial barriers to market uptake, e.g. higher upfront costs. Also, increased use of electricity in transport is a consequence of having electric vehicles on the road. The primary concern of consumers is about purchasing an electric vehicle, not necessarily about the fuel that their old or new vehicles consume. Instruments to do so include a range of market-based policy instruments that MSs are already using. Along with guidance or additional funds from the European Union, such instruments could be strengthened and also made available to more citizens across MSs. Instruments include subsidies for purchasing EVs or ownership taxes applied to commercial vehicles that include CO_2 emission levels in the final invoice. Targeted measures towards electric vehicle uptake in the market will increase electricity consumption in transport and generally add to the panoply of positive externalities related to system integration that are discussed in document B – Energy System Integration, subtask B2. Supporting the implementation of a sufficient recharging infrastructure is a further key prerequisite for such an uptake.

Self-regulation & co-regulation

Convergence of governance and/or national schemes as well as regional co-operation supported by active coordination and guidance by the EC could play an important role. However, the impact on increased renewable energies in transport is indirect and difficult to quantify. A major field of potentially relevant impact is the EU-wide harmonization and co-ordination of recharging and hydrogen refuelling infrastructures. Here, further co-ordination beyond EU borders, e.g. towards the Balkans, and other non-EU European countries, e.g. in co-operation with the Energy Community and the Transport Community, can help remove fundamental barriers to market uptake. In the Energy Community contracting parties, which have close connections to the EU in terms of transport including for tourism, building up recharging and hydrogen refuelling infrastructures can remove (perceived) barriers for vehicle uptake also in the EU. Supportive frameworks could also accelerate the market uptake of electric and hydrogen vehicles in these neighbouring countries as shown by electric vehicle uptake in Ukraine for example.[571]

[571] LBST, E4tech & S.E.E.C. (2020). Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties. Available at: https://www.energy-community.org/documents/studies.html

Information and co-education

Analysing the influence of soft measures such as information and co-education efforts working to change behaviour of citizens is difficult. In any case, such measures can complement other policy measures, but have limited impact on their own.

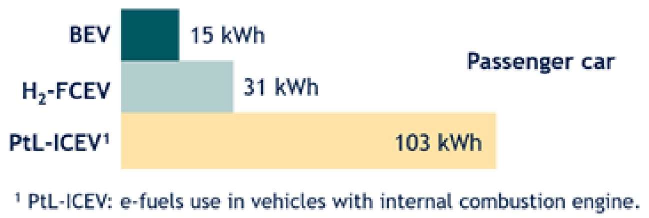
Option 2: Incremental improvements

More favourable treatment of hydrogen in road and rail

Differentiation between hydrogen in transport and RFNBOs

Existing provisions in RED II lack a clear differentiation between hydrogen on the one hand and hydrogen-based e-fuels on the other hand. Hydrogen is used as fuel for highly efficient fuel cells in fuel cell electric vehicles (FCEV) in transport or for small or large CHP units for electricity and heat production in heating and cooling. Hydrogen-based e-fuels (e.g. Power-to-Liquid (PtL) diesel, PtL kerosene), in contrast, require significantly more energy for their production (conversion losses) and are mainly used as fuel in less efficient combustion engines (see Figure 3-2).[572] While e-fuels allow decarbonising existing fleets and installations in a transition period, they should in the long-term only be used for applications which require their high volumetric energy densities, e.g. in long-distance aviation or maritime applications.

Figure 3-2: Renewable electricity demand for different drivetrains (kWh per 100 km) (Source: LBST based on Agora Energiewende 2017).



The lack of differentiation between hydrogen and (gaseous or liquid) e-fuels in the current definition of RFNBOs within RED II does not allow for a targeted promotion of highly efficient technologies, which the efficiency-first principle would require. Besides that, common understanding of efficiency often promotes direct electrification over indirect electrification with fuel cell electric vehicles. While this approach is valid for the case where a battery electric vehicle (BEV) is directly charged with renewable electricity at or near the location of its production, the overall efficiency relation changes in future scenarios with high amounts of fluctuating renewable electricity in the system. In those cases where no direct correlation between electricity production and demand exists or even no connection via the electricity grid is feasible (e.g. renewable electricity production outside the European Union), electricity has to be transformed into chemical energy carriers like hydrogen or hydrogen carriers for storage and/or for transport. This will narrow the efficiency gap between the application in BEVs, fuel cell electric vehicles (FCEVs), or even to a certain extent in vehicles with internal combustion engines fuelled with liquid e-fuels. Essentially, where renewable electricity needs to be transformed into hydrogen for storage and grid balancing purposes, or for facilitating long-distance transport of renewable energy, BEVs and FCEVs are roughly equal in overall efficiency as the transformation into

[572] Agora Verkehrswende. (2017). Mit der Verkehrswende die Mobilität von morgen sichern. 12 Thesen zur Verkehrswende. Available at: https://static.agora-verkehrswende.de/fileadmin/Projekte/2017/12_Thesen/Agora-Verkehrswende-12-Thesen_WEB.pdf

hydrogen and re-electrification steps are included in both pathways. Furthermore, with renewable energy imports expected to be a relevant element of future supply it is important to take a more holistic view on energy efficiency as solar and wind yields in other parts of the world may be around double those in the European Union.[573]

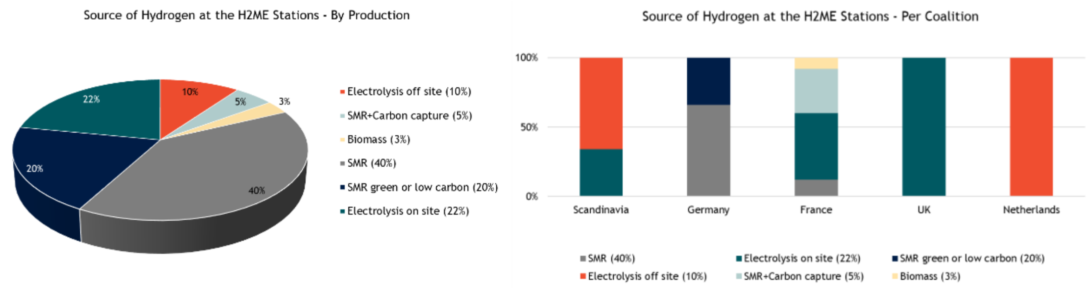
RFNBOs also provide long-term storage and therefore buffer characteristics, which are indispensable in a highly renewable-based energy system for system stability and overall system efficiency. The potential of hydrogen as future energy carrier is also underlined by industry activities: in April 2021, 23 European gas transport system operators (TSOs) have published a report, where an updated and extended version of the 2020 "*European Hydrogen Backbone*" is described. According to this concept, the gradual creation of a dedicated hydrogen transport infrastructure will comprise 11,600 km by 2030. Furthermore, the initiative envisages an extension of the grid to 266,100 km by 2035 and 39,700 km by 2040 with estimated total investment cost of €43-81 billion.[574]

Potential market ramp-up for FCEVs

Focussing on the role of RFNBOs in the transport sector today, the number of fuel cell electric vehicles (FCEVs) and hydrogen refuelling stations (HRS) is very limited. Based on data by Hydrogen Mobility Europe, in 2019, about 1,700 cars, 260 vans, and nearly 100 buses and trucks were deployed in the EU, as well as two hydrogen trains.[575] Based on data from H2stations, the number of hydrogen refuelling stations increased to 177 until the end of 2019.[576] However, the high dynamics in the political discussion around hydrogen as well as the targeted installation of 40 GW electrolyser capacity until 2030 may trigger a significant uptake of hydrogen technology in the road and rail transport sector.

At the same time, it has to be noted that today the overall hydrogen supplied to HRS is not produced exclusively via electrolysis. The respective data of 37 hydrogen refuelling stations in 8 countries deployed in the context of the Hydrogen Mobility Europe (H2ME) project are shown in Figure 3-3.

Figure 3-3: Hydrogen supply to HRS stations in the H2ME project (Source: LBST based on element energy 2020)



573 Frontier economics. (2020). Der Effizienzbegriff in der Klimapolitischen Debatte zum Straßenverkehr. Studie im Auftrag UNITI Bundesverband mittelständischer Mineralölunternehmen und des Mineralölwirtschafsverbands e.V. Available at: https://www.efuel-alliance.eu/fileadmin/Downloads/rpt-frontier-uniti_mwv_effizienz-antriebssysteme_26-10-2020-stc.pdf

574 Guidehouse. (2021). Extending the European Hydrogen Backbone – A European Hydrogen Infrastructure Vision Covering 21 Countries. Available at: https://gasforclimate2050.eu/?smd_process_download=1&download_id=669

575 Hydrogen Mobility Europe (H2ME). (2021). Final report phase 1, 14.01.2021. Available at https://h2me.eu/2021/01/14/completion-of-the-first-phase-of-hydrogen-mobility-europe-h2me/

576 H2Stations.org. (16 September, 2021). Global hydrogen refuelling infrastructure has been growing continuously for the last 5 years. Press release. Available at: https://www.h2stations.org/press-pelease-10-years-evaluation-of-hydrogen-refuelling-infrastructure/

An increased uptake of hydrogen as transport fuel, however, largely depends on a timely market introduction and ramp-up of fuel cell electric vehicles and hydrogen refuelling station (HRS) infrastructure. Several truck manufacturers have announced plans for market introduction in the coming years (see selected examples in Table 3-1). In addition, a number of companies have started offering fuel-cell retrofits for trucks (e.g. Clean Logistics, EVADE, Faun) and automotive suppliers have entered into fuel cell manufacturing, including Bosch, ElringKlinger and Plastic Omnium, Mahle, Freudenberg and Quantron, etc.

Table 3-1: Announced targets of selected truck manufacturers until 2030 (Source: LBST based on press releases up to March 2021)

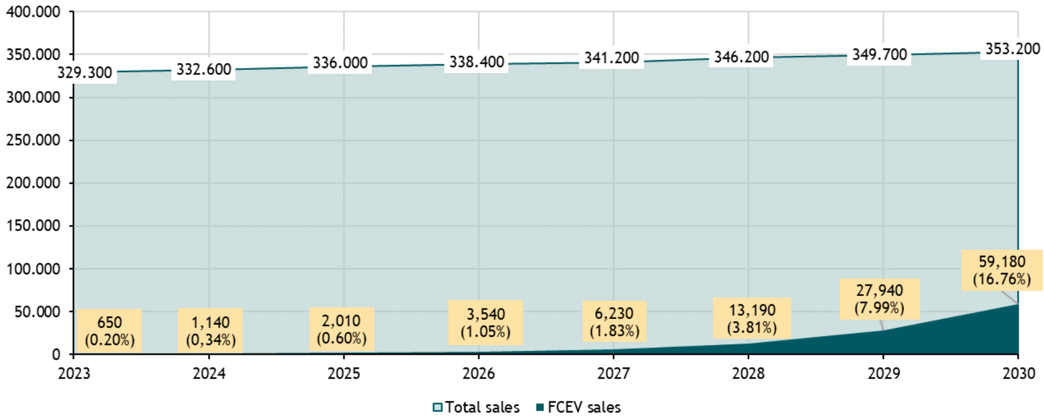
Manufacturer	Ramp-up targets and announcements
Hyundai	• Since 2020, 35 trucks are in operation in Switzerland • 1,600 Xcient fuel cell trucks in Europe by 2025 • Up to 25,000 trucks in operation by 2030
CNH/IVECO and Nikola	• Start of production of the Nikola Tre battery and fuel cell trucks announced for end of 2021 and 2023, respectively
Daimler, Volvo	• Expected production start of GenH2 long-haul truck from 2025 onwards
Stellantis	• Small series of light-duty fuel cell vehicles (Citroën Jumpy, Peugeot Expert and Opel Vivaro) • First delivery to customers announced for 2021
Symbio (Faurecia, Michelin)	• Truck demonstrator in 2021
Hyzon Motors	• Announced production capacities build-up for 40,000 fuel cell vehicles by 2025 (medium and heavy-duty fuel cell trucks and busses)
Toyota	• First deliveries of its Hino Profia and Hino FCET to customers and field tests in 2022
Qingling Motors (with Bosch)	• First field tests with 70 vehicles announced for 2021 (in China)
Dongfeng	• Rollout of 5,000 FC trucks by 2023 (in China)
BAIC, Foton Motor	• 15,000 FC trucks planned by 2025 (in China)

A recent study for the Fuel Cells and Hydrogen Joint Undertaking (FCHJU) on fuel cell hydrogen trucks expects them to be cost-competitive from a total cost of ownership (TCO-) perspective with conventional diesel or other alternative powertrains by 2030.[577] Preconditions are an adequate production scale-up as well as hydrogen refuelling prices below 6 €/kg (see also section *General economic impact: fuel costs, GHG reduction costs*). In that case, a high market penetration of up to 16.8 percent for heavy-duty fuel cell trucks on the annual total sales in Europe by 2030 is modelled (see Figure 3-4), with a cumulative total number of 110,000 heavy-duty trucks deployed on European roads or an overall 1.7% share of the existing 6.6 million medium and heavy-duty truck fleet in Europe. Assuming annual replacement rates between four and five percent[578, 579], the total number of 110,000

[577] Berger, R. (2020). Fuel Cells Hydrogen Trucks – Heavy-duty's high performance green solution. Study for FCHJU. Available at: https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks
[578] ACEA. (2019). Report Vehicles in use Europe 2019. Available at: https://www.acea.be/publications/article/report-vehicles-in-use-europe-2019
[579] ACEA. (24 March, 2021). Commercial vehicle registrations February 2021. Press release. Available at: https://www.acea.auto/cv-registrations/commercial-vehicle-registrations-3-3-first-two-months-of-2021-1-2-in-february/

trucks by 2030 would account for a share of about 4,2% of all purchases in the years 2023 to 2030. The optimistic scenario even projects a potential market share of the annual sales of FCEV of 51.3% in 2030.

Figure 3-4: European market potential of heavy-duty fuel cell trucks (Source: LBST based on Roland Berger, 2020: base scenario)



The result of the study was underlined by a "*Coalition Statement on the deployment of fuel cell and hydrogen heavy-duty trucks in Europe*" from several stakeholders to the European Commission in 2020, with the commitment "*to deploy up to 100,000 FCH heavy-duty trucks from 2030 onwards […] as well as up to 1,500 hydrogen refuelling stations*".[580] The involved parties call for a "*stricter legislation on emissions, as well as legislation supporting the uptake of HRS networks and clean vehicles […]*". Similar results for a comparison of total TCO have been presented for long-haul heavy-duty trucks. A cost-competitiveness with ICE trucks in 2030 can be achieved for hydrogen prices below 5 €/kg.[581] However, already in case of higher hydrogen prices, fuel cell trucks are outperforming other low carbon technologies, like battery electric trucks, catenary vehicles, and especially ICE trucks fuelled with e-fuels (liquid RFNBOs). Based on these numbers, a hydrogen demand of 23 TWh can be estimated for the heavy-duty segment by 2030 (for details, see option 3.1).

In April 2021, several car manufacturers sent a letter to the European Commission, asking to include higher ambitions for zero-emission heavy-duty vehicles in the review of the Alternative Fuels Infrastructure Directive (AFID).[582] They call for a rapid ramp-up of battery-charging and hydrogen refuelling infrastructure with dedicated and binding infrastructure targets on European and MS level. For hydrogen, a target of around 300 hydrogen refuelling stations (HRS) suitable for heavy-duty vehicles and 1,000 HRS until 2030 is requested (one HRS every 200 km of the TEN-T Core network with a daily capacity of at least 6 tonnes of hydrogen). A coordination between AFID and RED II is therefore required in order to ensure a consistent regulatory framework and to support the implementation of a sufficient infrastructure for both BEVs and FCEVs.

[580] Ruf et al. (2020). Fuel Cells Hydrogen Trucks – Heavy-Duty's High Performance Green Solution. Available at: https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks
[581] strategy& (PwC). (2020). Truck Study 2020: Routes to decarbonizing commercial vehicles. Available at: https://www.strategyand.pwc.com/de/en/insights/2020/green-trucking/truck-study-2020.pdf
[582] Transport & Environment (T&E). (2021). Making the EU fuel infrastructure law fit for trucks. Available at https://www.transportenvironment.org/publications/making-eu-fuel-infrastructure-law-fit-trucks

Beside trucks, further transport segments like fleets of smaller vehicles (e.g., taxi operators), busses, and coaches as well as rail or even the passenger cars market offer further possibilities for hydrogen application even before 2030. In the bus segment, several European companies already have vehicles on the road: European providers for coaches and buses include e.g., Solaris, Wrightbus, Van Hool, Caetano, ADL, VdL, or Safra/Symbio (joint venture of Michelin and Faurecia). The latter have announced in April 2021 to build up the production of 1,500 busses to be delivered starting in December 2021.[583] In the rail segment, hydrogen-based transport can substitute diesel trains on non-electrified rail sections. This is essential, since about 46% of the mainline network is still being served by diesel technology today.[584] In 2019, this accounted for an energy demand of gas/diesel oil of about 14.2 TWh or 51,373 TJ in EU27.[585] Main European manufacturers engaging in fuel cell train development are e.g., Alstom (Corodia iLint) or Siemens Mobility (Mireo Plus H) with first trains already in commercial operation since 2018.

Whereas the important role of hydrogen and fuel cell vehicles in the heavy-duty sector is common understanding, the Smart and Sustainable Mobility Strategy[586] as well as the Hydrogen Strategy[587] and System Integration Strategy[588] from the European Commission point out that light-duty vehicles and passenger cars might rather be battery-electric valorising the higher efficiency. A similar conclusion can be drawn from the hydrogen strategies of most European countries, which only see a limited role for hydrogen in passenger cars. This expectation, however, is not shared in the hydrogen strategies of Asian countries like Japan, Korea or China. [589]

Still, there are activities of OEM also scaling up production of fuel cell vehicles in these segments. BMW, Hyundai, Stellantis, and Toyota confirmed in a letter their commitment to developing fuel cell passenger cars and light commercial vehicles and urged the EC to support the expansion of the required 700 bar refuelling network.[590] Further activities are seen by Asian companies like Toyota and Honda, which repeatedly emphasized that the passenger vehicle market provides the possibility for significant scaling effects due to mass production, supporting also the penetration in the heavy-duty market. Up to today, Toyota has sold over 10,000 Toyota Mirai FCEV passenger vehicles (since 2014), however, with Europe accounting for only 6% of global sales. The second generation of the Toyota Mirai was brought to the market in 2020. Fleet and mobility services have shown to be an interesting field of application for such FCEVs, as already pointed out in the EC's Hydrogen Strategy: one example is the German mobility provider Clever Shuttle with over 45 Toyota Mirai in operation and over 5,500,000 km total driving distance.[591] Major customer benefits are short refuelling time and low infrastructure adaptation requirements.

[583] FuelCellsWorks. (9 April, 2021). Safra and Symbio are partnering to manufacture 1,500 hydrogen buses. Press release. Available at https://fuelcellsworks.com/news/safra-and-symbio-are-partnering-to-manufacture-1500-hydrogen-buses-2/
[584] COM(2020) 301 final.
[585] Based on Eurostat data: Complete energy balances (nrg_bal_c)
[586] COM(2020) 789 final.
[587] COM(2020) 301 final.
[588] COM(2020) 299 final.
[589] World Energy Council Germany & LBST. (2020). International Hydrogen Strategies. Available at: https://www.weltenergierat.de/wp-content/uploads/2020/10/WEC_H2_Strategies_finalreport.pdf
[590] H2view. (2021). We want more hydrogen stations! BMW, Hyundai, Stellantis, Toyota urge European Commission to expand Europe's network. Available at https://www.h2-view.com/story/we-want-more-hydrogen-stations-bmw-hyundai-stellantis-toyota-urge-european-commission-to-expand-europes-network
[591] F. Franz (Toyota Motor Europe Group). (2021). Presentation at the Hydrogen Online Workshop 2021. 26th March 2021.

Impact of increased market penetration of FCEVs

These developments, however, are not reflected in the CTP for heavy-duty vehicles (see Figure 3-5 and Figure 3-6), which do not foresee a significant role for hydrogen-fuelled vehicles by 2030, neither in the baseline, nor in more ambitious scenarios.[592]

Figure 3-5: Heavy Goods Vehicle stock by type of drivetrain in 2030 and 2050 (Source: SWD(2020) 176 final)

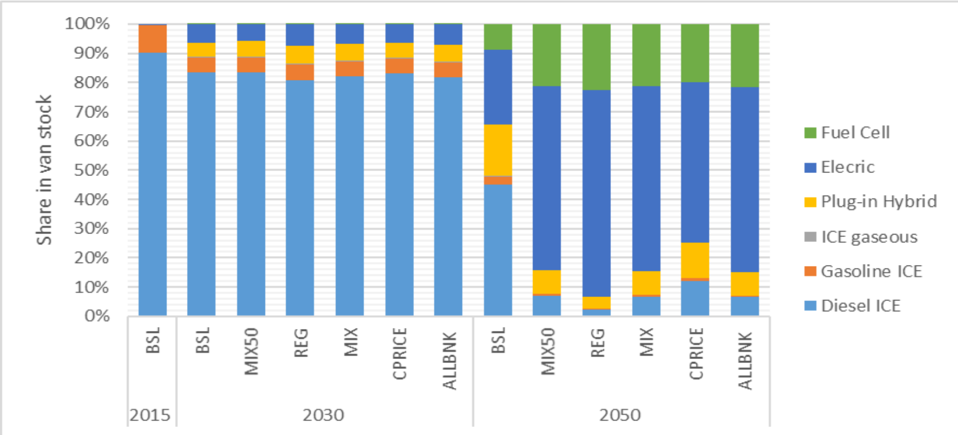
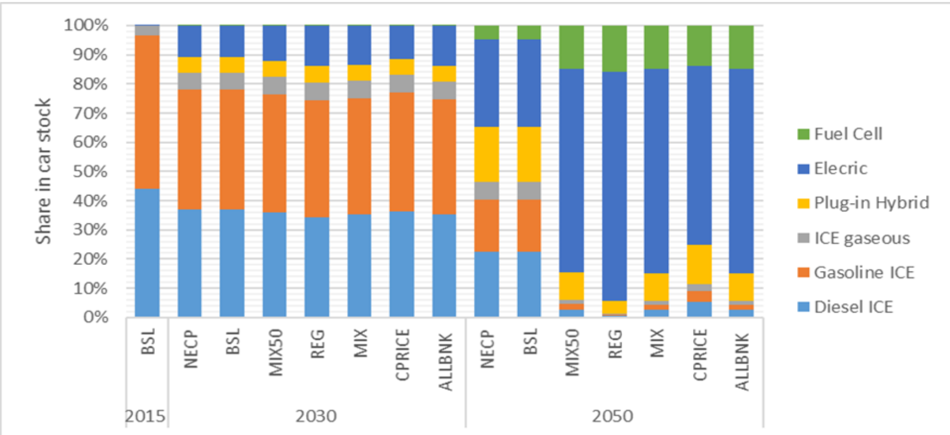


Figure 3-6: Car stock by type of drivetrain in 2030 and 2050 (Source: SWD(2020) 176 final)



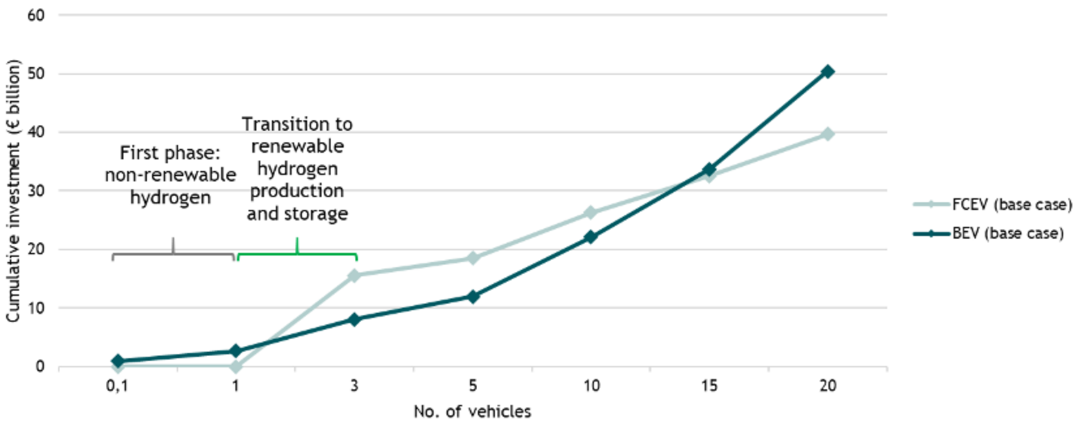
The impact of the option to introduce a multiplier for hydrogen usage in road, allowing fuel supplier to account the energy content of hydrogen to be counted twice towards RES-T (minimum share), is therefore highly dependent on the actual volume of hydrogen consumed as a fuel until 2030.

Since no increase in the ambition of the RES-T share of 14 percent by 2030 is assumed, it can be expected that an overall higher contribution of hydrogen will, especially in the second half of this decade, continuously replace other renewable fuels. The impact assessment of the CTP expects the contribution of renewable electricity to RES-T to significantly increase until 2030 (see Figure 3-10). This development is mainly driven by a high market penetration of BEVs in the car segment as well as the high multiplier of four for renewable electricity in transport.

[592] SWD(2020) 176 final.

From an infrastructure cost perspective, Robinius et al. 2018 showed that a BEV recharging infrastructure roll-out is more economic mainly for low-penetration scenarios.[593] In scenarios with a high number zero emission vehicles (scenario of about 20 million vehicles calculated for Germany), however, costs for battery charging infrastructure would exceed investment needs for a hydrogen refuelling infrastructure (see Figure 3-7).

Figure 3-7: Comparison of the cumulative investment of supply infrastructures (Source: LBST based on Robinius et al. 2018)



One option of a multiplier for renewable hydrogen in rail and road is to limit it to heavy-duty applications only. Whether a differentiation between fuel supply for fuel cell vehicles between the heavy-duty and passenger car segments is possible, strongly depends on the future design of hydrogen refuelling stations for both application. Refuelling concepts for heavy-duty vehicles are still under discussion, options including 35 MPa, 50 MPa, and 70 MPa compressed hydrogen as well as liquid or cryo-compressed hydrogen or even liquid organic hydrogen carriers LOHCs (see e.g. the PRHYDE project for gaseous hydrogen refuelling)[594]. In contrast to that, the majority of existing hydrogen fuelling stations in Europe is dedicated to light-duty vehicles mainly at 70 MPa level, while especially the UK has dual pressure equipment for 35 MPa and 70 MPa.[595] From the perspective of HRS operators, however, it may be beneficial to supply both, light as well as heavy-duty vehicles rather than to focus on heavy-duty vehicle alone.

Impacts of the adjustment of existing multipliers will be discussed in line with option 3.3.

Incremental improvements - Electricity in maritime

While it may benefit only a few operators, the introduction of a multiplier of 1.2 for niche marine applications is timely and reasonable, so electric propulsion is not disadvantaged compared to other renewable fuels in the maritime sector. Niche applications, such as short ferry routes, are going to play only a minor role in scaling up the electrification of the maritime sector. This is because major structural and technological issues hinder the broad adoption of electrification and it is unlikely that

[593] Robinius et al. (Forschungszentrum Jülich) (2018). Comparative Analysis of Infrastructures - Hydrogen Fueling and Electric Charging of Vehicles. Available at: https://content.h2.live/app/uploads/2018/01/Energie-und-Umwelt_408_Robinius-final.pdf

[594] PRHYDE - Refuelling Protocols for Medium and Heavy-Duty Vehicles, Call Identifier FCH-04-2-2019. Available at:https://prhyde.eu/

[595] Element Energy. (2020). Final report phase 1 of the Hydrogen Mobility Europe (H2ME) project: Emerging Conclusions. Available at https://h2me.eu/wp-content/uploads/2021/01/H2ME_Emerging-Conclusions2020.pdf

these are going to be resolved by introducing an additional multiplier. Currently batteries are too expensive and have too little energy density to be considered for applications other than e.g. short routes at modest speeds. Two major dimensions stand out regarding electrification in the maritime sector: alternative (electric) means of propulsion as well as increased use of shore power. Still too often, ships that are berthed run their on-board systems through diesel generators. "*In principle, a vessel can be connected to the power grid onshore while it is berthed. However, this does require the ship itself, the terminal quays and the power grid to be suited to this solution. [For example], every year, sea-going vessels moored along Rotterdam's quays consume as much electric power as 250,000 to 300,000 households. And in the process, they release various harmful emissions into the atmosphere, including 600,000 tonnes of CO_2 and 8,000 tonnes of nitrogen.*"[596]

Propulsion

Most seagoing ships today use heavy fuel oil (HFO), marine diesel oil (MDO), or marine gas oil (MGO) as their engine ('bunker') fuel, burned in a diesel engine. Introducing alternative fuels is linked to several challenges, including lower energy densities and hence requirements for larger storage volume as well as safety concerns.[597]

Large cargo ships are more efficient cargo carriers than smaller vessels. As the energy density of batteries is lower compared to fossil fuels, larger vessels or generally long distance, deep sea shipping are presently unsuitable for similar electric propulsion from a technical perspective. Smaller vessels have greater potential for earlier decarbonization through the development of e.g. high density electric energy storage systems for use onboard and adequate shore-based recharging facilities so vessels can recharge renewable energy from the grid. Despite the inferior (specific) energy density of batteries compared to liquid hydrogen, battery-electric propulsion could be more cost-effective for small and mid-size ships, depending on technological advances over the next decade.

Nonetheless, since about 60-70% of the EUs seaborne goods handled in the Union's main ports are related to short sea shipping (see Figure 3-8), a substantial share of European shipping could benefit in the coming years from increased efforts at electrification and eventually operate on zero emission journeys. However, entry burdens in terms of substantial upfront investment as well as technological barriers around life-time of batteries or safety concerns presently remain. Nevertheless, considering the increase in battery performance achieved over the past ten years with automotive being the key drivers. Currently still a niche application, it is expected that the technology will eventually reach maturity to be applied on a broader scale in the maritime sector. Adequate charging infrastructure is another barrier. Electrified vessels would require very high peak charging currents to ensure an adequate turnaround time and this places very high demands on the local grid. It is therefore important to set the right regulatory framework to incentivise the uptake of alternative low carbon (electric) propulsion technologies.

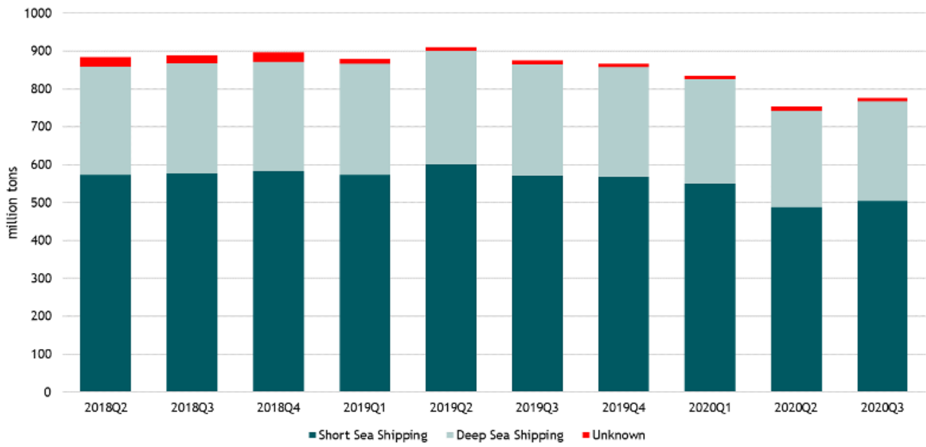
Next to seaborne goods that are transported on short routes, ferries, cruise ships and other smaller vessels, e.g. fishing vessels offer potential for increased electrification, either because their size and

[596] Offshore Energy & Navingo. (2020). Rotterdam rolls out ambitious strategy for shore power use. Available at https://www.offshore-energy.biz/rotterdam-rolls-out-ambitious-strategy-for-shore-power-use/

[597] Marketa Pape, European Parliamentary Research Service. (2020). Decarbonising maritime transport: The EU perspective. Available at: https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/659296/EPRS_BRI(2020)659296_EN.pdf

use are suitable for alternative means of propulsion or, but also because the environmental image is a potential commercial factor, as is the case with cruise ships.

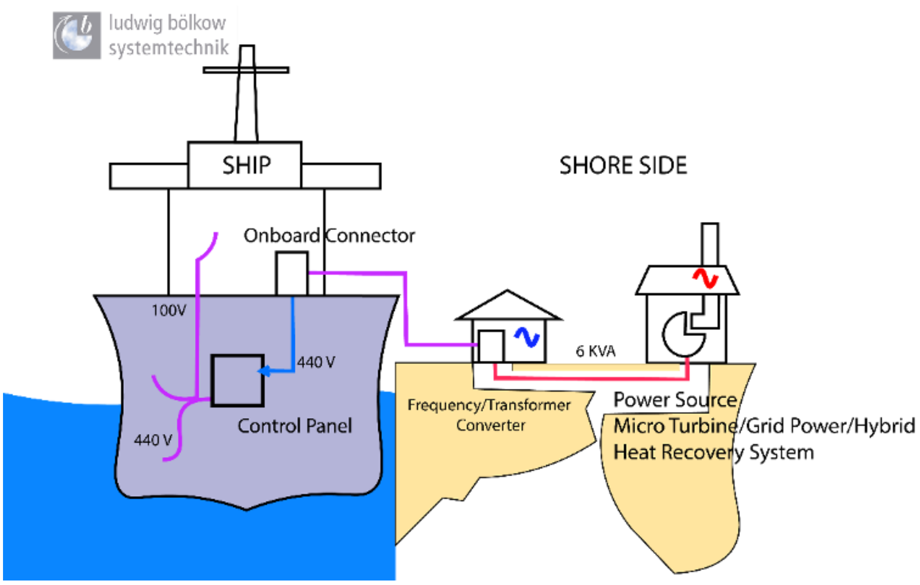
Figure 3-8: Gross weight of seaborn goods handled in main ports by type of shipping, EU-27, 2018 Q2-2020 Q2 (Source: LBST based on Eurostat data (data code: mar_qg_qm_ewhg))



Shore Power

When calling at a port, seagoing vessels need electric power. Most often, this is provided by auxiliary engines, generating emissions and noise pollution. These can be decreased by shutting down the vessel's auxiliary engines and providing it with external, shore-side power. Shore power reduces local emissions and noise while the ship is at berth, reduces local air pollution, and can also reduce CO_2 emissions, provided that the electricity is generated from clean sources (see e.g. concept in Figure 3-9). Currently, electricity produced from the combustion of marine fuel on board ships is tax-exempt, but when ships are at berth plug in to the shore-side electricity system, they are liable for local electricity taxes.

Figure 3-9: Concept drawing of shore power applications and shore side grid (Source: LBST)



Already in 2006, the EC recommended that MSs consider the installation of shore-side electricity for use by ships at berth in ports.[598] However, use of shore power has not picked up to the extent possible as infrastructure installation costs and energy taxes present significant burdens. One of the biggest hindrances seems the taxation related to shore-side electricity, which is why Sweden, Germany, Denmark, Spain, and France have asked for the possibility to reduce the respective tax rate.[599] This is despite earlier analyses indicating that measures on their own to support shore power, for example in the form of favourable taxation, operation or investment subsidies, are unlikely to encourage it.[600] To trigger adoption on a broader scale every additional incentive, such as the introduction of multipliers for electricity in the maritime sector, can be crucial but should not divert attention from fundamental structural and technological entry barriers.

Generally, the EU will need to decide how it will want to regulate all emissions, notably related to extra EU maritime navigation, and decide which part of these emissions it will include in the scope of its own GHG reduction target. Depending on the scope of the GHG target, this will impact the overall level of domestic climate action and the associated energy system actions required.[601]

Incremental Improvements – Credit Mechanism

The suggested credit mechanism, similar to the Dutch HBE system, would allow for trade of Renewable Energy Units (REUs) across the EU with separated trading of the energy and the REUs, i.e. no mass balancing. It is important to decouple the energy from the certificates to create a bigger, frictionless market. The option assumes that a suitable trading platform will be developed to facilitate the trade, which is fine-tuned to the reporting requirements in the Union Database to be developed and rolled out over the coming years.

In any case, the introduction of such a credit mechanism requires substantial efforts for harmonization of policies and regulation across MSs. Depending on the respective existing regulation on MS level, adaptation costs will vary across Europe as some MSs will have to adopt their existing governance and regulation to a greater extent than others. However, the various national registries and certification schemes for renewable energy offer a common footing for many MSs. Depending on the transition period, the introduction of such a credit mechanism poses a certain administrative burden, with a gradual transition being more suitable to minimize planning and harmonization costs across MSs. Naturally, some industry stakeholders would benefit from an institutional convergence across Europe, whereas others would oppose it out of fear for greater competition. Transport fuel suppliers would have to adopt to a new system of target compliance which is initially going to require training, but which is anticipated to be moderate.

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[598] Official Journal of the European Union. (2006). COMMISSION RECOMMENDATION of 8 May 2006 on the promotion of shore-side electricity for use by ships at berth in Community ports. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006H0339&from=EN

[599] Marketa Pape, European Parliamentary Research Service. (2020). Decarbonising maritime transport: The EU perspective. Available at https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/659296/EPRS_BRI(2020)659296_EN.pdf)

[600] Schroten, A., Kleijn, A., Boer, E.d., Blom, M., Vries, J.d. (CE Delft). (2020). Incentives for onshore power. Available at: https://www.cedelft.eu/en/publications/2510/incentives-for-onshore-power (accessed on 13.02.2021).

[601] European Commission. (2017). Electrification of the Transport System. Available at: https://ec.europa.eu/programmes/horizon2020/en/news/electrification-transport-system-expert-group-report

In the spirit of the Single Market Act, in effect since 1987, and given the major role that renewables are going to play over the coming decades, developing a European trading system for REUs is very timely. Generally, it can be expected that removing barriers to cross-border trade is going to result in welfare gains across the EU as it is going to increase efficiency and effectiveness of international competition. Similarly important is the incentivization of investment in renewables as a bigger market presents more opportunities, easier access, and security for investors. The level-playing field across fuels and MSs would create a bigger, healthier European energy market. However, a range of national support schemes, policies, or geographic preconditions are naturally going to distort competition across Europe to some extent. While this is not a problem by default, it should be closely monitored and subject to further evaluation once plans for the introduction of a credit mechanism are more refined. At present, various national renewable support schemes exist across the EU, which is a set-up that could "*hamper the potential cost-effectiveness gains of international trade and competition.*" Establishing a central EU scheme could unlock more low-cost renewable energy-production potential. "*Nevertheless, in the current political climate in most EU Member States it is considered highly unlikely that national budgets reserved for promoting the national production and use of renewable energies will be shared with other EU Member States. As a result, the EU market for renewable energies could remain strongly fragmented with resulting low levels of cross-border trade and competition.*"[602] Despite the latter, efforts should be made to establish a European wide credit mechanism for renewables in transport as the economic benefits through increased competition and investment will eventually substantially outweigh the costs associated to circumnavigating the administrative and political difficulties.

Option 3: Option 2 + Increase in ambition level

Sub-option 3.1: Continue current approach for promotion of renewable energy in the transport sector with increased ambition

The continuation of the current approach will – assuming an increased ambition level – require the RES-T target in Art. 25(1) to be increased above 14%. At the same time, the sub-target for advanced biofuels (biofuels from feedstock Annex IX (Part A)) as well as its trajectory, which defines a continuous ramp up from at least 0.2% in 2022, to 1% in 2025 and to at least 3.5% by 2030, may be subject to revision. The introduction of a new sub-target for RFNBOs can support efforts to increase the share of renewable energies in transport. Other aspects covered by this option are adaptions in current provisions under FQD as well as the introduction of a dedicated obligation for aviation and maritime fuels.

The impact assessment of the CTP[603] already gives a rough indication, which values for RES-T are required in -55% decarbonisation scenarios until 2030 (see Table 3-2). While these modelling results already require increasing the 14% target in the baseline scenario in 2030, necessary RES-T targets lie between 20.1% and 25.8% in those scenarios achieving higher decarbonisation.

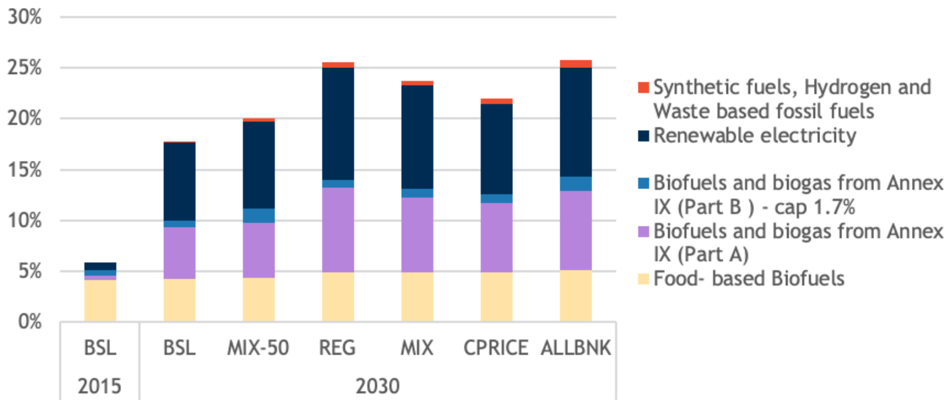
[602] Jin Climate and Sustainability. (2015). Case of the Netherlands and Germany: policy environment, key differences and harmonisation issues. Available at : http://jin.ngo/images/jin/publications/final_report_interreg.pdf
[603] COM(2020) 562 final.

Table 3-2: Comparison between RED II targets for RES-T and advanced biofuels to the status quo (based on SHARES 2019 results) and the modelling results of CTP for (baseline as well as two extreme scenarios)

	2030 RED II Art. 25(1)	2019 (SHARES, EU27)	2030 CTP (BSL)	2030 CTP (MIX-50) (min)	2030 CTP (ALLBNK) (max)
Minimum share (RES-T)	14.0%	7.5%	17.7%	20.1%	25.8%
Sub-target for / contribution of advanced biofuels (2030)	3.5%	0.9%	5.0%	5.4%	8.3%

Following this analysis, biofuels from crop- and food-based feedstocks will basically remain at 2015 level (see Figure 3-10). While there will be a phase-out of biofuels with a high ILUC risk until 2030, other food- and feed-based biofuels are limited to 7%, meaning at maximum one percentage point above the 2020 contribution towards the RES-T of a MS (Art. 26(1)). Based on the 2019 SHARES data and applying the calculation methodology of RED II, their contribution in EU27 was at 3.89%. Lowest contributions of biofuels from crop- and food-based feedstocks were reported for Cyprus (0.00%), Malta (0.16%), Ireland (0,48%), and Italy (0.89%), while highest contributions could be observed in France (6.77%), Romania (6.37%), and Austria (5.54%).[604]

Figure 3-10: Disaggregation of the renewable transport target RES-T as per RED II (Source: SWD(2020) 176 final)



Since biofuels (Annex IX (Part B)) are capped at 1.7% anyways, an increase in the contribution of hydrogen towards RES-T will accordingly mainly substitute or complement the required production capacity ramp-up for advanced biofuels (biofuels and biogas from Annex IX (Part A)) within the next years. While their contribution towards RES-T for EU27 in 2019 was only 0.85% based on SHARES 2019, the modelling for CTP shown in Figure 3-10 projects a significant increase to between 5.0% (BSL) and 8.3% (REG-scenario) by 2030. These scenarios, however, do not anticipate a potentially significant market ramp-up in FCEVs as described in option 2.

The predominant impact of increased targets in Art. 25(1) will therefore be the need for fuel suppliers to cover a higher amount of their fuels from renewable sources. Since both food-based biofuels as well as biofuels or biogas from Annex IX (Part B) are capped, three fuel categories can make up for the upcoming gap between existing 14% RES-T under current provisions and the more ambitious target of up to 26%:

[604] Own calculations based on eurostat 2020: SHARES 2019 – summary results.

- **Biofuels from Annex IX**: mainly Part A and to a limited extent also Part B (up to the cap of 1.7%), as drop-in-fuel for existing vehicle fleets with ICE;
- **Renewable electricity:** this is mainly limited by the number of BEVs in the market and the . The possibility for fuel suppliers to influence this development is limited to the installation of public (fast) charging infrastructure;
- **RFNBOs:** For hydrogen, both the timely market introduction of a significant number of FCEVs strongly depend on the sufficient installation of a public refuelling infrastructure. As discussed in Section B4, option 2, liquid RFNBOs will rather be used for maritime and aviation applications. Their role for achieving the 2030 target, however, strongly depends on the design of sector-specific quota obligations until 2030.

The contribution of each of these three options and consequently the impacts depend on several aspects, including market penetration of BEVs and FCEVs vehicles compared to ICE vehicles, feedstock availability of renewable electricity and biofuel feedstocks, fuel price developments driving their competitiveness against each other, and national strategies and support regimes. A deep decarbonization in transport will, however, require high amounts of renewable electricity consumed in the transport sector, either direct via BEVs or indirect via FCEVs. Whereas direct electrification promises high efficiencies in case of a direct regional and temporal correlation between renewable electricity production and end-customer demand, storage and transport needs might also require indirect electrification. In addition, the consumption of liquid RFNBOs with high energy densities will likely be necessary in sectors that are more difficult to electrify such as the aviation and maritime sectors.

Risk and challenges with regard to meeting the increased renewable fuels demand will be discussed in the following. For renewable electricity, further details are also discussed under document B, section B2.

Advanced biofuels

According to the 2030 Climate Target Plan, especially aviation and maritime will need to scale up efforts to improve the efficiency of aircraft, ships, and their operations, while increasing the use of sustainably produced renewable and low-carbon fuels. This will be assessed in greater detail in the context of the ReFuelEU Aviation and FuelEU Maritime initiatives, which aim to increase the sustainable fuels production for, and uptake of these sectors (see also document B – Energy System Integration, section B4). Advanced biofuels, however, may encounter difficulties fulfilling these requirements with regard to their volume availability as well as technological availability. As stated by the Sustainable Advanced Biofuels Technology Development Report 2020[605], advanced biofuels production for the transport sector remains limited on a commercial scale notably due to technological challenges, although in the last decade, considerable progress in technology development has been made.

Advanced biofuels technologies can be classified into three main categories, namely following the biochemical, thermochemical, or oleochemical route, with each of these categories including a number of sub-technologies. Despite the theoretical potential of biological and thermochemical routes, the

[605] Joint Research Centre (JRC). (2020). Sustainable Advanced Biofuels - Technology development report. Available at: https://ec.europa.eu/jrc/en/publication/sustainable-advanced-biofuels-technology-development-report-2020

current biofuel market is dominated by oleochemical production, mostly because this technology is well developed and has relatively low technological risks and low capital expenditure compared to other production routes.[606] Nonetheless, the production of sustainable advanced biofuels in general requires processes that are currently in pre-commercial, demonstration, or earlier stages of development in a number of plants. Fully commercial production of advanced biofuels routes is still limited since the production costs are too high and technical improvements have to be achieved.

Despite current technologies being able to produce a high quality innovative set of fuels, for large and medium-scale plants, another main barrier remains regarding the feedstock supply, especially with regard to the possibility to find materials not used by other sectors, in order to have the possibility to limit costs and price volatility. Based on the proposed minimum blending rates for advanced biofuels produced with feedstocks listed in Part A of the RED II, the consumption of these biofuels must increase significantly from 2020.

Domestic production could be supplemented by imports, although in general it is only practical to import feedstocks which have a high energy density. Sugar and starch crops, oil crops, and waste fats and oils are already commonly traded internationally. Forestry residues may also be traded, but typically over shorter distances due to their lower energy density and the fact that there are no well-established trading markets in these products yet.[607] For all other feedstocks, it is likely that they would be converted into fuel near to their point of production, meaning the final fuel would need to be imported.

Accordingly, the limited production capacity and specific feedstock limitations for Annex IX (Part A) biofuels can be seen as the most important challenges making it difficult for different MSs to reach the current 3.5% target by 2030[608], which is equivalent to a quantity of about 10,000 ktoe per year.[609] This would almost equal the current production of conventional biofuels, and would require about a hundred advanced biofuel plants with an annual capacity of 200 million litres per year each. So far, these waste- and residue-based biofuels do not play a significant role in the EU. The currently available biofuels produced from feedstocks listed in Part A are produced from tall oil (renewable diesel), glycerol (biomethanol) and saw dust (bioethanol). Although there is a large potential, especially for cellulosic ethanol (e.g. from straw) or via gasification of wastes and residues, the number of existing conversion facilities in Europe is low and investment costs for new commercial plants are high.[610] The comparison between their contribution in 2019 (0.44% without and 0.85% with multipliers, see Figure 3-11) and the required share in 2030 (5.0% to 8.3% with multipliers), however, requires a production scale-up by a factor of 5 to 10.

[606] Ibid.
[607] LBST, E4tech, & S.E.E.C. (2020). Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties. Available at: https://author.energy-community.org/enc-author-prd/dam/jcr:67ca5b20-edf1-4dd1-b9f9-80c9cc7d7711/RECG_LBST_0420.pdf
[608] The International Council on Clean Transportation (ICCT). (2019). Assessing the potential advanced alternative fuel volumes in Germany in 2030. Working Paper 2019-17. Available at: https://theicct.org/publications/potential-advanced-fuel-volumes-germany
[609] USDA Foreign Agricultural Service. (2019). EU-28: Biofuels Annual – EU Biofuels Annual 2019. Available at: https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_The%20Hague_EU-28_7-15-2019.pdf
[610] European Commission. (2017). Building up the future cost of biofuel. Sustainable Transport Forum – Sub Group on Advanced Biofuels (SGAB). Available at: https://op.europa.eu/en/publication-detail/-/publication/13e27082-67a2-11e8-ab9c-01aa75ed71a1/language-en/format-PDF

Economically, an increased sub-target for advanced biofuels would result in an increased demand for advanced biofuels, which generally are more expensive compared to other biofuels (see section General economic impact: fuel costs, GHG reduction costs). It can therefore be expected that the increase in the targets will drive the market development for advanced biofuels by creating additional motivation for capacity increase and steering it to the road as well as aviation and maritime market (see also section *General economic impact: Investment volumes* for related investment volumes). For the latter, however, the interactions with sector-specific quota on the consumer or supplier side need to be considered. For details, one may refer to the respective activities of the ReFuelEU Aviation or FuelEU Maritime initiative (see also document B – Energy System Integration, subtask B4).

From the environmental perspective, an increase in ambition level applying the current methodology of RED II for transport will foster the demand for renewable energies and accordingly the scale up of existing production capacities, especially for advanced biofuels. This will increase their market share as a drop-in fuel in road, aviation and maritime application and in a consequence increase the GHG emission reductions in those sectors. Noise emissions and air pollution will however not be reduced, since biofuels will continuously be used in vehicles with internal combustion engine.

Among the social impacts, potential job creation along the respective supply chains involved in providing renewable electricity (RES production, BEVs, charging stations) or advanced biofuels (straw, waste industry, biofuel production) are relevant. Especially for advanced biofuels this may be a significant push, however, limitations regarding the time-shift between regulation, implementation and actual production ramp up need to be taken into account (see also section *General social impact: employment*).

Renewable electricity in transport

The uptake of renewable electricity in transport is in in contrast to biofuels, less linked to the fuel supply but also dependent on a high market penetration of BEVs in Europe. BEV sales were about to start a significant growth in core markets when COVID-19 hit, disrupting automotive sales worldwide. But unlike other BEV key markets, Europe has seen significant growth in this sector. In 2019, sales increased by 44%, the highest rate since 2016.[611] Nonetheless, the necessary market ramp-up, especially of passenger cars and light-duty vehicles (LDVs), may become an issue, as the market penetration will not be sufficient with regard to the integration of renewable energy into the transport sector. A study from element energy for Enel, Iberdrola, Transport & Environment, and Group Renault, has projections for the penetration of BEVs in the European car stock of 4% by 2030 (similar to the prediction of the IEA[612]), 21% for 2040 and 44% for 2050 (PHEVs not included)[613]. Regarding LDVs, their

[611] McKinsey. (2020). Electric Vehicle Index: Europe cushions a global plunge in EV sales. Available at: https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive and Assembly/Our Insights/McKinsey Electric Vehicle Index Europe cushions a global plunge in EV sales/McKinsey-Electric-Vehicle-Index-Europe-cushions-a-global-plunge-in-EV-sales-vF.pdf?shouldIndex=false

[612] IEA. (2020). European Union 2020 – Energy Policy Review. Available at: https://www.iea.org/reports/european-union-2020

[613] Elementonwheels. (2019). Batteries on wheels: the role of battery electric cars in the EU power system and beyond. Available at: https://www.transportenvironment.org/sites/te/files/publications/2019_06_Element_Energy_Batteries_on_wheels_Public_report.pdf

share of sales in Europe for 2030 will remain below 20% according to the IEA[614]. In absolute terms this would result in approx. 11.5 million BEVs on Europe's roads in 2030, with an annual (renewable) electricity demand of between 17 and 19 TWh[615], compared to approx. 0.96 TWh of renewable electricity consumed in road transport in 2019 according to Eurostat[616]. In terms of meeting the renewable energy target in the transport sector (including multipliers), the contribution of BEVs to the RES-T target would therefore be 2–3% by 2030 in addition to other electricity consumption, notably in rail, showing a potential lack of offtakers for renewable energy in the transport sector. Making significant contributions to renewable energy consumption in transport in 2030, a massively increased market uptake of BEVs, not only for passenger cars, but also for light and potentially heavy-duty transport (e.g. buses, delivery trucks, etc.; see next section), would have to be achieved.

The large and growing importance of road freight means that any strategy for reducing the carbon intensity of the energy system must include a solution for trucks. However, the trade-offs between battery weight, range, and payload mean that electrification remains a challenge for long-haul battery-electric transport. Even though recent developments in battery technology are making electric heavy-duty trucks technically and commercially more viable, battery electric trucks have not been a real option to replace heavy-duty trucks until now because of the high energy requirements and limited energy density of batteries. Battery electric heavy-duty trucks currently on the market have ranges suitable for distribution purposes, but not for long-distance transport across Europe. Despite all activities currently undertaken, analysts do not expect battery-electric heavy trucks to take a large share of the market within the next decades. Referring to Wood Mackenzie's base case forecast, battery-electric trucks will displace about 700,000 barrels a day of oil demand in 2040, about 0.6% of world consumption[617]. The majority of that impact comes from light to medium trucks mostly driving short distances where battery range is less of an issue. At the same time, half of EU's total truck activity is driven over distances of less than 300 km, meaning these distances could theoretically be covered by electric trucks.[618] However, long-haul freight transport represents the bulk of energy consumption by trucks. Some companies such as most notably Traton and Tesla, are developing pure battery-electric long-haul heavy-duty trucks, but many other companies active in this field are trying to address the decarbonisation of long-haul heavy-duty vehicles through different approaches and a combination of different technologies including notably fuel cell-electric approaches (as a main source of energy or as range extenders).

Following widespread deployment, BEV charging will play an important role in the future power system. The way in which vehicles are charged will determine how far BEV charging will represent a burden to the power system. As power systems will be more and more dominated by fluctuating renewable production, the operation of the system will move away from production responding to load and instead will need to manage demand depending on production. Accordingly, storage elements and demand

[614] IEA. (2020). Global EV Outlook 2020.
[615] Assuming an annual electricity consumption per vehicle of 1550 kWh/yr based on: Forschungszentrum Jülich. (2018). Comparative Analysis of Infrastructures: Hydrogen Fueling and Electric Charging of Vehicles. Available at: https://juser.fz-juelich.de/record/842477/files/Energie_Umwelt_408_NEU.pdf?version=1
[616] Eurostat. (n.d.). SHARES summary results 2019. Available at: https://ec.europa.eu/eurostat/web/energy/data/shares
[617] Crooks (Wood Mackenzie). (2020). The long haul for electric heavy trucks. Available at: https://www.woodmac.com/news/opinion/the-long-haul-for-electric-heavy-trucks/
[618] Transport & Environment. (2020). Unlocking Electric Trucking in the EU: recharging in cities. Available at: https://www.transportenvironment.org/sites/te/files/publications/2020_07_Unlocking_electric_trucking_in_EU_recharging_in_cities_FINAL.pdf

response will be key to balance demand and supply. Smart BEV charging can shift the BEV charging demand out of times of peak demand, and into times where there is a surplus of renewable energy. Vehicle-to-Grid (V2G) on the other hand can provide supplementary energy when needed. Such flexibility options exist only with charging solutions where vehicles are connected over longer periods of time – fast charging represents an instantaneous power demand without flexibility. Nonetheless, fast charging also has times of peak demand and times of lower demand, which are compensated for already today by installed stationary battery capacities; in the future, also fuel cells are envisaged as supporting power supply to fast chargers (and have already been installed in individual cases).

At the same time, the grid integration of BEV charging represents only a solution for short-term flexibility, i.e. hours or days. They do not provide a solution for longer-term flexibility or storage with a view to periods such as weeks, months or even seasonal, meaning the additional storage capacity through the large deployment of BEVs cannot address the issue of long-term storage. As stated in a study for H2Mobility[619], especially seasonal storage is a key feature for a secure fuel supply. Long-term storage capacities are needed in scenarios involving a high share of renewables in order to secure electricity supply. As the batteries of BEVs are designed to fit daily mobility needs they cannot offer additionally capacity for longer-term electricity storage.

As solar electricity generation is limited to day hours, smart charging absorbing solar electricity would have to take place at daytime when cars may be in operation or out of home (notably cars used for commuting). As a consequence, vehicle charging needs to be established where cars are parked at daytime, while feeding solar electricity back to the grid will be needed in the evenings and at night (V2G). This increases the number of charging points per BEV. For wind power, fluctuations are more seasonal than daily, requiring longer-term (seasonal) balancing based on other technologies (hydrogen). In essence, smart charging will be essential to limit the burden of BEVs on electricity balancing and V2G will be essential to ensure a contribution of BEVs to grid balancing on short timeframes (for details, also see document B - Energy System Integration, section B2). Longer-term balancing up to seasonal will require other solutions, most notably hydrogen.

Sub-targets for hydrogen and RFNBOs

High costs and a lack of dedicated support prevent a high contribution of RFNBOs to transport so far. RFNBOs in form of liquid e-fuels will, however, in any case be a substantial part of our future energy system. Initiatives like ReFuelEU Aviation -Sustainable Aviation Fuels initiative[620] and the FuelEU Maritime - Green European Maritime Space initiative[621] drive the stepwise uptake of sustainable aviation fuels in aviation, and e-fuels in the maritime sector. The introduction of a supply obligation or quota is currently being discussed as a first step[622], however the support provided for hydrogen as transport fuel in a decarbonized transport sector largely depends on the gap between the actual RFNBOs sub-target and RFNBO offtake in aviation an maritime. Potential demand pathways for hydrogen

[619] Forschungszentrum Jülich. (2018). Comparative Analysis of Infrastructures: Hydrogen Fueling and Electric Charging of Vehicles. Available at: https://juser.fz-juelich.de/record/842477/files/Energie_Umwelt_408_NEU.pdf?version=1
[620] European Commission. (2020). ReFuel EU Aviation: Inception impact assessment. Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels
[621] European Commission. (2020). FuelEU Maritime: Inception impact assessment. Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12312-FuelEU-Maritime
[622] For further details, it is referred to the respective initiatives and the on-going impact assessment.

in transport are discussed in option 2 (more favourable treatment of hydrogen in transport). Sector-overarching aspects of RFNBO consumption and possible targets (in combination with low carbon fuels) in aviation, maritime, and industry are covered in document B – Energy System Integration, section B4.

A sub-target for RFNBOs can support other existing European provisions, which require the market introduction of a large number of low and zero emission vehicles (ZEVs) in all transport segments by 2030. These include e.g. fleet emission targets for heavy-duty vehicles (HDV) of -30% GHG emissions by 2030 (compared to 2019)[623] and minimum public procurement targets for the share of clean vehicles according to the Clean Vehicles Directive (up to 38.5% for light-duty vehicles, 15% for trucks and up to 65% for busses, half of which zero-emission buses, from 2026 onwards).[624] A further push towards low and zero emission vehicles is also expected by the European CO_2-based toll charges for trucks, which shall be in place starting 2023. The interinstitutional negotiations began January 2021.[625] It is expected that zero-emission vehicles (ZEV) are eligible for a toll reduction of up to 75% below the highest rate (on the basis of a EURO VI truck toll).[626]

In addition, several European cities and countries have already announced bans of existing or new vehicles with internal combustion engines (ICE) in general or diesel engines specifically to reduce local pollutant and noise emissions. Some of these pledges already affect the period before 2030, e.g. diesel engines in Paris, London, Milan, Strasbourg, or Oslo by 2025.[627] It is important to note that such a general ban of ICE vehicles would also affect the use of advanced biofuels or e-fuels in vehicles with internal combustion engines, whereas electric vehicles with battery or fuel-cell system can significantly reduce urban air and noise pollution. A target for hydrogen (instead of or as part of a RFNBO sub-target) in transport would thus show a high coherence, complementing other legislative instruments such as CO_2 standards, the Clean Vehicles Directive (CVD), or the Alternative Fuels Infrastructure Directive (AFID, currently under revision) covering among others the hydrogen refuelling infrastructure.

In general, an overall target for RFNBOs in the whole transport sector as already described for advanced biofuels (see sub-option 3.1 above), possibly including a trajectory until 2030, would ensure the necessary demand ramp-up for hydrogen and e-fuels in the transport sector by providing investment security, e.g. for the required production capacities and infrastructure installation. Taking into account both demand pull (strategies, regulations, customer needs) and supply push (market ramp-up for hydrogen vehicles in the different segments), a significant increase in hydrogen demand in transport can be expected by 2030. This is further supported by the important role of hydrogen (and RFNBOs in general) for sector integration and as energy transport and storage vector in deep decarbonisation scenarios (see document B – Energy System Integration (section B4)).

[623] Regulation (EU) 2019/1242.
[624] Directive (EU) 2019/1161.
[625] Scordamaglia, D., European Parliamentary Research Service. (2021). Briefing: Revision of the Eurovignette Directive. Available at: https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI%282017%29614625
[626] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, COM(2017) 275 final – (2017) 0114 (COD).
[627] Wappelhorst, S., The International Council on Clean Transportation (ICCT). (2020). Briefing: The end of the road? An overview of combustion-engine car phase-out announcements across Europe. Available at https://theicct.org/publications/combustion-engine-car-phase-out-EU

Although MSs reported no contribution of RFNBOs as fuel for the transport sector in 2019, the potential increase especially in the consumption of hydrogen in the heavy-duty segment could drastically change this situation. Assuming a hydrogen demand of 7 kg/100 km and a milage of 100.000 km per year, the overall hydrogen demand to supply a heavy-duty vehicle fleet of 100.000 fuel cell would be about 23 TWh hydrogen per year, or an electrolyser capacity of 8.2 GW.[628] In terms of 2019 energy demand for transport in EU27, this would account for a share of renewable hydrogen alone of 0.72% in transport (without multiplier) or about 1.4% in case an increased multiplier of two is defined[629].

Changing perspective to the supply side, the 40 GW electrolyser target in the European Union until 2030 (as included on the EC's hydrogen strategy) should serve as a starting point. Accordingly, domestic RFNBO production could make up for about 110 TWh per year (hydrogen)[630] or around 55 TWh per year (e-fuels, assuming conversion losses from hydrogen to e-fuels of 50%[631]) which could be supplied to the different sectors. Under the assumption that the transport sector will consume about half of this renewable energy (i.e. 27.7 TWh/yr hydrogen plus 13.8 TWh/yr e-fuels), RFNBOs could contribute some 1.3% towards RES-T (not considering any multiplier for hydrogen or RFNBOs) based on current energy consumption in transport. Accordingly, 1.3% could be a first benchmark for a 2030 target for RFNBOs (which should be adapted accordingly, in case multipliers are to be included), only considering the domestic targeted renewable hydrogen production capacity in 2030; a target differentiating between hydrogen and e-fuels could then be 0.9% for hydrogen and 0.4% for e-fuels. In addition imports of RFNBOs will complement these numbers, especially due to low-cost production conditions in non-European countries.

In any case, such a target will stimulate further market growth along the RFNBO supply chain with positive impacts on stakeholders, including job creation (see section *General social impact: employment*; see also Section B4, option 2). In addition, the environmental impact will be high, especially in case the gap to the 2030 target of RES-T cannot be filled adequately by advanced biofuels, due to limitations in production ramp up.

Adaptions in FQD

The FQD is part of the climate acquis of the European Union (lead: DG CLIMA) while RED II is an element of the energy acquis (lead: DG Energy. However, there are substantial overlaps as described above in aiming at a reduction of GHG emissions and in ensuring sustainability of biofuels.

FQD focuses on GHG reductions, while RED II focuses on renewable energies. In concrete terms, FQD counts both renewable energies as long as they can demonstrate minimum GHG reductions, and non-renewable energies that reduce GHG emissions; in contrast, RED II only counts renewable energies (and allows MSs to count recycled carbon fuels). Furthermore, RED II sets additional requirements motivated by energy system aspects such as technology development and commercialization, system integration issues, energy diversification, security of energy supply, etc.

[628] Assuming 4,000 full load hours of the electrolyser and an overall efficiency of 70%.
[629] Applying the current methodology of RED II.
[630] Assuming 4,000 full load hours of the electrolyser and an overall efficiency of 70%.
[631] Assumption for simplification only: In reality, conversion efficiency from hydrogen to e-fuels can be up to 75%.

In this respect recital 88 of RED II states: "*Advanced biofuels […], renewable liquid and gaseous transport fuels of non-biological origin, and renewable electricity in the transport sector can contribute to low carbon emissions, stimulating the decarbonisation of the Union transport sector in a cost-effective manner, and improving, inter alia, energy diversification in the transport sector while promoting innovation, growth and jobs in the Union economy and reducing reliance on energy imports. An obligation on Member States to require fuel suppliers to ensure a minimum share of advanced biofuels and certain biogases, is intended to encourage continuous development of advanced fuels, including biofuels.*"

A number of issues related to the fact that FQD and RED II have major overlaps in scope, detailed provisions and overall objectives, have consequences that may limit effectiveness and efficiency; major overlaps and differences relevant to this analysis include:

1. The scope of fuels covered is similar, but not identical: FQD includes renewable and non-renewable fuels; RED II includes renewable fuels only (plus optionally recycled carbon fuels);
2. The scope of transport sectors covered is similar, but not identical: FQD includes road transport; RED II covers road and rail transport, and for some provisions also further transport sectors (see 2.4 above);
3. For demonstrating compliance with FQD, fuel suppliers can form groups choosing to be considered as a single supplier; for demonstrating compliance with RED II, MSs are free to set rules for fuel suppliers to exchange fuel quantity compliance, e.g. through bilateral contracts or through credit mechanisms, etc.;
4. Definition of fuel supplier: while FQD seems to differentiate between "*fuel*" and other forms of "*energy*" (notably electricity), RED II seems to include "*electricity*" in " *fuel*"
   FQD Art. 2(8): "*'supplier' means the entity responsible for passing fuel or energy through an excise duty point or, if no excise is due, any other relevant entity designated by a Member State*"; in any case, FQD covers electricity supplied to road transport
   RED II (Art. 2 (38): "*'fuel supplier' means an entity supplying fuel to the market that is responsible for passing fuel through an excise duty point or, in the case of electricity or where no excise is due or where duly justified, any other relevant entity designated by a Member State*"; in RED II (Art. 25 (1)), "*Member States may exempt, or distinguish between, different fuel suppliers and different energy carriers when setting the obligation on the fuel suppliers*"; as a consequence, obligated parties under FQD and RED II may not be identical;
5. The overall ambition and time horizon are different: FQD sets a GHG reduction target of 6% for 2020 and thereafter (which is roughly equivalent to the 10% renewable energy target of RED for 2020 given the GHG reduction requirements on biofuels of around 60%), while RED II sets a 14% renewables target for 2030; the latter is to be increased through the revision of RED II (a revision of FQD is not foreseen for the time being) based on increased climate ambition expressed by the Green Deal.

An evaluation of FQD was carried out in 2017; however, Art. 7a was excluded from the evaluation: "*Due to the fact that the Article 7a FQD implementing legislation was only adopted in 2015 and has to be transposed only by 2017 it has been excluded from the scope of this evaluation. The Article obliges* *fuels suppliers to reduce the greenhouse gas intensity of the fuel mix they supply by 6% in 2020 compared to 2010.*"[632]

Removing the FQD Art. 7a target/supplier obligation and the sustainability and greenhouse gas saving criteria from the FQD would have a number of impacts.

The Art. 7a target/supplier obligation is roughly equivalent to the RED target/supplier obligation for 2020. Beyond 2020, the FQD target is already obsolete through the RED II target for renewable energies in transport for 2030 as FQD does not increase the GHG reduction ambition after 2020, which RED II does. A further increase of the ambition for 2030 through a revision of RED II towards a 22-26% renewables in transport objective following results of the Climate Target Plan is anticipated to be necessary in order to achieve the increased climate ambition. Therefore, the FQD target/supplier obligation is a relic that has no effect any more.

The sustainability criteria and GHG saving criteria for biofuels were originally defined identically in FQD and RED, and revised in 2015 through Directive (EU) 2015/1513[633]; see recital 3 of this Directive: "*Directive 2009/28/EC sets out sustainability criteria with which biofuels and bioliquids need to comply in order to be counted towards the targets in that Directive and to qualify for inclusion in public support schemes. The criteria include requirements on the minimum greenhouse gas emission savings that biofuels and bioliquids need to achieve compared to fossil fuels. Identical sustainability criteria for biofuels are set out in Directive 98/70/EC.*" However, the sustainability requirements and GHG savings criteria have been strengthened by RED II. Therefore, sustainability requirements and GHG savings criteria are now less strict in FQD than in RED II, so that reporting under FQD is even less comparable to RED II achievements than before (see list of differences between FQD and RED II above). In this sense, coherence deficits between FQD and RED II have increased further; coherence could be established through removing sustainability requirements and GHG savings criteria for biofuels from FQD. In case the Art. 7a target/supplier obligation would not be removed (in spite of the conclusions above), reference should be made in FQD to RED II sustainability and GHG savings criteria rather than to have two directives cover them, and that inconsistently.

The major effect of removing the FQD Art. 7a target/supplier obligation and the sustainability and greenhouse gas saving criteria from the FQD would be to reduce administrative burden from public administrations and fuel suppliers for data and information collection, management and reporting. Furthermore, inconsistent scope, reporting requirements and other provisions between FQD and RED II as elaborated above would be eliminated even if the data reporting by suppliers defined in FQD would be taken up by the revision of RED II, however, in way consistent with RED II provisions. A minor drawback would be that the time series of such data would be discontinued, and started on a new basis because of changes in scope. The impacts of taking up the reporting requirements from FQD in the revised RED II (consistent with RED II provisions) would be minimal compared to eliminating them entirely.

[632] European Commission. (2016). Evaluation Roadmap for the Evaluation of the Fuel Quality Directive 98/70/EC of 13 October 1998 relating to the quality of petrol and diesel fuels as amended. Available at: http://ec.europa.eu/smart-regulation/roadmaps/docs/2015_clima_021_evaluation_fuel_quality_en.pdf

[633] Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources (Text with EEA relevance), OJ L 239, 15.9.2015, p. 1–29.

The economic impacts are thus positive in the short-term, however to a limited extent, for public administrations and fuel suppliers. A limited number of jobs would thus be lost; however, there would also be the opportunity to save the jobs in a way as to produce added value (which they are not doing under the current combined regime of FQD and RED II based on the required rather unproductive double work), further increasing the economic impacts, and keeping job impacts neutral. A certain, rather short transition period would be needed to adjust to the changes. Environmental impacts would be zero as explained above.

Sub-option 3.2: Broaden the scope of the target to all transport modes with increased ambition

Sub-option 3.2 covers three different aspects:

1. Broaden the scope included in the calculation of RES-T to all transport modes (including aviation and maritime);
2. Introduction of a sub-target for advanced biofuels and RFNBOs;
3. Dedicated obligation for aviation and maritime fuels (mainly covered by ReFuelEU Aviation or FuelEU Maritime initiatives).

The detailed analysis of the effect of an inclusion of the aviation and maritime sector on RES-T in 2030 requires modelling data which were not available at the time of preparing this document. The following analysis will therefore focus on high-level considerations and estimations. Further aspects with regard to RFNBOs in maritime and transport are discussed in document B – Energy System Integration, subtask B4.

The main impact of a changed methodology - where not only renewable energy in aviation and maritime are considered in the numerator of RES-T, but also the overall energy consumption (renewable and non-renewable) in these sectors is included in the denominator – will decrease the overall RES-T share in all MSs, independent of the current fraction of renewable energies in aviation and maritime. Based on SHARES 2019 results, the quantity of liquid biofuels in all other transport modes beside road and rail transport in the EU27 summed up to 5.59 ktoe compared to about 21,566 ktoe considered for the numerator (including multipliers). Accordingly, the "*bonus*" which currently is provided can be considered to be rather limited. In 2017, final energy consumption in road transport accounted for about 72.7% of the overall energy consumption in transport in the EU28. While energy consumption for rail transport (1.70%) and domestic navigation (1.14%) are considerably low, international marine bunkers account for 10,8% and domestic and international aviation for 13.64%.[634] In case, these values are considered in the RES-T denominator, it can be expected that the current value for 2019 (EU27: 7.45%, EU28: 7.26%) will directly be reduced to 5.37% (EU28). Accordingly, even in case of the 14% RES-T target, more ambitious decarbonisation measures are required. As described above for sub-option 3.1, the gap has mainly to be filled with renewable electricity, advanced biofuels, or RFNBOs (hydrogen and e-fuels). A realistic option for maritime and aviation are, however, only liquid drop-in fuels in a short- to mid-term perspective.

The economic impacts will accordingly mainly focus on the stakeholders involved in those supply chains. Also, the aviation and maritime industry will face additional costs through the integration into the

[634] Based on Eurostat data.

supply obligations since it can be expected that national implementations will not exclude them from the burden of decarbonising their sectors (see also analysis in document B – Energy System Integration, subtask B4). As described above, energy consumption from aviation and maritime transport in 2017 summed up to about 107.500 ktoe, with a share of biofuels being below 0.01%. A significant increase in demand can thus be expected for renewable fuels in those sectors, resulting in positive effects on investments and job creation. The additional costs may be passed on to passengers and clients. However, especially in domestic aviation, price sensitivity will be higher due to alternatives like rail and road.

The environmental effect will consequently also be positive, as long as the RES-T target is not reduced by a correction factor taking the changed methodology into account. With regard to aviation and maritime, bunkering and tankering activities may be moved to non-EU countries in case different regulations apply. A detailed analysis should focus on whether e.g. international aviation or maritime transport should be considered or whether this only increases the risk of carbon leakage. This, however, needs to take the results of the consultation process in ReFuelEU Aviation or FuelEU Maritime initiatives into account.

Sub-targets for advanced biofuels and RFNBOs (as discussed in Sub-option 3.1) need to be adjusted accordingly, in case the calculation methodology of RES-T is changed.

Sub-option 3.3 Streamline multipliers

The use of multipliers is generally viewed critically because target compliance on paper can interfere with the actual goal of greenhouse gas reduction. Multipliers that are too small can be ineffective because they do not compensate for the difference to fossil fuels. And higher multipliers can undermine the actual fuel supply on the road, e.g. a multiplier of 4 means that a quarter of the fuel is required to meet the same target. The impact of eliminating or changing existing multipliers or the introduction of new ones also strongly depends on the respective multiplier and sector. If all multipliers were to be eliminated as of 2019, the overall (de facto) RES-T share would be (is) 6.0% instead of the official 7.5%. Adopting the streamlined multipliers would reduce the discrepancy between the RES-T share on paper and on the road with an overall share of 6.5% (see Figure 3-11).

Depending on what renewable fuel countries rely on most strongly and most importantly on the magnitude of their existing RES-T share, some would be more disadvantaged by an elimination of all multipliers, while others may be comparatively advantaged as their lack of predisposition to certain incentives improves their ranking relative to other MSs. For example, Finland's reported RES-T share (heavily reliant on biofuels and biogas) would drop by 7.9 percentage points (compare Figure 3-12 and Figure 3-13), whereas Austria's share, which constitutes mostly food-based biofuels and renewable electricity would only drop by 0.7%. France (8.4%) and Italy (8.0%) have similar shares with multipliers, but eliminating them would see France drop to 7.7%, whereas Italy would fall back to 5.0%. A much more detailed discussion around more nuanced incentives based on target achievement in order to ensure continued effort may be reasonable and potentially overlap with streamlining certain multipliers (for certain sectors). Similar considerations apply in regard to including specific sectors in the target calculation, or not, as discussed in sub-option 3.2. A complete elimination of multipliers seems therefore a hard sell and is unlikely to garner support by countries disadvantaged the most .

Figure 3-11: RES-T share for EU-27 with multipliers, without multipliers and with streamlined multipliers (Source: LBST calculations based on SHARES 2019)

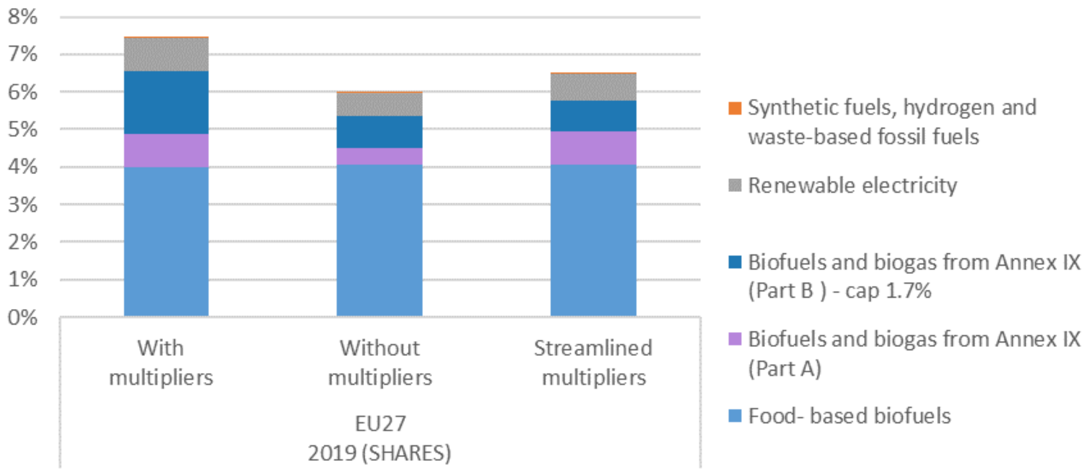


Figure 3-12: Current RES-T shares for EU-27 including multipliers (Source: LBST calculations based on SHARES 2019)

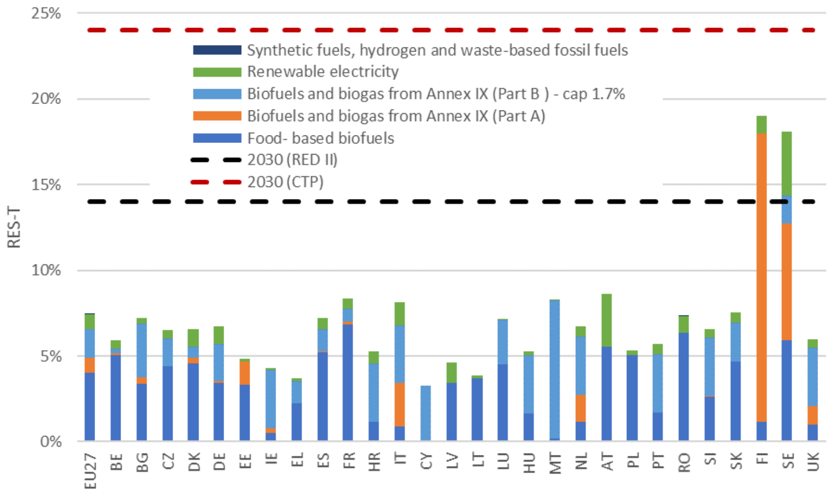


Figure 3-13: Current RES-T share for EU-27 without multipliers (Source: LBST calculations based on SHARES 2019)

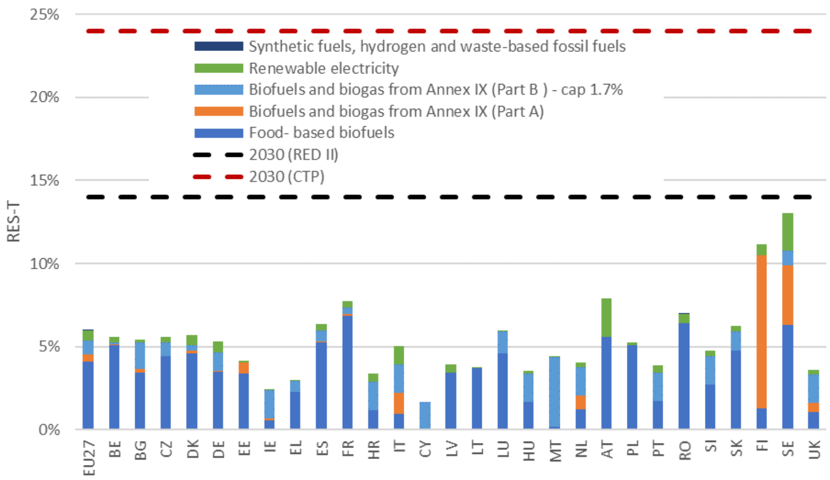
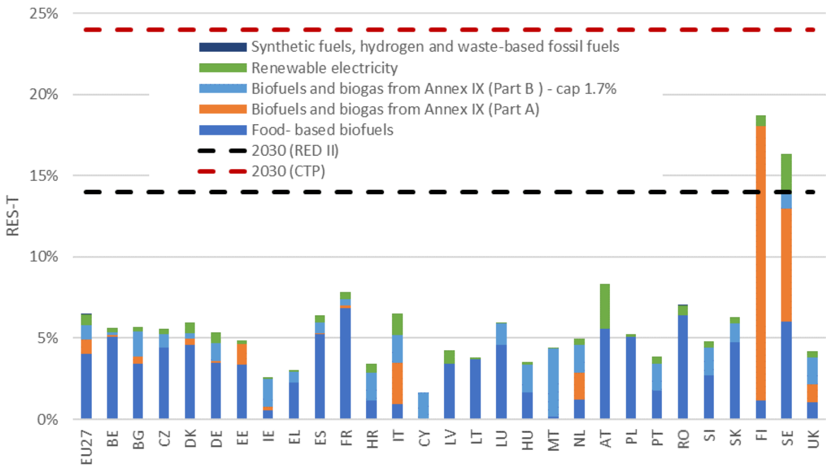


Figure 3-14: RES-T share for EU-27 with streamlined multipliers (Source: LBST calculations based on SHARES 2019)



Electricity

As is the case with EVs, multipliers have so far been the instrument of choice to acknowledge the impact of (more efficient) transport electrification in a legislation that focuses on the share of final energy use in transport. However, next to always having been a controversial instrument, advances in the measuring methodology for renewable electricity in transport, as laid out above as well as in document B – Energy System Integration, section B2 – Option 3, make the multiplier of 4 for electricity in road ripe for revision. Additionally, and this is becoming more and more relevant as countries electrify further, “*higher rates of electrification of road transport, possibly fortified by a multiplier for the direct use of electricity in vehicles, can have a significant impact on the remaining obligation of fuel suppliers, depending on the share of RES electricity in the generation mix of the country in question.*”[635] The accounting methodology should therefore be streamlined and in case a different statistical approach is chosen, the multiplier of four should be reduced substantially. This is to say that the multiplier should not be revised unless efforts of maintaining a reasonably level playing field between the different technologies should have been made. Eliminating the multiplier without alternative provision to account for the electricity would indeed disadvantage the electrification of (road) transport and the generally associated economic, environmental and social benefits of it. Examples that relate to electricity and that would cover a panoply of benefits include a dedicated credit mechanism, which is discussed in greater detail in subtask B2. Generally, reducing the multiplier for electricity in road would give way to different kinds of target expression and allow for a more transparent reporting of the de facto energy mix in the European transport sector.

Comparatively little economic, social, or environmental impact can be expected from the introduction of a multiplier of 1.2 for maritime applications. As laid out above, this is reasonable to not disadvantage the technology for niche applications, e.g. short ferry routes, where it may be useful and relevant. However, this incentive is generally outweighed by structural and technological challenges and concerns that hinder broader uptake of electricity in the sector. Since the idea behind this revision is to match the multiplier other fuels in the sector, the multiplier for electricity could also be increased

[635] Öko-Institut. (2017). Improving the accounting of renewable electricity in transport within the new EU Renewable Energy Directive. Available at: https://www.oeko.de/fileadmin/oekodoc/Improving-accounting-of-renewable-electricity-in-transport.pdf

to 1.5, which is the same value that is suggested for RFNBOs in sub-variant B. This would still likely be insignificant compared to the fundamental challenges around electrification that the maritime sector faces.

RFNBOs

While RFNBOs currently do not benefit from a multiplier (except for their application in aviation and maritime), creating a better environment for supplying such fuels would likely push the sector and speed up their journey on the way to commercial viability and competitiveness with other fuels. Generally, this multiplier should reflect the comparable efficiency of hydrogen in FCEVs compared to liquid RFNBOs or advanced biofuels consumed in vehicles with internal combustion engine. The impact of introducing a multiplier for hydrogen usage in road allowing the energy content of hydrogen to be counted twice towards RES-T (minimum share), is highly dependent on the actual volume of hydrogen consumed as a fuel until 2030, which is explained in greater detail in option 1.

There have been concerns from the biofuel industry that the introduction of a multiplier for hydrogen would "*start a process of displacement at the expense of established sustainable biofuels that are indispensable for climate protection as the introduction of multipliers will disadvantage crop and even waste-based biofuels.*" As laid out above in option 1 on incremental improvements, it has to be noted that since biofuels from Annex IX Part B are capped at 1.7% anyways, an increase in RFNBOs', e.g. Hydrogen in road, contribution towards RES-T will accordingly mainly substitute or complement the required production capacity ramp-up for advanced biofuels (biofuels and biogas from Annex IX (Part A)) within the next years. That being said, it is well-known that biofuels can originate from third countries and require substantial transport at times, while also raising questions around what 'sustainable' land-use and food security entail, so incentivising a partial shift to alternative options is worth considering. This is not to say that a multiplier for biofuels is redundant as they can help stimulate uptake in sectors that lack clear alternative renewable options. However, creating incentives for RFNBOs, and especially hydrogen, would not only benefit the respective industry but also lay the foundation for a major, green industry of the future and potential for increased job creation in the sector.

Biofuels

Removing the multiplier for biofuels Annex IX Part B is potentially politically unfeasible and may disadvantage certain players in the biofuel industry. At the same time, a higher multiplier, as is sometimes called for, risks diluting the biofuel target and reducing overall GHG reduction. Efforts to support the biofuel industry must rather be focused on supporting the development of (advanced) biofuel technologies and comparative affordability to fossil alternatives. For example, de Jong et al. (2018) find that the introduction of renewable jet fuel could offset 53-84% of projected emission growth of the sector by 2030, which is inter alia largely driven by the 1.2 multiplier.[636] However, it is important to not create a technological lock-in. Further discussions on the role of biofuels can be found in Option 2 and sub-option 3.2.

636 deJong et al. (2018). Renewable jet fuel supply scenarios in the European Union in 2021-2030 in the context of proposed biofuel policy and competing biomass demand. Available at: https://www.rug.nl/research/portal/files/78581204/Jong_et_al_2018_GCB_Bioenergy.pdf

Option 4: Option 3 + Partly harmonise and simplify target and obligation

Sub-option 4.1: Further harmonisation of the scope of the supply obligation

The supply obligation put on fuel suppliers by the MSs has a scope defined by three major dimensions:

1. the different fuel suppliers obligated;
2. the different energy carriers covered by the obligation;
3. the transport sectors covered.

Further elements of the supply obligation related to multipliers, caps, and minimum shares include:

4. the application of multipliers (Art. 27(2));
5. the possibility to include recycled carbon fuels in the obligation (Art. 25(1) third subparagraph);
6. the cap on conventional biofuels (Art. 26(1));
7. the cap on the share of high indirect land-use change-risk biofuels (Art. 26(2));
8. the cap on the share of biofuels and biogas produced from the feedstock listed in Part B of Annex IX;
9. the minimum shares of advanced biofuels and biogas produced from the feedstock listed in Part A of Annex IX (Art. 25(1)).

Penalties:

10. Another element for potential harmonisation are the penalties to be imposed on fuel suppliers for non-compliance with the obligation.

Trajectory towards 2030:

11. Finally, the obligation may not only contain a 2030 minimum share, but also a trajectory to be complied with including interim minimum shares (as already the case for advanced biofuels specifically).

In a very general perspective, harmonization of the supply obligation increases the integration of the European market for transport fuels, but reduces the possibility for MSs to adjust the obligation to national circumstances. Therefore, the objective of this analysis is to identify the aspects of the supply obligation to be harmonized, and to identify those aspects that should be at the discretion of the MSs. On this basis the impacts of such partial harmonisation are assessed.

In this perspective, the elements of the supply obligation most strongly affecting the European market integration should be harmonised, while the elements most strongly subject to national differences should remain a national choice. The following table gives a qualitative overview of the two aspects. Where national differences are weak and the effects on the European market integration are strong, a harmonisation should result in strong positive impacts, while in the opposite case, positive impacts should be weak, or the impacts could even be negative.

Further elements of a supply obligation as defined in other options, e.g. a credit mechanism (see option 2), would follow the same logic of harmonisation at EU level, but is not covered here in detail. Nonetheless it should be noted that for a credit mechanism a European harmonisation and scope is specifically advantageous.

Table 3-3: List of elements possibly subject to harmonisation

Area	No.	Elements possibly subject to harmonisation	National differences	Effect on EU market integration
Scope	1	fuel suppliers	limited	strong
	2	energy carriers	limited	strong
	3	transport sectors	weak	limited
Multipliers, caps and minimum shares	4	application of multipliers	limited	strong
	5	inclusion of recycled carbon fuels, and low carbon fuels	strong	strong
	6	cap on conventional biofuels	strong	limited
	7	cap on the share of high indirect land-use change-risk biofuels	limited	limited
	8	cap on the share of biofuels and biogas based on feedstock in Part B of Annex IX	limited	strong
	9	minimum shares of advanced biofuels and biogas based on feedstock in Part A of Annex IX	limited	strong
Penalty	10	Penalty	?	weak
Trajectory	11	Trajectory towards 2030	strong	strong

The scope of the obligation may cover different types of suppliers, which are mainly defined by the type of fuel they supply. Suppliers of conventional road transport fuels (petrol and diesel) are generally included in the obligation by MSs as they supply the largest share of energy for transport. Many of these fuel suppliers do business in more than one MS, often in many, and as a consequence, national differences are rather limited. Supply obligations may have different de minimis rules, i.e. threshold values for annual fuel sales below which fuel suppliers are not included in the obligation. Suppliers of natural gas (compressed or liquid), biogas, liquefied petroleum gas, and electricity for road transport use may or may not be covered by the MSs supply obligations. Also, suppliers of energy to rail, maritime, and aviation may or may not be covered. The national diversity of such fuel suppliers is generally higher than with petrol and diesel suppliers. In the other perspective, European market integration is strongly affected by the inclusion or exclusion of certain types of suppliers at MS level. Therefore, a European harmonisation of the scope of the supply obligation would have positive economic impacts leveraging synergies within individual fuel suppliers across MSs borders, and enhancing competition to the benefit of fuel consumers. On the other hand, fuel suppliers operating in only one MS may face stronger competition without synergy potential.

As a general observation, markets for conventional transport fuels, most notably petrol and diesel for road transport, are an international business. At European level, the FQD sets minimum requirements for petrol and diesel. Furthermore, European and international standards define the fuels. Therefore, national differences in the EU mainly relate to the renewable components of the fuels.
Another element of national differences is the consumption levels of petrol relative to diesel. FQD sets a blending limit of 7% for FAME in diesel, which is both by volume and by energy, and a blending limit of 10% by volume of ethanol in petrol, which is equivalent to 6.8% by energy.[637] However, E10 blends are currently available in 14 EU MSs, while in the remaining 13 MSs only E5 is available. Where E10 is available, the market share relative to E5 varies between 100% in Bulgaria and Romania, and 14% in Germany[638]. In order to achieve a 7% by energy share in conventional fuels, E10 would have to be introduced in the remaining MSs, and/or higher blends would have to be introduced into the market.

[637] ICF et al. (2015). Impact of higher levels of bio components in transport fuels in the context of the Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998, relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC.
[638] ePURE. (2020). Fuel Blends, Low ethanol blends – E5 and E10. Available at: https://www.epure.org/about-ethanol/fuel-market/fuel-blends/

The latter is possible without changes to FQD for drop-in biofuels such as pure diesel-like hydrocarbons made from biomass using the Fischer-Tropsch process (BTL, Biomass to Liquid) or hydro-treated vegetable oil (HVO). The caps on food and feed-based biofuels, however, set a supply limit to higher blends. The major national difference thus is the market introduction and share of E10. ICF (2015) indicates that national differences in retail ownership structures may differently affect fuel retailers in a market introduction of E10 or other (new) fuel blends. However, as fuel qualities will continue to be harmonised at European level and vehicles which cannot be operated on E10, are phased out over this decade, the barriers to the introduction of E10 will gradually disappear.

While it is obvious that all liquid and gaseous renewable transport fuels should be eligible to contribute to the obligation, and that this should be harmonised at EU level, it is less obvious whether in the future suppliers covering only specific fuels such as CNG/LNG, LPG, electricity, or hydrogen should be included in the obligation in a harmonised way at EU level.

In road transport, the contributions of natural gas (compressed or liquid), biogas, and liquefied petroleum gas are very diverse in the EU MSs. In 2018, LPG represented 9.5% of energy consumption in road transport in Poland, 5.4% in Italy, 1.4% in the Netherlands, 0.7% in Germany, and 0.2% in France.[639] LPG consumption is not negligible in some MSs, it rather has a marginal contribution in the rest of the Union. CNG consumption in 2018 represented some 2.6% in Italy, 0.6% in the Netherlands.

While for LPG there is the theoretical possibility to produce chemically identical products from biomass feedstocks, such production is not done commercially in significant quantities at present. In contrast to that, biogas production is commercially established, and biomethane consumption in road transport is too, e.g. in Sweden.

As LPG is a mineral oil product from refineries, there is a strong link to petrol and diesel, and the quantities supplied are significant in some MSs. Therefore, LPG should be included in the harmonisation. In order to avoid unnecessary administrative burden, a MS threshold value should be defined below which LPG would not be included in the obligation in the respective MSs.

CNG consumption in road transport is less relevant than LPG and links to the natural gas sector rather than to the refinery sector. Nonetheless, some consumption of biomethane in transport should have a chance of being counted towards the obligation, notably in view of advanced biogas based on Annex IX Part A feedstocks such as manure. As for LPG (see above), a MS threshold value should be defined below which natural gas would not be included in the obligation in the respective MS.[640]

Electricity in road transport is a specific case for inclusion into a harmonised supply obligation at EU level. On the one hand, battery-electric vehicles have started to gain relevant market shares, and they have a major potential for decarbonising road transport. Not including this would thus exclude the most promising option. On the other hand, electricity in road transport is not a drop-in fuel, but requires both dedicated vehicles and dedicated recharging infrastructure. The market introduction of the

[639] Eurostat. (2020). Energy balance sheets.

[640] LNG is discussed as a possible fuel for long-haul freight transport requiring a dedicated supply infrastructure. So far however, consumption is negligible. In case LNG is established and consumption becomes significant, it should be combined with CNG consumption and treated as an energy carrier for the target calculations in RED II.

vehicles and infrastructure will not be strongly incentivised by a supply obligation, but is determined by business cases for the supply infrastructure, consumer choices for respective vehicles, etc. Other policy instruments fostering infrastructure build-up and vehicle market uptake such as tax incentives, subsidies for vehicle buyers, etc., are much more effective here. The supply obligation can only be of minor importance as an incentive. However, the renewable share in the electricity supplied to road transport could be increased through the supply obligation. At the same time, using the national electricity production mix to calculate the renewables share as the "*default*" in RED II, depends on the national mix, which cannot be influenced by fuel suppliers. The options for counting the electricity as 100% renewable seem very restrictive, so it is doubtful that any electricity supplier to road transport can fulfil them. In this sense it does not seem to make sense to include electricity suppliers into a harmonised supply obligation at EU level. Allowing electricity suppliers to road transport to provide contributions to a supply obligation put on other types of suppliers (i.e. of liquid and gaseous fuels) would provide some revenue streams to electricity provider that would be beneficial to infrastructure build-up (see discussion in Section B – Energy System Integration, subsection B2).

Electricity in rail transport shows significant national differences. In some cases, it may even not be integrated into the national electricity system. Nonetheless, it represents an important contribution to energy consumption, and should thus be included in the supply obligation in a harmonised way at EU level.

Domestic and more importantly international navigation and aviation should be harmonised at European level[641], in order to avoid fragmentation and not to provide opportunities for transport operators to systematically bunker only in MSs where maritime/aviation are not included in the obligation. It should be noted, however, that such avoidance strategies will be possible to a certain extent by bunkering in countries outside the EU. One way of harmonisation is to include aviation and maritime in the obligation on fuel suppliers in transport. This will provide additional incentives to supply renewable fuels to these sub-sectors (see also analysis below in including maritime and aviation in the calculation method for the minimum shares). However, as long as there are no dedicated sub-obligations for maritime or aviation (see analysis of sub-option 3.2 above) lower costs of renewable fuels for other transport sectors may result in this incentive not being sufficiently strong to achieve renewables in maritime and aviation.

Hydrogen is an emerging transport fuel covered as an optional element in the Alternative Fuels Infrastructure Directive (AFID);[642] discussed in Section B – Energy System Integration, subsection B4. Hydrogen is covered under "*biogas*" or "*RFNBO*" by RED II, but can also be of non-renewable origin. Hydrogen refuelling infrastructure is currently being built up, but supply is still very low. Nonetheless, hydrogen suppliers other than the current suppliers of petrol and diesel may emerge in the coming years. As this is an emerging sector, including hydrogen suppliers in a harmonised supply obligation could be beneficial in spite of national difference. As for LPG (see above), a MS threshold value should be defined below which hydrogen would not be included in the obligation in the respective MS.

[641] E.g. aviation is included in the EU Emissions Trading System.

[642] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure, OJ L 307, 28.10.2014, p. 1–20.

The application of multipliers should be harmonized in MSs as existing differences in accounting different renewable fuels strongly affect the market conditions in the MSs, resulting in a fragmented European fuel market. Deviating national prerequisites and conditions in fuel supply that would require such differences in multipliers seem rather limited, so that a European harmonisation seems suitable.

In contrast, the potentials for recycled carbon fuels and low carbon fuels strongly differ between MSs, both depending on industry structure and natural resources (e.g. for carbon capture and storage, CCS). As a consequence, harmonised rules may unduly limit application in MSs with high potentials, while MSs with low potentials could be overburdened.

National differences in the level of food and feed-based biofuels are strong and as a consequence, the same holds for the cap on these conventional biofuels. A harmonisation will have visible, but rather limited effects in market integration; in contrast, it could create market changes requiring adaptation strategies from fuel suppliers without accompanying positive environmental effects. Therefore, this cap should continue to be defined in RED II for the national minimum share calculation, but does not lend itself to a harmonisation of the supply obligation.

The cap on the share of high indirect land-use change-risk biofuels has limited national differences, but also limited effect on EU market integration. Nonetheless, the phase-out until 2030 should be defined as part of the obligation in RED II, while the national trajectories towards 2030 should be defined at MS level.

The feedstock potentials listed in Part B of Annex IX show some diversity between MSs. However, defining different obligations related to biofuels and biogas produced from these feedstocks in MSs would strongly fragment the EU fuel market. The same holds for advanced biofuels and biogas based on feedstock listed in Part A of Annex IX. As such, the supply obligation should be harmonised at EU level for these fuels. An important element of such a European harmonisation would be to have a uniform definition of such fuels in all MSs.

Penalties on fuel suppliers for non-compliance do not have a strong impact on EU market integration as long as they are effective, proportionate, and dissuasive; so there is no need for a European harmonisation.

RED II does not define a trajectory towards the 2030 minimum share; only for advanced biofuels, a trajectory for their minimum share is included. Such trajectories may be defined by MSs, while the 2030 value should be defined in RED II.

The following table provides an overview of the harmonisation elements as discussed above.

Table 3-4: Suggestion for harmonisation approaches in RED II

			Definition by	Identical for all MSs?
Scope	1	fuel suppliers	EU	yes
	2	energy carriers	EU	yes
	3	transport sectors	EU	yes
Multipliers, caps and minimum shares	4	application of multipliers	EU	yes
	5	inclusion of recycled carbon fuels, and low carbon fuels	MS	no
	6	cap on conventional biofuels	MS	no
	7	cap on the share of high indirect land-use change-risk biofuels	EU: 2030 level MS: trajectory	0 in 2030; trajectory different
	8	cap on the share of biofuels and biogas based on feedstock in Part B of Annex IX	EU	yes
	9	minimum shares of advanced biofuels and biogas based on feedstock in Part A of Annex IX	EU	yes
Penalty	10	Penalty	MS	no
Trajectory	11	Trajectory towards 2030	EU: 2030 level MS: trajectory	2030 level identical; trajectory different

This harmonisation approach would provide positive economic impacts based on enhanced European market integration providing for more synergies within companies, and increased competition between companies. These impacts are rather short-term, and mainly affect fuel supplier. However, consumers may benefit through enhanced competition, and public administrations should also benefit from the harmonisation after a certain period required for the national adjustments. On the other hand, potential negative economic impacts are limited by leaving flexibility to MSs where national differences support different national choices and where national differences have limited effects on market integration.

Furthermore, enhanced market integration reduces the possibilities of fuel suppliers active in more than one MS to minimise their renewable energy quantities by optimally using differences between supply obligations in different MSs. This should provide for additional environmental benefits, that should materialize rather in the longer-term.

The economic benefits may lead to some limited job losses.

Art. 27(1) lays down the provisions for calculation of the minimum shares referred to in Article 25(1): "*(a) for the calculation of the denominator, that is the energy content of road- and rail-transport fuels supplied for consumption or use on the market, petrol, diesel, natural gas, biofuels, biogas, renewable liquid and gaseous transport fuels of non-biological origin, recycled carbon fuels and electricity supplied to the road and rail transport sectors, shall be taken into account*".

The calculation of the denominator thus does not include energy consumption in transport sectors other than road and rail, i.e. notably shipping and aviation (both domestic and international), and it does not include LPG in spite of its contribution to road transport consumption, at least in some MSs (see above). Including LPG in the calculation of the denominator would simply correct an omission. Including domestic navigation and aviation in the calculation of the denominator represents a minor change as these two sub-sectors represent small shares of overall energy consumption in transport. Data for domestic navigation and aviation are covered by Eurostat statistics. The new calculation will, however, lead to systematically lower renewable shares as the denominator increases. Including international navigation (marine bunkers) and aviation, however, represents a more important change as these consumptions are significantly higher than the domestic ones. As international navigation and aviation quantities are generally not covered in Eurostat energy balance statistics[643], it does not seem practical to include them here.

"*(b) for the calculation of the numerator, that is the amount of energy from renewable sources consumed in the transport sector […], the energy content of all types of energy from renewable sources supplied to all transport sectors, including renewable electricity supplied to the road and rail transport sectors, shall be taken into account.*"

The calculation of the numerator thus includes renewable energy (including electricity) supplied to shipping and aviation (see discussion in Section B – Energy System Integration, subsections B2 and B4). This could be made more explicit in a revision of RED II in order to avoid misunderstandings. This should also cover energy supplied to international navigation and aviation. However, care should be taken that there are no unintended conflicts in relation to the ongoing *ReFuelEU Aviation -Sustainable Aviation Fuels* initiative[644], and the *FuelEU Maritime - Green European Maritime Space initiative*[645].

The changes described above would have positive impacts on the consistency and comprehensiveness of the scope of the calculation of the minimum shares. Relevant economic, environmental and social impacts would, however, depend on the scope of the supply obligation rather than on the calculation method for the minimum shares.

Sub-option 4.2: Sub-option 4.1 + Define the way the supply obligation is expressed

As explained above, expressing the obligation in terms of fuel volumes is equivalent to expressing it in terms of energy volumes as long as volumes (quantities) are specified for each renewable fuel separately. It would therefore not require relevant administrative efforts to switch to an expression of the obligation in terms of energy, neither in the governments nor for the fuel suppliers.

RED II has the double objective of increasing the consumption of renewable energies in all sectors, and of reducing GHG emissions. Obviously, increasing renewable energies reduces GHG emissions. However, not all measure reducing GHG emissions necessarily increase renewable energies. It should be noted that FQD expresses the obligation defined there in terms of GHG reduction. This is also reflected in the fuel scope of the obligation: RED II in principle includes all renewable fuels (including electricity) plus optionally recycled carbon fuels in the obligation[646], while FQD includes renewable fuels and all other fuels that reduce GHG emissions. Section B – Energy System Integration discusses enlarging the scope of RED II towards low carbon fuels. The question of whether to express the supply obligation in terms of energy or in terms of GHG emissions has to take this double objective and scope of RED II into account.

[643] Eurostat. (2020). Energy balance sheets.

[644] European Commission. (2020). ReFuel EU Aviation: Inception impact assessment. Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-ReFuelEU-Aviation-Sustainable-Aviation-Fuels

[645] European Commission. (2020). FuelEU Maritime: Inception impact assessment. Available at https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12312-FuelEU-Maritime

[646] MSs are free to define the detailed scope of the obligation nationally in terms of fuel suppliers obligated, fuels covered as well as transport sectors covered; see section above.

Expressing the supply obligation in terms of energy or in terms of GHG reduction will impact both the quantities of renewable fuels consumed and GHG emitted.[647] Fuels are eligible for counting towards the obligation if they comply with a number of sustainability requirements, including GHG reductions compared to the fossil fuel comparator, i.e. the conventional fossil fuels without renewable components. As an example, supplying one MJ of fuel type A to the market makes a contribution of one MJ to an energy obligation as long as the fuel has at least e.g. 60% GHG reduction compared to 94 g CO_{2eq}/MJ. Accordingly, a fuel A ,that has a reduction of 60%, is eligible, as well as a fuel B, that has 95% reduction. For an energy obligation, both count as 1 MJ. For a GHG reduction obligation, fuel A counts as 60% reduction (56.4 g CO_{2eq}/MJ reduction) while fuel B counts as 95% reduction (89.3 g CO_{2eq}/MJ reduction). So, a GHG reduction obligation provides a stronger incentive than an energy obligation to supply fuels that have very high GHG reductions. This is more in line with the 2050 carbon neutrality objective.

Another aspect to consider is the potential of different types of fuels to achieve very high GHG reductions. As a rule of thumb, biofuels have limited GHG reduction potentials compared to RFNBOs or electricity, notably where feedstocks are based on crops and not on wastes or residues. Depending on the feedstock, biofuels have relevant upstream GHG emissions other than CO_2 from agricultural processes, which limit the GHG reduction potential. The typical and default values in RED II Annex V demonstrate this issue clearly. Biofuels based on food and feed crops generally have higher GHG emissions than biofuels based on residues such as straw as listed in Annex IX Part A (advanced biofuels). Also, low carbon fuels such as hydrogen produced through steam methane reforming of fossil natural gas with carbon capture and long-term geological storage have relevant upstream emissions including methane slip in production and transport. And the CO_2 capture rates are typically at 75-90%, while additional energy is required for the capturing, CO_2 transport and storage processes.[648]

Thus, expressing the obligation in terms of energy has a stronger focus on the renewable energy objective, and expressing the obligation in terms of GHG reduction has a stronger focus on climate protection. Consequently, the latter provides more incentives to market fuels that have very high GHG reductions. Nonetheless, a GHG reduction obligation will provide additional incentives for fuels with a very high GHG reduction potential and thus fosters technology development and commercialization, energy diversification, security of energy supply, and also system integration through RFNBOs, which are key objectives of RED II.

Another aspect to consider is the scope of fuels included in the supply obligation. Currently, RED II covers renewable fuels (including electricity), and MSs can choose to include recycled carbon fuels. However, the FQD includes low carbon fuels in principle. Section B – Energy System Integration, subsection B4, of this study discusses the extension of the RED II scope to low carbon fuels. Defining the supply obligation in terms of GHG reduction needs to be aligned with the scoping aspects.

[647] And may impact the overall amount of fuels consumed.

[648] Hydrogen Council. (2021). Hydrogen decarbonization pathways – A life-cycle assessment. Available at: https://hydrogencouncil.com/wp-content/uploads/2021/04/Hydrogen-Council-Report_Decarbonization-Pathways_Part-1-Lifecycle-Assessment.pdf

A harmonisation of the scope of the obligation is another important aspect to take into account (see sub-option 4.1 above). Consistency between such harmonisation of the expression of the obligation needs to be ensured.

In summary, both expressing the obligation in terms of energy or in terms of GHG reduction is a suitable approach, while a GHG reduction expression would provide additional incentives to fuels allowing for very low emissions in line with the 2050 full decarbonization target.

However, having different types of obligations defined in the different MSs provides for mixed incentives to fuel suppliers which are active in various MSs. Such a fragmentation of the European market allows fuel suppliers to take advantage of arbitrage between different MSs, by supplying fuels with very high GHG reductions to MSs expressing the obligation in terms of GHG reduction (such as Germany) and supplying other (less GHG favourable) fuels to other MSs.

Avoiding such fragmentation and eliminating possibilities for arbitrage between MSs will allow for a more integrated European market for transport fuels, and will thus have positive economic, environmental and social impacts (see discussion of European market integration under sub-option 4.1 above).

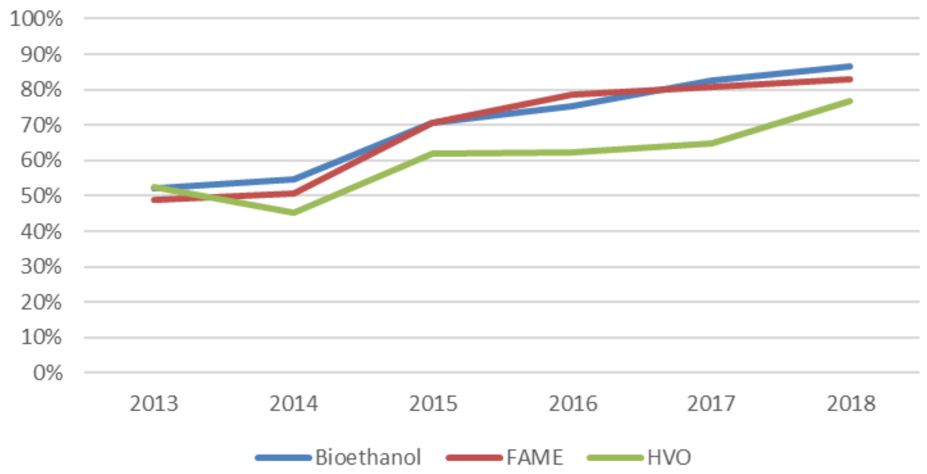
Another aspect to take into account is timing: expressing the target in terms of energy has as one major objective supporting the market ramp-up of renewable energy technologies and solutions in transport. The time perspective of this is around 2030 when the technologies for advanced biofuels and RFNBOs should be well-established in the market for achieving high market shares thereafter in order to provide substantial contributions to full decarbonisation by 2050. This perspective would favour expressing the target in terms of energy until 2030, and then switching to a GHG expression incentivising the then commercial technologies allowing for very low emissions in line with the 2050 full decarbonization target.

This approach is also supported by the fact that reported and certified GHG reductions in Germany under a GHG approach (see section below) are substantial on the one hand, but on the other hand, there are indications that these are based on effects that do not, or only in a limited way, reduce actual GHG emissions to the atmosphere as explained in the next section. At the same time, certification and auditing costs may have increased because of the increased use of actual values in biofuels supply chain GHG reduction calculations rather than using the default values provided in RED II Annex V. As a consequence, it may be more appropriate to establish a GHG-based approach once several alternative fuel groups compete in the market, namely food and feed-based biofuels, advanced/residue-based biofuels, and RFNBOs, which is anticipated to be the case by 2030. A GHG-based approach would then lead to a competition between these different fuel groups rather than spurring competition within biofuels between different feedstocks, countries of origin, or geographies with the consequences described above and assessed in the section below.

GHG savings in Germany

Germany has switched in 2015 from expressing the target in terms of energy to expressing it in terms of GHG savings. This provided for an incentive to reduce GHG savings below the thresholds, which did not exist before 2015. The development of the GHG savings of the most relevant biofuels shows a significant jump from 2014 to 2015, and a further increase thereafter as shown in Figure 3-15, based on data from BLE (2019)[649] and earlier reports from the same public administration in Germany.

Figure 3-15: GHG savings by bioethanol, FAME and HVO in Germany since 2014 (Source: LBST based on BLE (2019)[109])

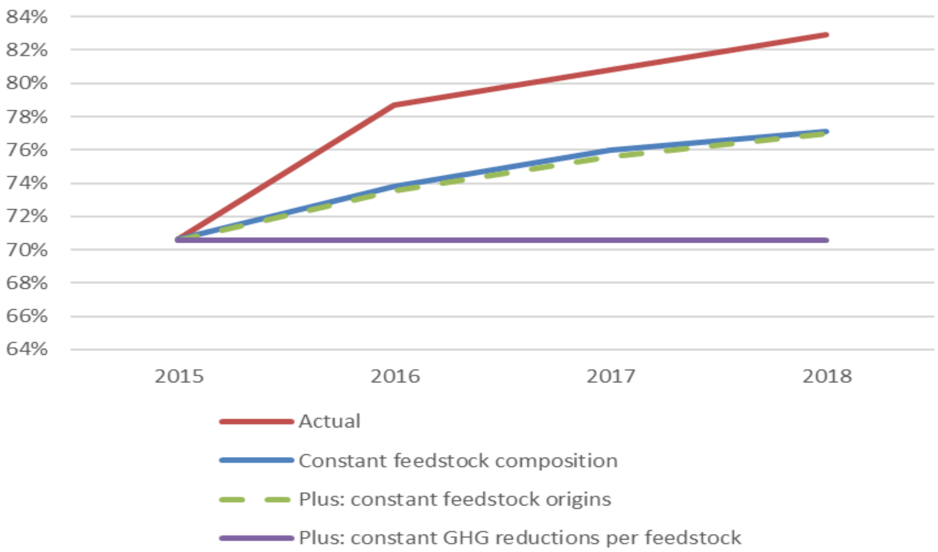


Focussing at FAME, and starting in 2015 as the necessary detailed data are not available prior to 2015, the increase in GHG savings (see red line in Figure 3-16) has three drivers:

1) The composition of the feedstocks used for FAME production have changed (see Figure 3-17). Without this change, the emissions savings would have been as shown by the blue line in Figure 3-16. This drives just below 50% of the change;
2) The origins of the feedstocks have changed (see Figure 3-18). As available data only differentiate between Germany, the EU without Germany, and third countries, the effect is blurred and cannot be determined well enough. Without this change (and the change from 1)), the emissions savings would have been as shown by the green dashed line in Figure 3-16: no change can be identified compared to 1);
3) The GHG emission savings for FAME production by feedstock have increased (see Figure 3-19). Without this increase (and the two previous changes from 1) and 2)), the emissions savings would have been as shown by the purple line in Figure 3-16 (so no effect). This drives just above 50% of the change.

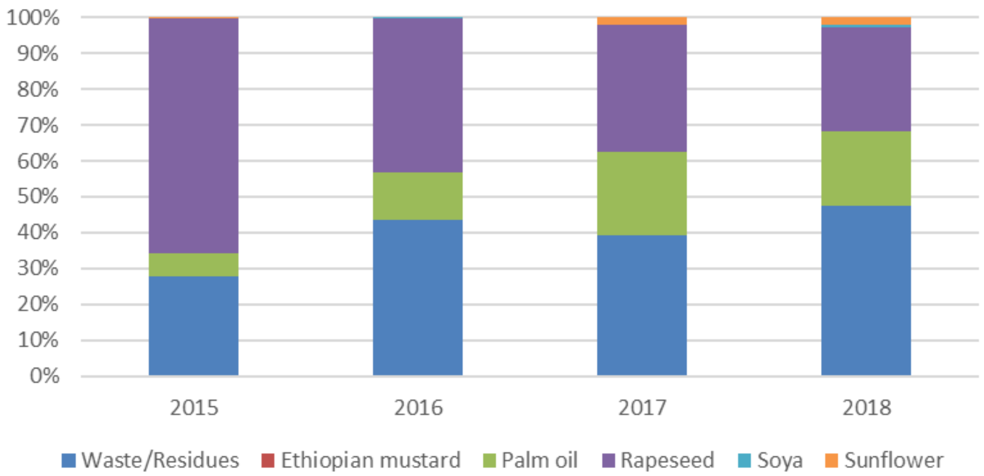
[649] Federal Office for Agriculture and Food. (2019). Evaluation and Progress Report 2018, Biomass Energy Sustainability Ordinance, Biofuel Sustainability Ordinance. Available at: https://www.ble.de/SharedDocs/Downloads/EN/Climate-Energy/EvaluationAndProgressReports2018.pdf?__blob=publicationFile&v=2

Figure 3-16: Emission savings of FAME in Germany (Source: LBST based on BLE (2019)[109])



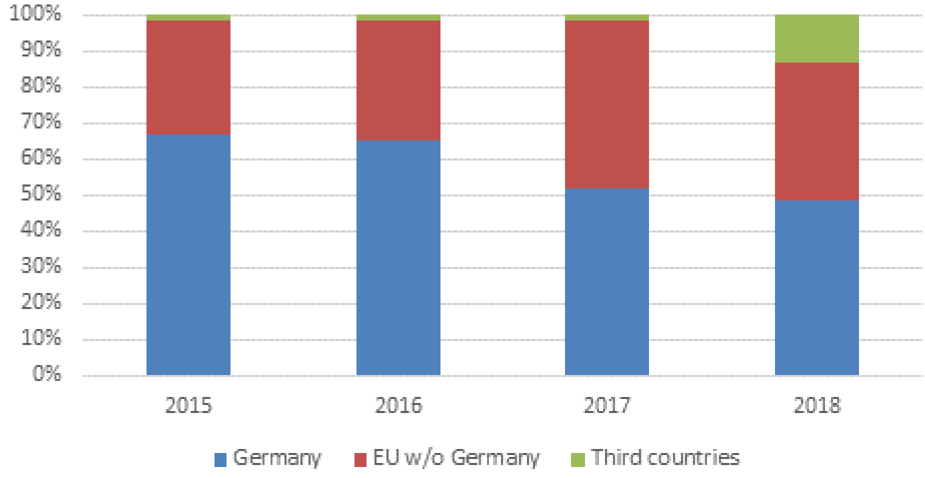
Additional information on driver 1: From 2015 to 2018, rape seed (with high emissions) goes down significantly from 65% to 30%, waste (with low emissions) goes up from 30% to 50% – both changes reduce emissions; in contrast, palm oil (with high emissions) goes up from 5% to 20% – this increases emissions (see Figure 3-17).

Figure 3-17: Feedstock composition of FAME for consumption in Germany (Source: LBST based on BLE (2019)[109])



Additional information on driver 2: Rape seed originating from Germany decreases, while rape seed from other EU MSs and from third countries increase – for all three, emissions savings increase individually. Therefore, this driver could only become visible if the origin of rape seed from other MSs was provided by MSs (see Figure 3-18).

Figure 3-18: Origin of rape seed for FAME production for consumption in Germany (Source: LBST based on BLE (2019)[109])



Additional information on driver 3: Emission savings increase for the major feedstocks: waste shows a limited increase, rape seed shows a significant increase from 60% to 70%, palm oil also shows a significant increase from 70% to 80% (see Figure 3-19). It is, unfortunately, not possible to assess the background for these improvements. However, some plausible assumptions can be made.

First of all, the use of default values as provided in RED II is a very efficient way of calculating the GHG reduction of a given pathway. Most economic operators choose this option as long as the reduction is sufficient to pass the threshold defined in RED II. However, where actual values lead to improved GHG reductions, price premia may be possible as further GHG reductions above the RED II thresholds have an economic value for obligated parties in MSs that use a GHG emissions obligation rather than an energy obligation such as Germany. SquareCo in their regular Biodiesel Market Reports include price premia for "*German high GHG*"[650], i.e. prices on top of standard biodiesel prices for higher GHG reductions. Typical values are 20 USD/t compared to a standard price of 1000 USD/t for RME (October 2020), or 140 USD/t compared to a standard price of 1250 USD/t (April 2021), equivalent to 2% and 11.2% price premium, respectively.

Secondly, higher reduction biofuels will preferably be sold in Germany where they have a price premium, while "*simply*" compliant biofuels will be sold preferably in other national markets (arbitrage between national markets).

Thirdly, there is some speculation that calculation rules are applied in a way that may not be intended by RED II, but that is accepted by the voluntary schemes. An indication of this may be the fact that palm oil-based biodiesel has default values in RED II of 20% GHG reduction for open effluent pond palm oil biodiesel, and of 45% for palm oil biodiesel where there is a process with methane capture at the oil mill. In contrast to that, the average palm oil biodiesel GHG reduction in Germany is the highest of all crop-based biofuels at 79.7%. Unfortunately, it is not possible to check the certified GHG reduction values for palm oil biodiesel as data are not publicly available. Also, the responsible German Federal Office for Agriculture and Food does not have the relevant data to check the validity of these data.

650 Square Commodities. (2020). Biodiesel Market Report. Issue N° 357, October 29, 2020.

Potentially, the Union Database to be established may allow for such verifications. According to the default values defined in RED II, cultivation of palm oil should account for 28% of GHG emissions compared to the fossil fuel comparator, palm oil processing should account for another 20%, and transport to Europe and distribution should account for another 7%, adding up to the above-mentioned total of 55% emissions, or a 45% reduction. It would be highly desirable to understand how such massive improvements are possible. One potential element are emission savings from soil carbon accumulation via improved agricultural management that may be applied to actual values, and also cultivation and processing emissions may substantially deviate from the default values in RED II. While the default values are conservative, typical values should be close to an average situation. Typical values are 28% emissions for cultivation (identical to the default value), 14% for processing, and 7% for transport and distribution (identical to the default value), totalling 49% (or 51% reduction). Also for typical values, actual values reported for Germany of 80% on average are massively higher.

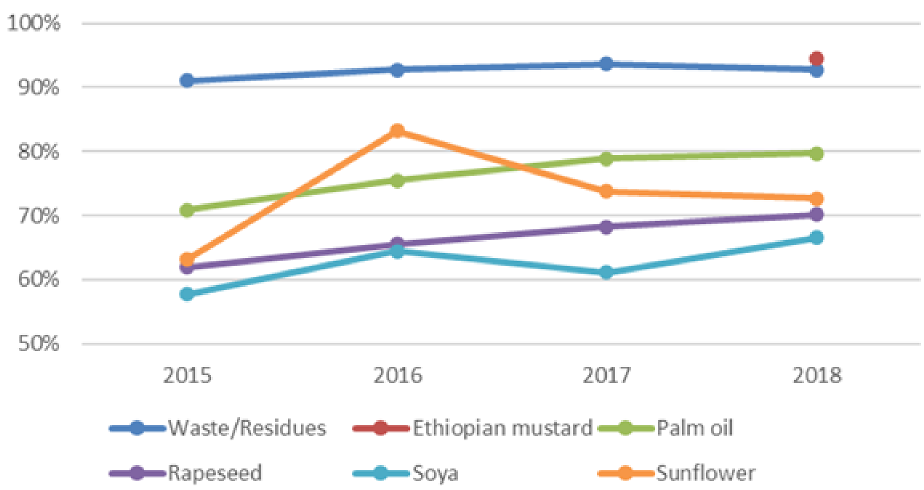
Also for rape seed biodiesel, soybean biodiesel, and sunflower biodiesel, GHG reduction default values in RED II are substantially lower than reported in Germany:

- Rape seed biodiesel: default reduction value: 47% vs. 70.2% reported in Germany;
- Soybean biodiesel: default reduction value: 50% vs. 66.5% reported in Germany;
- Sunflower biodiesel: default reduction value: 52% vs. 72.7% reported in Germany;
- Palm oil biodiesel (process with methane capture at oil mill): default reduction value: 45% vs. 79.7% reported in Germany.

Obviously, the difference between default values and reported values is highest for palm oil.

The three effects mentioned above are theoretical effects without actual GHG reductions that would contribute to climate protection. Only the third factor may include some actual GHG reductions by improvements of the supply chains from production to the point of consumption. Again, it is not possible to verify this at present.

Figure 3-19: Emission savings by feedstock for FAME (Source: LBST based on BLE (2019)[109])



In essence, pathways become better (which may be related to selecting different origins of the feedstocks – see point 2 above; or it may be related to improvements in the supply chains), see Figure

3-19. This drives half of the improvements and other feedstocks are used, which drives the other half of the improvements. The origin of the feedstock may also have a significant impact. However, data are not detailed enough to identify this. An indication of this are the N_2O emission intensities, which strongly vary across Europe (and the world): the variation identified for Europe by Lugato et al. (2017)[651] has massive effects on the GHG savings: at the upper end of the scale, N_2O emissions already account for 50% of the fossil fuel comparator alone. Therefore, selecting feedstock origins according to low N_2O emissions can significantly increase GHG savings. However, feedstock from worse soils simply go to other uses, and overall GHG emissions remain unchanged. Therefore, the GHG expression of the target partly incentivises changes providing improvements in transport in this geography, but leading to deteriorations in other uses and/or geographies. Only actual improvements in the supply chain provide for overall contributions to climate protection.

Certification Costs

Certification costs are a major component of administrative costs of economic operators. They have three major elements: voluntary scheme fees, auditing costs, and internal and possibly external costs for preparing and supporting certification and auditing. Voluntary scheme fees can have several elements that are annual or depend on the number of sites involved in certification per company, or on the quantity of biofuels certified. In Figure 3-20, certifications fees of the REDcert voluntary scheme have been used as an example applied to biodiesel or HVO production. Plant sizes range from very small (500 t/yr), over small (1,000 t/yr), large (5,000 t/yr), X large (25,000 t/yr, XX large (100,000 t/yr) to XXX large (400,000 t/yr). For comparison: Neste's HVO plant in Porvoo (Finland) has an annual capacity of 400,000 t/y (denoted "*XXX large*" here), while the Rotterdam (Netherlands) plant has double this capacity. Biodiesel plants in the USA have typical sizes of 25,000 to 280,000 t/yr, but there are also much smaller plants of below 10,000 t/yr ("*large*").

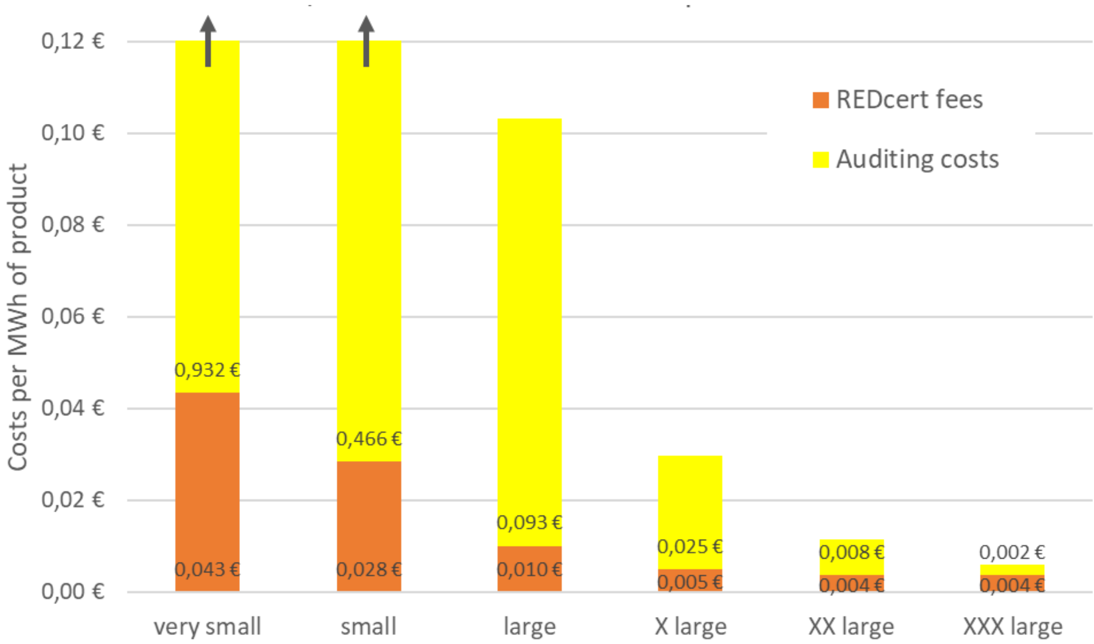
REDcert certification fees have all three components mentioned above: a fixed annual fee (slightly reduced for very small and small participants) plus a fee per site (with decreasing costs per site with increasing number), and a fee per biofuel quantity certified. The annual fee leads to very high specific costs per quantity certified scaling very strongly with the certified quantity. For Figure 3-20, only one production site is assumed, and upstream certification (first gathering points, upstream processing plants, traders, etc.) are not taken into account, but come on top for a total cost calculation. Auditing costs are taken to vary only slightly by plant size as the objects of validation or verification are similar for each plant audited. It has been assumed here that auditing costs for the XXX large plant are only double those of very small plants. This explains the very strong scaling behaviour of the costs per energy quantity audited. As can be seen from Figure 3-20, auditing costs strongly dominate costs for very small to X large plants, while even for XX large plants they are still double as high as certification fees. Only for XXX large plants, auditing costs are below certification fees because of the third element of certification fees – the per output fees. Overall, certification costs have a very strong scaling characteristic. On the other hand it must be emphasized that certification costs represent a small share of total production and delivery costs.

[651] Lugato, E., Paniagua, L., Jones, A., de Vries, W., Leip, A. (2017). Complementing the topsoil information of the Land Use/Land Cover Area Frame Survey (LUCAS) with modelled N2O emissions. PLoS ONE 12(4): e0176111. Available at https://doi.org/10.1371/journal.pone.0176111

Upstream certification costs need to be added, most notably for the certification and auditing of cultivation (agricultural operation and first gathering point) as well as of processing units such as oil mills; in many cases traders are also an important element of the supply chains. For these elements scaling effects apply in a similar way as for fuel production units. As a rough estimate, certification and auditing costs may be taken as 3 to 4 times the costs estimated above (see Figure 3-20). However, it also needs to be taken into account that sustainability requirements defined in RED II include the life-cycle GHG emissions require more efforts for auditing of cultivation than for auditing of downstream operations as estimated above.

Because of the strong scaling behaviour of certification and auditing costs, the share of such costs for production plants is in the range of 1.3% for very small plants, 0.035% for X large plants, and 0.030% for XXX large plants. Assuming the total certification and auditing costs to be four times those for the production plant, these amount to 5.2% for very small plants, 0.14% for X large plants, and 0.12% for XXX large plants. Internal and possibly external costs of companies for preparing and supporting certification and auditing come on top.

Figure 3-20: Estimate of certification fees and auditing costs per MWh of product by plant capacity (Source: LBST)



Voluntary schemes have not yet been accepted by the EC for certification of hydrogen and more generally RFNBOs. Also, the concrete requirements RFNBOs need to fulfil for counting as renewable transport fuels are to be defined in delegated acts by the end of 2021. Therefore, it is with significant uncertainties that certification costs can be estimated presently. In general, certification and auditing costs of RFNBOs could be similar to those estimated above for biofuels. The production plant sizes defined above for illustrative purposes translate to the following electrolysis capacities (based on input electricity capacity); the current reality of electrolysis systems worldwide is indicated for each size in order to allow for an appreciation of their relevance:

- Very small: 1.8 MW_e; at least 12 electrolysers are in operation world-wide currently between 1 and 1.8 MW_e capacity;

- Small: 3.7 MW_e; at least 6 electrolysers are in operation world-wide currently between 1.8 and 3.7 MW_e capacity;
- Large: 18 MW_e; at least 7 electrolysers are in operation world-wide currently between 3.7 and 18 MW_e capacity;
- X large: 92 MW_e; at least one electrolyser is in operation world-wide currently with a capacity of 20 MW_e; more electrolysers in this capacity range are under construction or have been announced;
- XX large: 370 MW_e; an electrolyser was installed in Egypt in the 1960ies powered by the Aswan dam power plant with an installed capacity of above 200 MW_e; some projects in the xoo MW_e range have been announced;
- XXX large: 1.5 GW_e; some projects in the GW_e range have been announced, including in Europe, Saudi Arabia, Australia, China as well as in North and South America.

Efforts required for the certification of RFNBOs compared to biofuels are most significant in the requirements related to input electricity for RFNBO production (new installation, additionality, temporal and geographic correlation) versus the sustainability requirements related to biofuels. Both issues are complex to verify. For biofuels, such certification is well-established while for RFNBOs the detailed requirements are still being developed, and certification processes still need to be developed and established. Therefore, a cost comparison still has large uncertainties. Nonetheless, auditing and certification costs for RFNBOs may be similar to those for biofuels if the requirements are defined in a way as to allow for efficient certification.

Option 5: Option 4 + Detailed specification of supply obligation and no targets

Building on option 4 above, a full harmonisation of the fuel supply obligation at EU level is defined for this option. The obligation will include a minimum share to be achieved through the obligation in each MS individually; the definition and calculation of a national target will thus not be needed in this option.

The analysis of option 4 clearly shows the disadvantages of a full harmonisation, notably where aspects are harmonised that relate to significant national differences such as e.g. the current share of biofuels from food or feed crops, or the potentials for recycled carbon fuels or low carbon fuels. Building on national differences today, also trajectories towards 2030 would have significant national differences.

Another aspect to take into account here is that some MSs such as notably Sweden and Finland have already achieved high shares of renewables in transport (even though currently, Sweden has a high contribution from biofuels based on food and feed crops significantly beyond the 7% cap defined in RED II), while other MSs have only achieved limited shares so far, such as Cyprus, Greece, and Ireland. Fully harmonising the supply obligation in a revised RED II for all MSs would have to define a target level of achievement in 2030. Defining such a target level would have to be a compromise between MSs with already high levels today, and MSs will low levels today. In this sense, it may overburden some MSs, while not providing room for increase to other MSs, or even incentivising a reduction of renewables shares in some MSs. This would imply both severe economic impacts as well as compromise on the intended environmental impacts in terms of GHG savings.

In this perspective, option 5 would have significantly less positive economic, environmental, and social impacts than option 4. It is even conceivable (but difficult to assess) that negative impacts compared to the baseline of the current RED II may result.

General economic impact: fuel costs, GHG reduction costs

RED II differentiates between different renewable fuels for transport, biofuels based on food and feed crops, advanced biofuels (see also discussion in sub-option 3.2), biofuels produced from feedstocks listed in Annex IX Part B, RFNBOs, electricity, and recycled carbon fuels. Each category includes a number of different fuels. And the number of productions pathways for these fuels is very high. A selection is included in RED II Annex V, which provides estimated typical and default values for the GHG emissions savings, both for the full supply chain and disaggregated values for individual steps in the supply chain.

Combined with production cost data, GHG reduction costs for the fuels can be calculated as an indicator for the efficiency of the regulatory framework provided by RED II.

For established biofuels, some market data are available; these price data are used here. For other fuels, notably those not yet commercially well established, production cost data are taken from literature. As an exception, for RFNBO-hydrogen, both production costs and supply costs including production and distribution including hydrogen refuelling stations are used here highlighting the economic importance of the downstream supply chain elements. Also, current status values are included as well as 2030 estimates demonstrating the cost reduction potential in the timeframe for the targets of RED II. For liquid RFNBOs the range of cost estimates is very large. Therefore, we include here only one pathway for a Fischer-Tropsch-type liquid transport fuel for the 2030 perspective. Electricity for road transport is not included here as the complexity of this issue is very high.[652]

Fuel price data are taken from Greenea,[653] GAIN (2019),[654] and Neste[655] using three or five year minimum and maximum values for the ranges considered here. Production cost data for advanced biofuels and HVO based on waste lipids are taken from IEA bioenergy (2020).[656] Hydrogen cost estimates are taken from Hydrogen Council (2021)[657] for production costs, LBST Hinicio (2019)[658] for hydrogen

[652] See e.g. Trinomics et al. (2020). Study on energy prices, costs and their impact on industry and households. Available at: https://ec.europa.eu/energy/studies_main/final_studies/study-energy-prices-costs-and-their-impact-industry-and-households_en
[653] Greenea. (2020). Waste – Based Market Performance. Available at: https://www.greenea.com/fr/analyses-marche/
[654] Global Agricultural Information Network. (2019). EU-28, Biofuels Annual, EU Biofuels Annual 2019. Available at https://gain.fas.usda.gov/
[655] Neste. (2021). Biodiesel prices (SME & FAME). Available at: https://www.neste.com/investors/market-data/biodiesel-prices-sme-fame
[656] IEA Bioenergy. (2020). Advanced Biofuels – Potential for Cost Reduction. Available at: https://www.ieabioenergy.com/wp-content/uploads/2020/02/T41_CostReductionBiofuels-11_02_19-final.pdf
[657] Hydrogen Council. (2021). Hydrogen decarbonization pathways—A life-cycle assessment; Potential supply scenarios. Available at: https://hydrogencouncil.com/en/hydrogen-decarbonization-pathways/
[658] LBST & HINICIO. (2019). Future fuel for road freight, Techno-economic & environmental performance comparison of GHG-neutral fuels & drivetrains for heavy-duty trucks, an expertise for Foundation Tuck in the context of “The Future of Energy” call for proposals 2018. Available at: http://fondation-tuck.fr/jcms/r_27438/fr/future-fuel-for-road-freight-techno-economic-environmental-performance-comparison-of-ghg-neutral-fuels-drivetrains-for-heavy-duty-trucks

refuelling station costs, and Asset (2018)[659] for hydrogen distribution costs by road tube-trailers. Production cost data for PtL are taken from Guidehouse et al. (2021).[660]

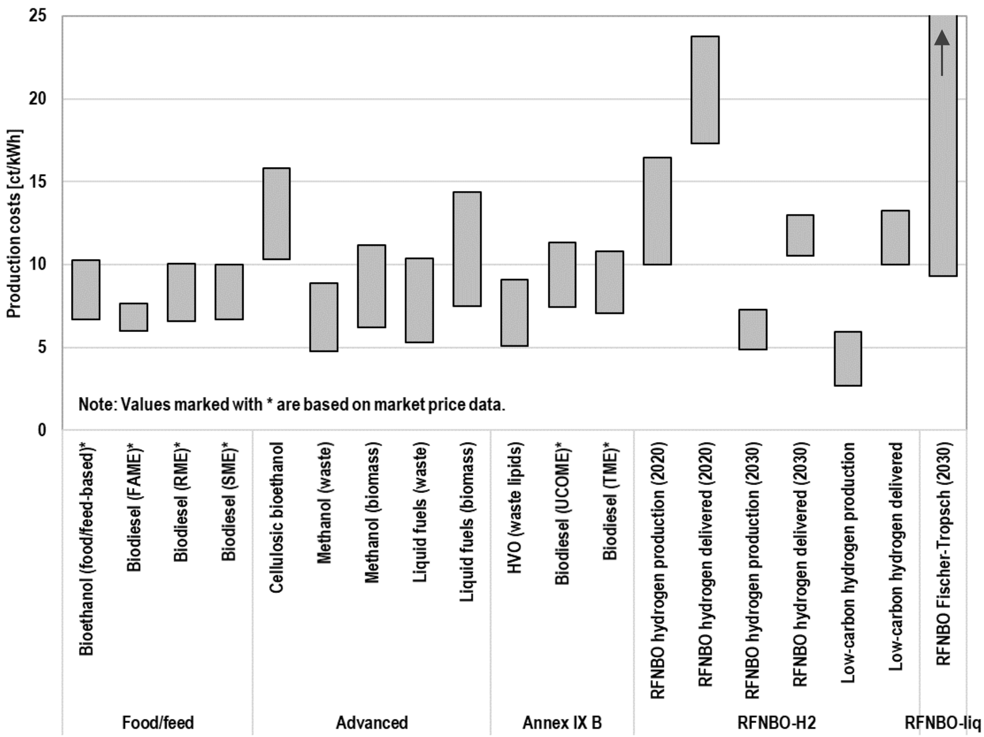
Figure 3-21 provides an overview of the fuel cost ranges. Conventional biofuels based on food and feed have the lowest prices, with biofuels based on feedstocks from Annex IX Part B are in the same price range, partly slightly lower. However, the feedstocks potentials are limited. Different types of advanced biofuels have rather low cost estimates, but are based on residues with limited availability, or have higher costs where they are based on dedicated biomass cultivation. Production capacities are very limited indicating that either the cost estimates may be optimistic, the risks associated with such projects are high, or other barriers exist that need to be overcome. Hydrogen production costs based on renewable electricity (RFNBO) are higher today than any of the established renewable fuels. However, the 2030 estimate demonstrates a substantial cost reduction potential based on three factors: 1) further cost reduction in renewable power generation, 2) cost reduction in hydrogen production equipment (electrolysers), and 3) economies of scale along the full RFNBO supply chain (transport, distribution, refuelling). The coast ranges for hydrogen including the full supply chain to road vehicles shows the importance of distribution including refuelling, both for today and for 2030. Low-carbon hydrogen produced from natural gas with carbon capture and geological storage has lower production costs mainly depending on the natural gas prices; however, there is an overlap with the renewable hydrogen production cost range estimate for 2030.

Liquid RFNBO cost estimates for 2030 start at the higher end of biofuels prices/costs, and are higher than hydrogen production costs as PtL fuels are synthesized and refine on the basis of hydrogen.

[659] ASSET (European Commission). (2020). Sectoral integration - long-term perspective in the EU Energy System, Final report. Available at: https://op.europa.eu/en/publication-detail/-/publication/a0868328-4f06-11eb-b59f-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search

[660] Guidehouse et al. (2021): Technical assistance to assess the potential of renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs) as well as recycled carbon fuels (RCFs), to establish a methodology to determine the share of renewable energy from RFNBOs as well as to develop a framework on additionality in the transport sector; 2nd interim report | Task 1 Assessment of the potential of RFNBOs and RCFs over the period 2020 to 2050 in the EU transport sector. (Unpublished).

Figure 3-21: Fuel costs/prices (Sources: see text)

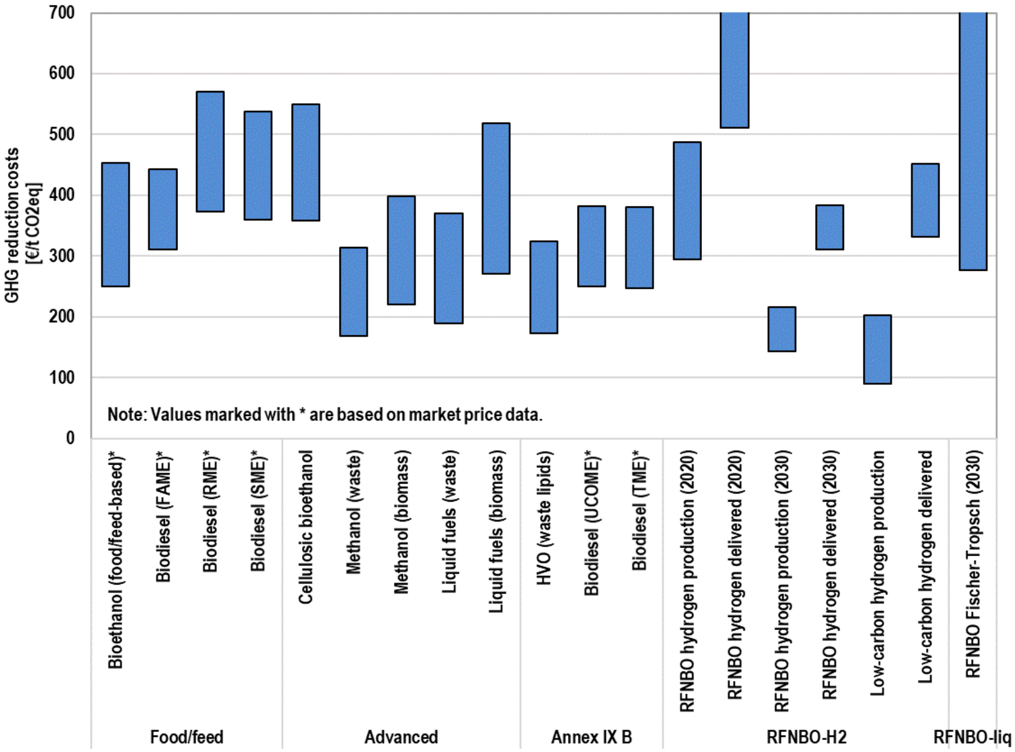


Combining the fuel prices/costs with GHG savings, using typical values provided in RED II Annex V for biofuels, gives the GHG reductions costs in € per ton of CO_2 equivalent avoided compared to conventional fossil fuels (see Figure 3-22). Advanced biofuels, based on their higher GHG savings compared to conventional biofuels, have lower GHG reduction costs than food and feed crop-based conventional biofuels. This provides a major motivation for providing policy support to these fuels. Also, Annex IX Part B biofuels have low GHG reductions costs. As these have already entered the market, at least to a certain extent, specific support in RED II may be reconsidered.

GHG savings of renewable and of low-carbon hydrogen are taken from Hydrogen Council (2021).[661] GHG savings of PtL are taken from JEC (2020).[662] GHG reduction costs of delivered renewable hydrogen in the 2030 perspective are well in the range of biofuels. GHG reductions costs of PtL start at comparable levels with hydrogen, but still have a large range upwards.

[661] Hydrogen Council. (2021): Hydrogen decarbonization pathways, A life-cycle assessment; Hydrogen decarbonization pathways. Potential supply scenarios. Available at https://hydrogencouncil.com/en/hydrogen-decarbonization-pathways/
[662] JRC, EUCAR, CONCAWE & JEC (2020): Well-to-Tank report v5. Available at: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/jec-well-tank-report-v5

Figure 3-22: GHG reduction costs using RED II typical values (Source: own calculation)

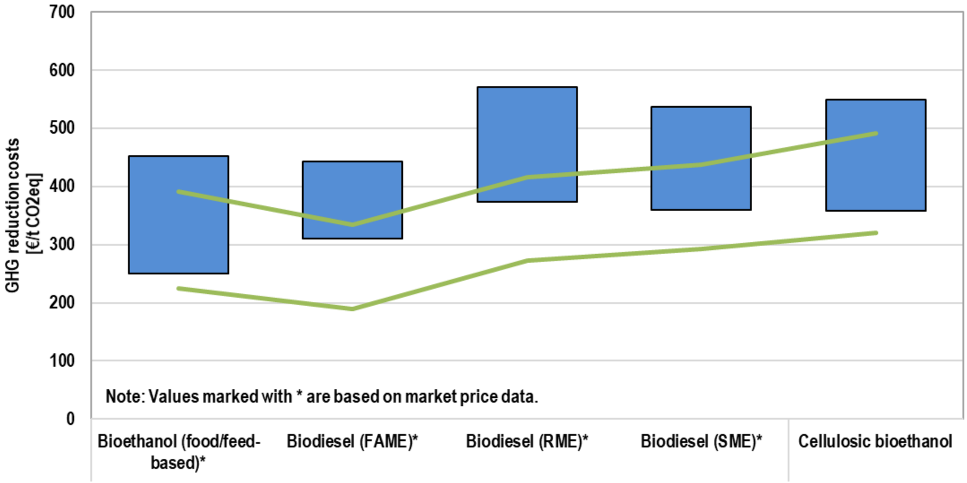


In Germany, the target for renewable fuels in transport is expressed in terms of GHG reductions (see *Analysis - Option 4*), which provides for an incentive to reduce GHG savings down to zero, while in MSs where the target is expressed in energy terms, there is no incentive to reduce GHG savings below the threshold values defined in RED II. GHG savings of biofuels in Germany are significantly below the typical values of RED II Annex V as reported in BLE (2019).[663]

Using these GHG savings values, or ranges of values depending on feedstock, leads to lower GHG reduction costs for biofuels consumed in Germany. Figure 3-23 shows that using BLE values leads to significantly lower GHG reduction costs. A discussion of the GHG savings values in Germany is provided under *Analysis - Option 4*).

[663] Federal Office for Agriculture and Food. (2019). Evaluation and Progress Report 2018, Biomass Energy Sustainability Ordinance, Biofuel Sustainability Ordinance. Available at: https://www.ble.de/SharedDocs/Downloads/EN/Climate-Energy/EvaluationAndProgressReports2018.pdf?__blob=publicationFile&v=2 (accessed on 31.05.2021).

Figure 3-23: GHG reduction cost comparison using RED II typical values (blue columns) versus BLE (green lines) GHG savings values (Source: own calculation)



General economic impact: Investment volumes

Investment volumes[664] required to achieve the 2030 target for transport are analysed here with a focus on advanced biofuels and on RFNBOs. As described under option 4, sub-option 4.1, RED II has the double objective of increasing the consumption of renewable energies in all sectors, and of reducing GHG emissions. For that purpose, advanced biofuels and RFNBOs require a policy framework supporting market uptake of these fuels in transport.

The necessary cumulative investment volumes until 2030 for advanced biofuels and RFNBOs depend on the specific investment needs for each fuel type, and on the quantities of each fuel to be supplied by 2030. For estimating the order of magnitude, the Climate Target Plan scenario ALLBNK for advanced biofuels, hydrogen as gaseous RFNBO and Power-to-Liquids (PtL) as liquid RFNBO was applied. Fuel volumes to be consumed in 2030 require investments into production facilities with sufficient capacity. As production capacities for advanced biofuels and RFNBOs are very limited today, it is assumed that for all such fuels supplied in 2030 new production facilities have to be installed. The estimate here should be rather understood as a lower limit as the methodology applied here assumes 100% utilization of the capacities, and further investments would be required in the late 2020ies to go onstream in 2031+ for an accelerated ramp-up of renewable fuel use in transport towards full decarbonisation by 2050.

In order to account for the remaining uncertainties related to the specific investment costs for advanced biofuels and RFNBOs, ranges are identified here based on available literature. For advanced biofuels, we rely on IEA (2020);[665] for hydrogen we rely on Trinomics, LBST (2020),[666] and for liquid RFNBOs we rely on Guidehouse et al. (2021).[667]

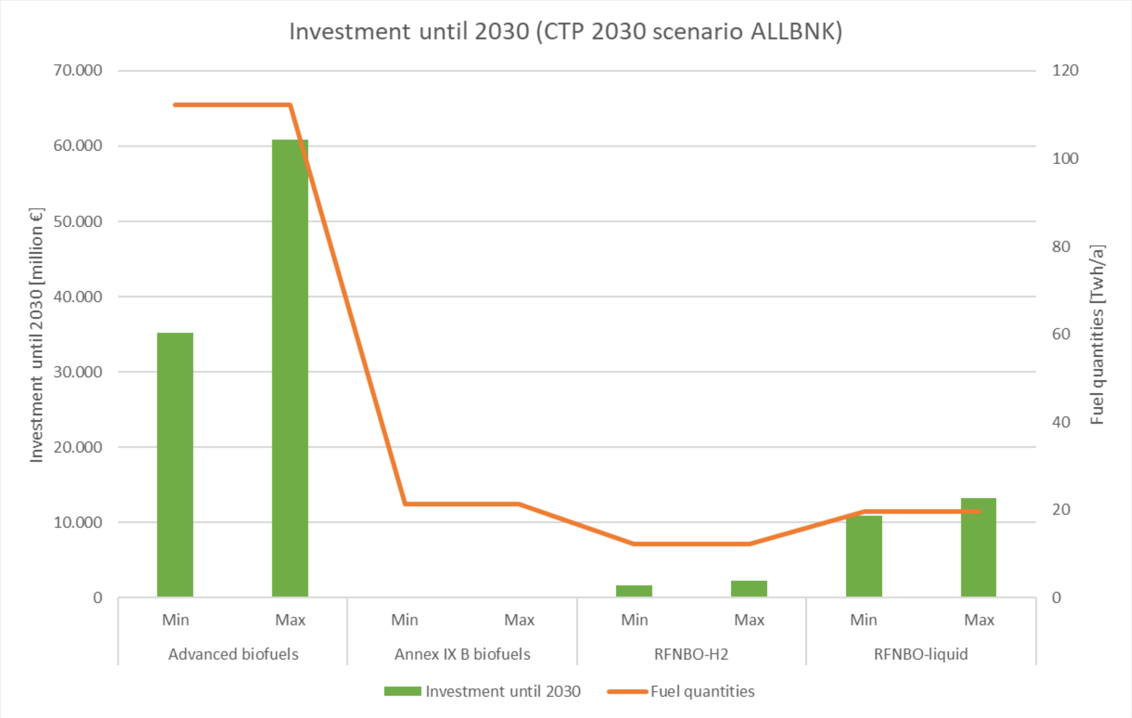
[664] Overnight capital spending for erecting production facilities.
[665] IEA Bioenergy. (2020): Advanced Biofuels – Potential for Cost Reduction. Available at https://www.ieabioenergy.com/wp-content/uploads/2020/02/T41_CostReductionBiofuels-11_02_19-final.pdf
[666] Trinomics & LBST. (2020). Study on Opportunities arising from the inclusion of Hydrogen Energy Technologies in the National Energy & Climate Plans. Available at: https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans
[667] Guidehouse et al. (2021). Technical assistance to assess the potential of renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs) as well as recycled carbon fuels (RCFs), to establish a methodology to

While for all liquid fuels only investments in production facilities are included here as distribution efforts are much smaller and would remain within the ranges of investments in production facilities, for hydrogen distribution hydrogen refuelling stations are included as the cost are more substantial than for liquid fuels.

Figure 3-24 and Figure 3-25 show the assumed fuel volumes in 2030 following the CTP scenario ALLBNK and other sources for the two RFNBO types, respectively, as orange line linked to the right vertical axis. The green columns linked to the left vertical axis show the investment volumes until 2030 for the three types of fuels; biofuels from feedstocks listed in Annex IX B (used cooking oil and animal fats) are also included for comparison. However, no investments are assumed here as substantial HVO capacities exist in Europe that - thus far - only partly use such feedstocks.

The hydrogen consumption levels assumed here on the basis of the aforementioned sources are equivalent to an installed electrolysis capacity in the Union of 5.5 GW (CTP scenario ALLBNK) and 7.7-24.1 GW based on Trinomics, LBST (2020)[123]. This should be compared to the target in the hydrogen strategy of installing 40 GW of electrolysis capacity in the Union by 2030 for hydrogen consumption in all relevant sectors, plus an indicative further 40 GW to be installed in neighbouring regions for hydrogen production and import to Europe.[668]

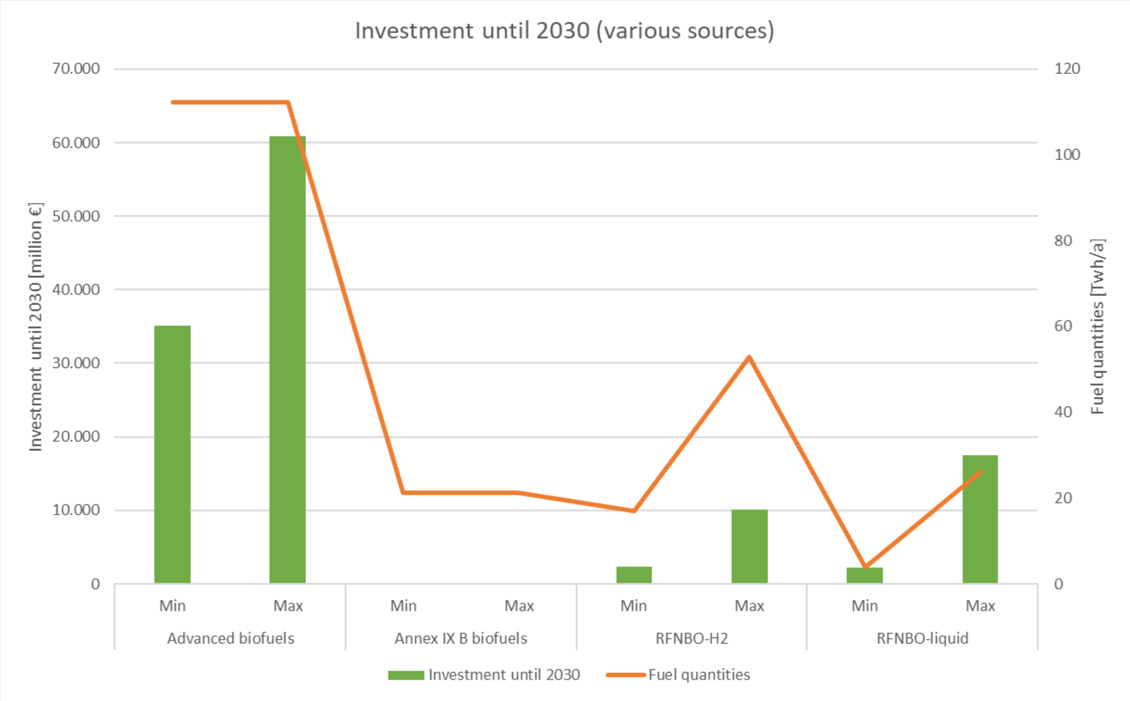
Figure 3-24: Fuel quantities based on CTP ALLBNK and cumulative investment volumes until 2030 by fuel type (Source: own calculations)



determine the share of renewable energy from RFNBOs as well as to develop a framework on additionality in the transport sector; 2nd interim report | Task 1 Assessment of the potential of RFNBOs and RCFs over the period 2020 to 2050 in the EU transport sector. (Unpublished).

[668] COM(2020) 301 final.

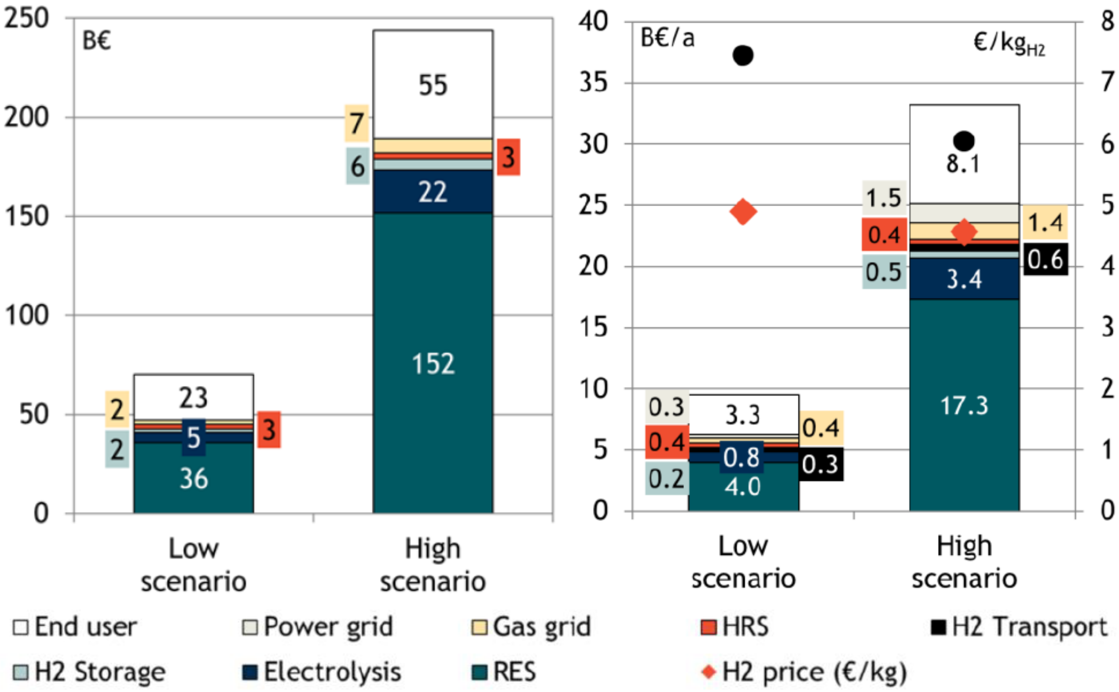
Figure 3-25: Fuel quantities based on various sources and cumulative investment volumes until 2030 by fuel type (Source: own calculations)



For hydrogen and liquid RFNBOs, further substantial investments are necessary, notably in the renewable energy power plants to feed the electrolysis and, in the case of PtL, further production processes. In fact, investments in renewable capacities are significantly higher than into electrolysis. The following figure shows the level of investments required in a low and a high scenario defined in Trinomics, LBST (2020),[669] for all sectors in 2030. For comparison with Figure 3-25 above, covering electrolysis and refuelling stations for hydrogen with an investment of 2.3 to 6.3 billion €, the investment of 22 billion € in electrolysis in the high scenario in Trinomics, LBST (2020) compares to an investment volume of 152 billion € in renewable power plants to feed the electrolysers. Thus, an investment of 1.7-2.3 billion € in hydrogen for transport (CTP scenario ALLBNK), of which 1.4-1.5 billion € in electrolysis, would trigger investments of around 10 billion € in renewable capacities; and an investment of 2.3-10.0 billion € in hydrogen for transport (various sources), of which 2.0-6.3 billion € in electrolysis, would trigger investments of 14-43 billion € in renewable capacities.

[669] Trinomics & LBST (2020). Study on Opportunities arising from the inclusion of Hydrogen Energy Technologies in the National Energy & Climate Plans. Available at: https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans

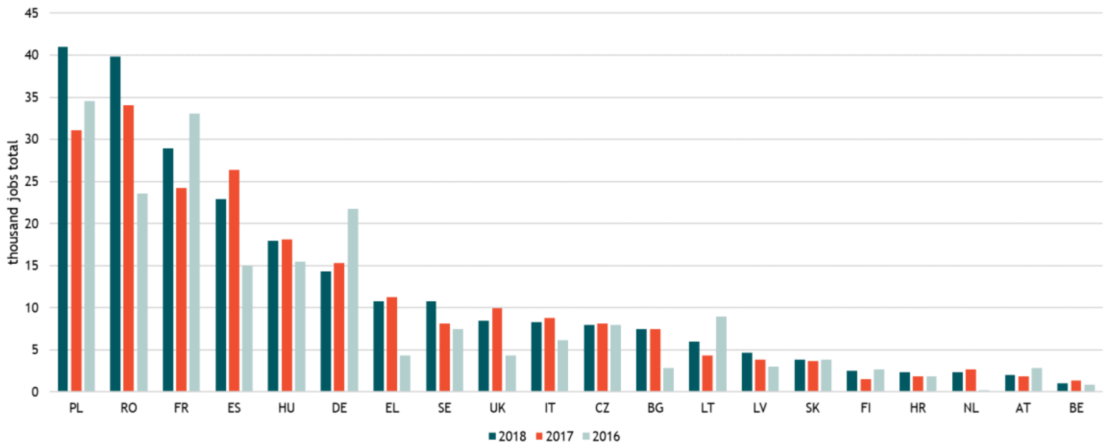
Figure 3-26: Cumulative investment volumes until 2030 (left) and annual costs (right) including renewable power generation (Source: Trinomics, LBST (2020))



General social impact: employment

Biofuels are a major employment factor in Europe; liquid biofuels are the third largest renewable employer, according to JRC (2020).[670] In 2018, the sector had some 248,000 jobs in total (Figure 3-27).

Figure 3-27: Liquid biofuels employment in selected EU MSs, 2016-2018 (Source: LBST based on JRC (2020))

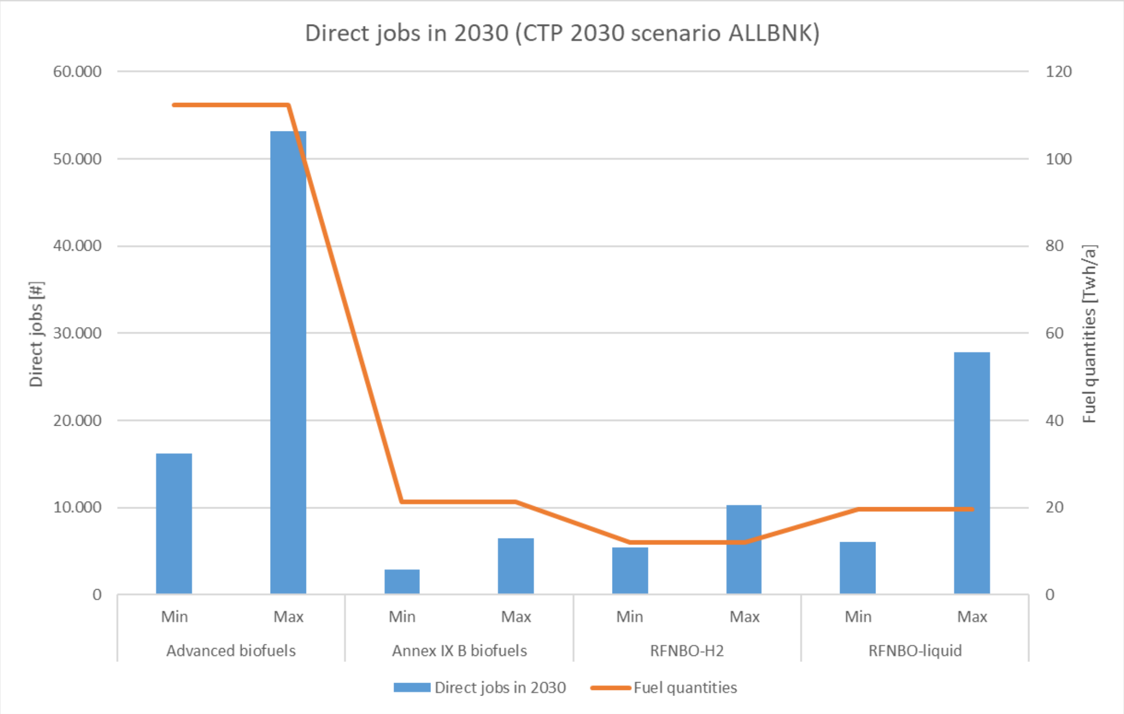


[670] Joint Research Centre (JRC). (2020). Employment in the Energy Sector - Status Report 2020 Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC120302/employment_energy_status_report_2020.pdf

The investments estimated in section 3.8 above until 2030 will lead to the creation of jobs. Typical employment rates for different sectors are often used to estimate direct employment related to investments. Applied rates range from 3.0 jobs per million € of annual revenue[671] for advanced biofuels as identified by EC (2017)[672] and for Annex IX B biofuels [673] to a rate of 3.1-3.3 for hydrogen and PtL[126].

The result of this estimate of direct jobs is shown in Figure 3-28 and Figure 3-29 below.

Figure 3-28: Direct employment generated by investments in fuel production based on the CTP scenario ALLBNK (Source: own calculations)

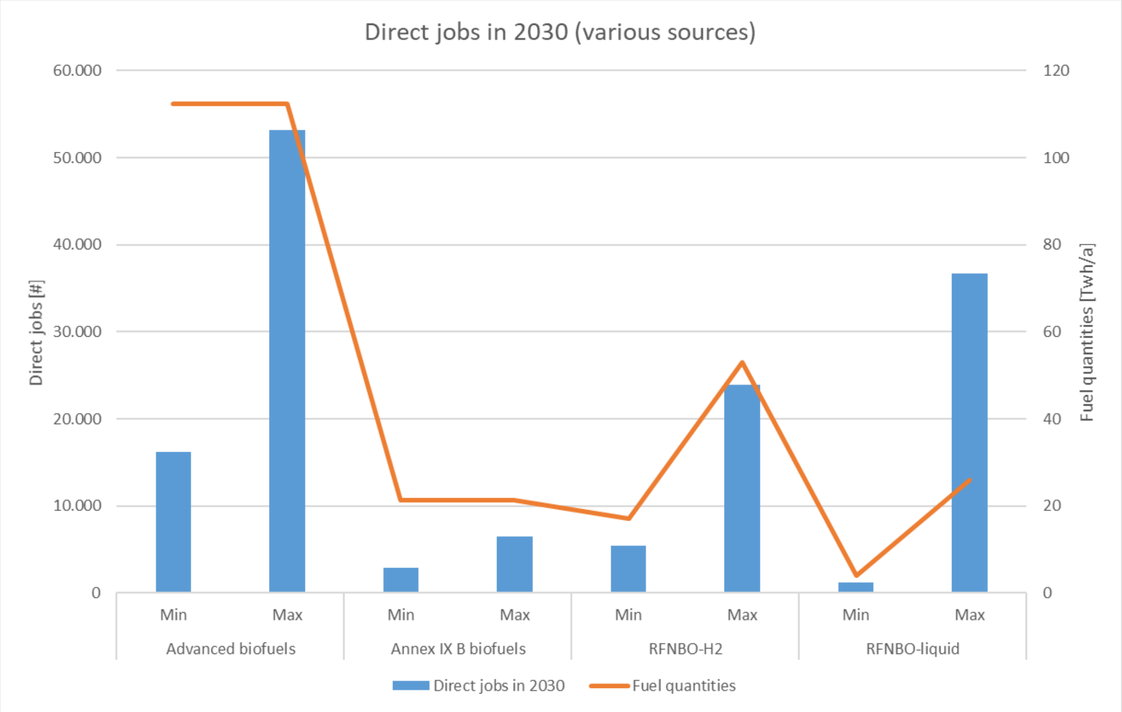


671 Revenue is assumed here to be fuel price or costs times annual fuel volume in 2030.

672 European Commission. (2017). Research and Innovation perspective of the mid- and long-term Potential for Advanced Biofuels in Europe – D2.1 Potential contribution of advanced biofuels for achieving the 2020 RED/ILUC targets, November 2017. Available at: https://op.europa.eu/en/publication-detail/-/publication/9895d9b2-0639-11e8-b8f5-01aa75ed71a1/language-en

673 Ibid.

Figure 3-29: Direct employment generated by investments in fuel production based on various sources (Source: own calculations)



In addition to direct jobs created, the production of advanced biofuels would create or support indirect jobs in the sectors supplying the feedstocks and components. For a rough estimate of these indirect impacts, EC (2017)[674] uses the job multiplier of chemicals in the EU, which is estimated at 2.2 in 2020; so each direct job creates or supports 1.2 indirect jobs.

As described above, investments into renewable power plants feeding hydrogen or PtL production are substantially higher than investments in the fuel production facilities themselves. For each € invested in a hydrogen electrolyser, 7 € would be invested into renewable power plants. Assuming the same employment rate per money invested, each direct job in hydrogen production would thus create seven jobs in the renewable power plant sector.

[674] European Commission. (2017). Research and Innovation perspective of the mid- and long-term potential for Advanced Biofuels in Europe – D2.1 Potential contribution of advanced biofuels for achieving the 2020 RED/ILUC targets. Available at: https://op.europa.eu/en/publication-detail/-/publication/9895d9b2-0639-11e8-b8f5-01aa75ed71a1/language-en

Synthesis

The options defined for this analysis have been designed to allow for a differentiated analysis of impacts in a qualitative and semi-quantitative way. Quantitative analyses based on rigorous modelling have been carried out separately.

Other definitions of options are possible, and may be more suitable for a revision of RED II. Notably for option 4, other combinations of elements could be suitable based on the results of the analysis. As such, MSs could be required to set an obligation on fuel suppliers that ensures the achievement of the target, with possible sub-options including:

- Expression of the obligation in terms of energy plus defining minimum shares for advanced biofuels and RFNBOs plus all fuels need to achieve minimum emission savings requirements;
- Expression of the obligation in terms of emission savings without any sub-targets for advanced biofuels, RFNBOs, or other;
- Expression of the obligation in terms of emission savings with operators being required to achieve minimum shares for advanced biofuels and RFNBOs;
- The choice between the such options is left to the MSs (as in the current RED II);

The following sections provides an overview of economic, social and environmental impacts across options.

Economic

Compared to the baseline (option 0), non-regulatory measures (option 1) and incremental improvement (option 2) will have positive, potentially significant economic impacts (e.g. for the hydrogen market), mainly in the longer-term. Market-based measures will affect the entire transport sector, while self/co-regulation would mainly affect fuel producers. An increased ambition level (option 3) would provide for positive economic impacts of medium scale in the short to mid-term. A respective adaptation of the existing sub-target for advanced biofuels as well the introduction of a new sub-target for RFNBOs will foster investments in both technologies, enabling an increased market ramp-up. In case of hydrogen and RFNBOs, significant supply push and demand pull effects have been identified. However, broadening the scope to aviation and maritime will have negative impacts as the costs for fuels in these sectors will increase, while producers of advanced biofuels and RFNBOs will benefit. Streamlining multipliers will have a positive, but limited long-term impacts on the transport sector, and fuel suppliers in particular. Harmonising the supply obligation and defining the way the obligation is expressed at EU level (option 4) would have significant positive short-term impacts on fuel suppliers and public administrations through reduced costs and enhanced European market integration. In case of biofuels and RFNBOs, additional administrative costs from certification of biofuels and RFNBOs may apply, depending on the selected approach of target formulation. A detailed specification of the supply obligation without defining targets at European level may have significantly negative impacts because of the substantial differences in renewable levels in different MSs.

Social

Social impacts of non-regulatory measures (option 1) and incremental improvements (option 2) would be positive, but yet initially limited and only come to full fruition in the long-term, notably in terms of overall social equity and job creation in the entire transport sector covering fuel producers, suppliers and administrations. Medium-sized social impacts could be expected for option 3 (increased ambition level) in the short to mid-term and would include job creation in the electricity, RFNBO, and advanced biofuels supply chains as well as in the manufacturing of BEV and FCEVs and recharging/refuelling infrastructure. Harmonisation of the supply obligation and defining its expression (option 4) would likely yield cost reductions for fuel suppliers and streamline processes on the administrative side, which to some extent may lead to limited job losses. Not defining targets at the European level would have negative social impacts.

Environmental

Compared to the baseline (option 0), non-regulatory measures (option 1) and incremental improvements (option 2) will have positive, albeit limited and the long-term environmental impacts. In all options, GHG emissions are the most important environmental impact category. Pollutant emission reductions are the second impact category of general relevance. Notable advances will be provided by the use of renewable electricity in transport, either direct in BEVs or indirect by FCEV, which both have zero emissions on the road. The extent of positive environmental impacts would benefit in the mid-term from an increase in the ambition level (option 3). And when approaches are coordinated and harmonised (option 4), enhanced market integration will allow for positive environmental impacts in the longer-term. The definition of the overall supply obligation in terms of energy or GHG emission reduction offers a way to either focus solely on the promotion of renewable energy technologies or to stimulate all technologies with reduced GHG emissions, independent of their renewable character. A lack of targets at the European level (option 5) will have mixed, and to some extent negative environmental effects.

Annex G - Industry Options Analysis

Annex G to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

Abbreviation	Full name
ACEA	European Automobile Manufacturers Association
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Utilisation and/or Storage
CTBO	Carbon Takeback Obligation
EED	Energy Efficiency Directive
EU	European Union
EII	Energy Intensive Industry
ETS	Emissions Trading Scheme
ESR	Effort Sharing Regulation
GHG	Greenhouse Gases
GO	Guarantee of Origin
H&C	Heating and cooling
LCOH	Levelized Cost of Hydrogen
LCCA	Life Cycle Cost Analysis
MS	Member State
NGO	Non-Governmental Organisation
RFNBO	Renewable Fuels of Non-Biological Origin
RED	Renewable Energy Directive
RES	Renewable Energy Sources
SME	Small and Medium Enterprises
SPP	Simple Payback Period
VA	Voluntary Agreement

Background

A major long-term challenge for decarbonising our economies is the low-carbon production of industrial commodities such as cement, steel and non-ferrous products, chemicals, pulp and paper, and glass. The production of these products is currently very carbon-intensive, while they are, and will continue to be, needed in large quantities to build the sustainable infrastructure and the cities of the future.[675] Recent research finds that global greenhouse gas (GHG) emissions from material production have increased by 120% over a period of 20 years (1995 to 2015), with 11 billion tons of CO_2-equivalent emitted in 2015, mostly due to a strong growth in demand for materials.[676] This also emphasises the importance of complementing strategies to decarbonise industrial production processes with circular economy policies focusing at reducing demand.[677] Moreover, a particular challenge in industry, particularly for cement and steel, is that a large part of the GHG emissions are process-related, and cannot thus be addressed simply by replacing the source of energy by renewable or low-carbon options. Energy use in industry is still heavily reliant on the direct use of fossil fuels (see Figure 0-1 and Figure 0-2).

Introducing renewables for heat in the industrial sector is problematic mainly for two reasons: either energy is a minor component in the production process, and therefore it is considered not worth to invest time and resources to decarbonise it; or conversely energy is a fundamental part of the process contributing significantly to production costs and companies are reluctant to take technical and economic risks necessary for change.

For many energy-intensive industries, energy costs make up a significant share of their overall production costs and hence increases in energy costs can have a significant impact on industrial competitiveness. Since renewable energy is often still significantly more expensive than fossil fuels, the uptake of renewables in the industrial energy mix remains limited. There are also other barriers for renewables uptake, such as a lack of trust in and experience with renewable energy technologies and the costs related to downtime of industrial plants needed for the refurbishment of the processes. Energy costs in manufacturing accounted for between 1 and 10% of production costs in the period 2010 to 2017 in the EU.[678] However, for energy-intensive sectors such as paper, clay building material, iron and steel and cement these costs accounted for more than 10% of production costs in at least one year in that period. The study did not focus on the effects of increased renewables uptake on the total energy costs for the manufacturing industry, but it is clear that such uptake will have an effect on costs, which in turn should translate into a consideration on competitiveness.

[675] Delbeke, J.; Vis, P. (Eds.). (2019). Towards a Climate-Neutral Europe – Curbing the Trend. Available at: https://library.oapen.org/viewer/web/viewer.html?file=/bitstream/handle/20.500.12657/47034/9781000750713.pdf?sequence=1&isAllowed=y
[676] Hertwitch, E.G. (2021). Increased carbon footprint of materials production driven by rise in investments. Available at: https://www.nature.com/articles/s41561-021-00690-8
[677] Material Economics. (2019). 'Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry'. Available at: https://www.cisl.cam.ac.uk/resources/publication-pdfs/material-economics-industrial-transformation-2050.pdf
[678] European Commission. (2020). Study on energy prices, costs and their impact on industry and households. Available at: https://ec.europa.eu/energy/studies_main/final_studies/study-energy-prices-costs-and-their-impact-industry-and-households_en

Figure 0-1 Final energy consumption per sector and total across energy intensive industries[679]

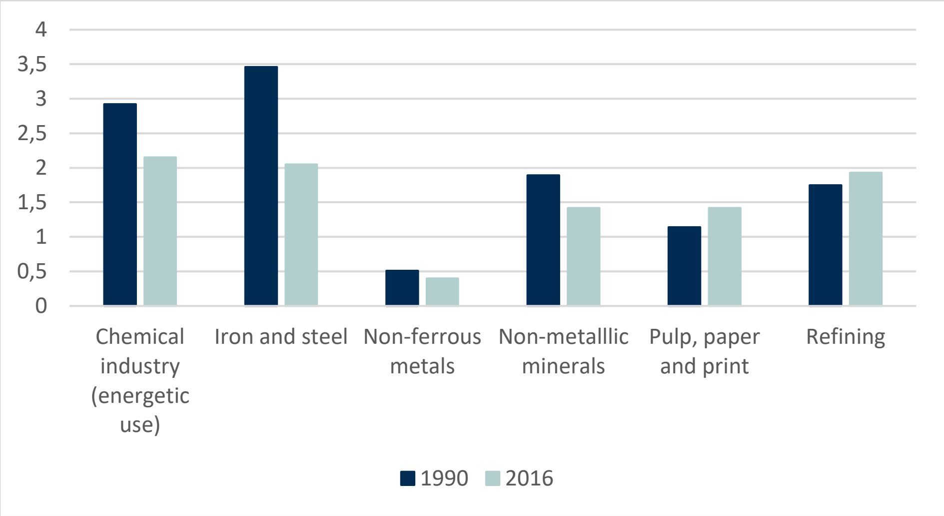
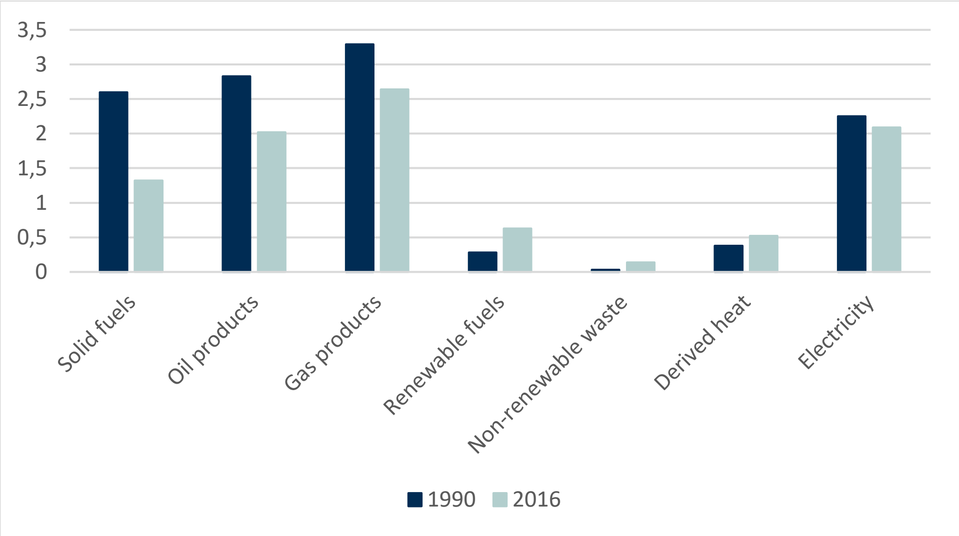
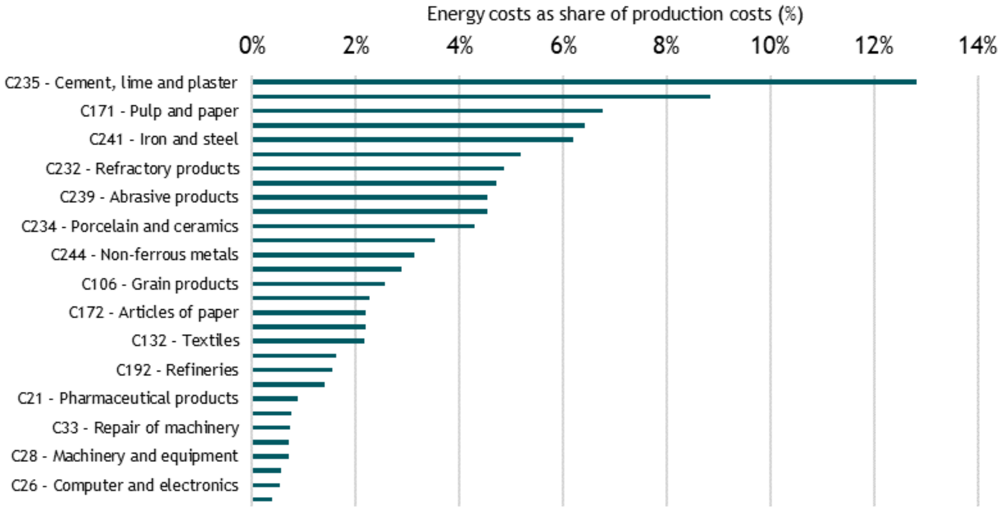


Figure 0-2 Final energy consumption per energy vector in energy intensive industries



[679] Own elaboration based on data from Vrije Universiteit Brussels - IES (2020) Industrial Value Chain - A Bridge Towards a Carbon Neutral Europe. Available at: https://www.ies.be/files/Industrial_Value_Chain_25sept_0.pdf

Figure 0-3 Energy costs as a share of total production costs for different sectors in 2017[680]

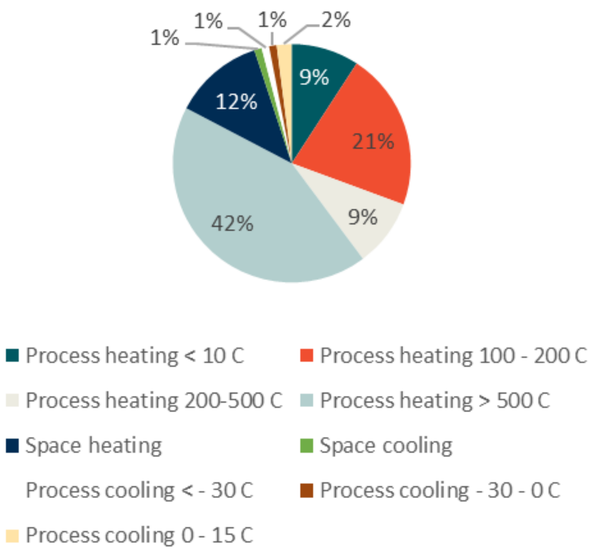


Even with the increased cost competitiveness of renewables observed in recent years, one of the main barriers to achieve zero-carbon production processes lies in the availability of large quantities of renewable energy sources.[681] In a report published by Eurelectric, a scenario where energy emissions are reduced by 95% by 2050, sees a 50% increase in total industrial electrification.[682] Overall, this scenario foresees an increase of electricity in industry's final energy demand form 33% in 2015 to 50% in 2050 or even 60% as the indirect electricity consumption for the production of hydrogen and synthetic fuels is taken into account. An indicative estimate based on sector studies and calculations gives a range of 2,980 TWh to 4,430 TWh aggregated possible future electricity demand from energy-intensive industries following the wide-scale deployment of low-CO_2 processes.[683]

Another challenge is of technical nature. A substantial share of the industrial energy demand relates to the need for process heat (about 81% in 2015 as illustrated by figure 1-4), which is still mostly generated from fossil fuels. In 2015, 83% of the final energy demand for heating and cooling in industry came from fossil sources. Several options are available for the provision of renewable process heat, but especially for the higher temperatures the deployment of renewables represents a significant cost, due to higher energy costs often combined with the need for (costly) changes (sometimes even complete replacement) to the existing production processes. Often, direct integration of renewables into the existing process can be done to some extent, but becomes rather expensive and a suboptimal solution when striving for high emission reductions. In such cases, the deployment of renewables often needs to be combined with a redesign of the industrial processes, to make the decarbonised solution more cost efficient.

680 European Commission. (2020). Study on energy prices, costs and their impact on industry and households. Available at: https://ec.europa.eu/energy/studies_main/final_studies/study-energy-prices-costs-and-their-impact-industry-and-households_en
681 Carbon Market Watch. (2019). Cracking Europe's Hardest Climate Nut – How to kick-start the zero-carbon transition of energy-intensive industries? Available at: https://carbonmarketwatch.org/publications/cracking-europes-hardest-climate-nut/
682 Eurelectric. (2018). Decarbonisation pathways Part1 – European economy. Available at: https://cdn.eurelectric.org/media/3558/decarbonisation-pathways-all-slideslinks-29112018-h-4484BB0C.pdf
683 Vrije Universiteit Brussel – Institute for European Studies. (2020). Industrial Value Chain – A Bridge Towards a Carbon Neutral Europe. Available at: https://www.ies.be/files/Industrial_Value_Chain_25sept_0.pdf

Figure 0-4 **Final energy** demand in industry for H&C by end-use (EU28, 2015)[684]



Different industries have different temperature profiles and specific requirements related to their processes, which means that the most optimal renewable or low-carbon solution often differs per industry. Also, the relative costs of deploying a certain renewable energy source or energy carrier can differ substantially across sectors.

• The Emissions Trading Scheme and the Renewable Energy Directive and their interactions

The EU ETS was implemented as the main instrument for the decarbonisation of energy-intensive industries because such a market-based system should lead to decarbonisation in the most cost-effective manner. This means that additional measures will theoretically reduce the cost efficiency of the ETS as the degrees of freedom to select the most cost-optimal solutions will be limited to some extent. However, this assumes that there are no market failures and that the ETS price on its own will provide a sufficiently large incentive to implement emission abatement measures that go beyond incremental improvements. In practice, there are more barriers to the deployment of renewables in industry than only the cost differential with fossil fuels, such as a lack of experience and trust in new technological solutions. Secondly, even though the ETS price has increased recently, the *effective price,* taking into account free allocation, is still rather low and as a consequence, GHG abatement in industry happens at a relatively low pace. Furthermore, price fluctuations and developments at rather short timeframes provides additional risk, which is costly, and thus a barrier to RES adoption. In order to ensure sufficient progress to meet the 2030 and 2050 climate targets, the implementation of flanking measures such as a (limited) renewable energy obligation may be justifiable.

With the Masterplan for a Competitive Transformation of EU Energy-intensive Industries (EIIs) Enabling a Climate-neutral, Circular Economy by 2050[685], EU EIIs have collectively identified a range of

[684] Own elaboration based on data from Heat Roadmap Europe. (2017). Profile of heating and cooling demand in 2015. Available at: https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2017/3-1_Profile_of_the_heating_and_cooling_demand_in_the_base_year_in_the_14_MSs_in_the_EU28.pdf
[685] High-Level Group on Energy-intensive industries. (2019). Masterplan for a Competitive Transformation of EU Energy-intensive Industries Enabling a Climate-neutral, Circular Economy by 2050. Available at: https://ec.europa.eu/docsroom/documents/38403/attachments/1/translations/en/renditions/native

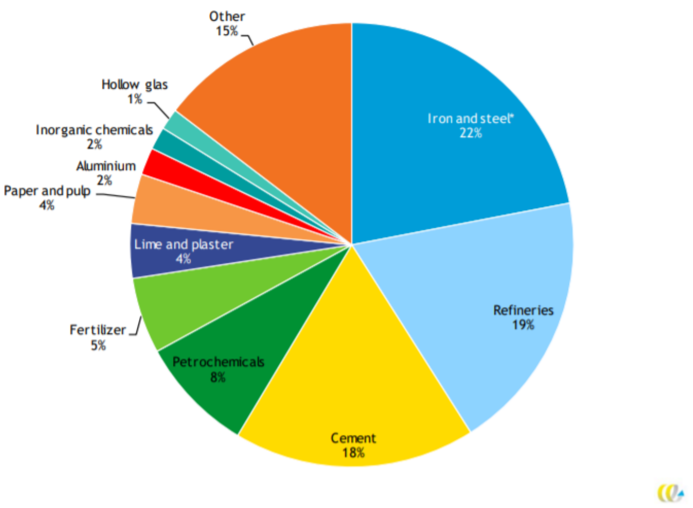
technological pathways that can deliver deep emission reductions and companies are working at concrete projects to progress further. Renewable energy carriers are part of these pathways, and mainly touch upon electrification (via renewable electricity), bio-energies (mainly biomethane replacing natural gas), and Renewable Fuels of Non-Biological Origin (RFNBOs), i.e., hydrogen and fuels produced from it. Renewables are also fully integrated solutions in industrial processes, when applying circular principles, industrial symbiosis and increased energy efficiency requiring a systemic approach to decarbonization. Having this in mind, the industry should be addressed under the Renewable Energy Directive (RED), but with a strong link to existing provisions under Energy Efficiency Directive (EED), and other EU instruments such as the Emissions Trading System (ETS), the Hydrogen Strategy[686] and the European Industrial Strategy,[687] and the Circular Economy Action Plan[688].

Some articles of the Renewable Energy Directive recast already address industry directly and indirectly, these are:

- Article 15 on administrative procedures, regulations and codes
- Article 18 on information and training;
- Article 23 on mainstreaming renewable energy in heating and cooling;
- But also article 14 of the Energy Efficiency Directive (potential assessment, policies, including a long-term decarbonisation strategy, and cost-benefit analysis) is important to consider.

The figure below shows the emissions of industrial sectors in the EU ETS, according to the European Transaction Log. This figure shows that the iron and steel sector has the largest share of emissions followed by refineries, cement, petrochemicals and fertilizer. Together, these five sectors make up over 70% of industrial emissions in the EU ETS. The glass sector's emission contribution is very small compared to these five main sectors.

Figure 0-5 Share of CO_2 emissions in the total industrial CO_2 emissions in the EU ETS in 2018[689]



[686] European Commission. (2019). Hydrogen. Available at: https://ec.europa.eu/energy/topics/energy-system-integration/hydrogen_en#eu-hydrogen-strategy
[687] European Commission. (n.d.). European industrial strategy. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en
[688] European Commission. (2020). Circular Economy Action Plam – For a cleaner and more competitive Europe. Available at: https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf
[689] EP – ITRE. (2020). Energy- intensive industries: Challenges and opportunities in energy transition. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652717/IPOL_STU(2020)652717_EN.pdf

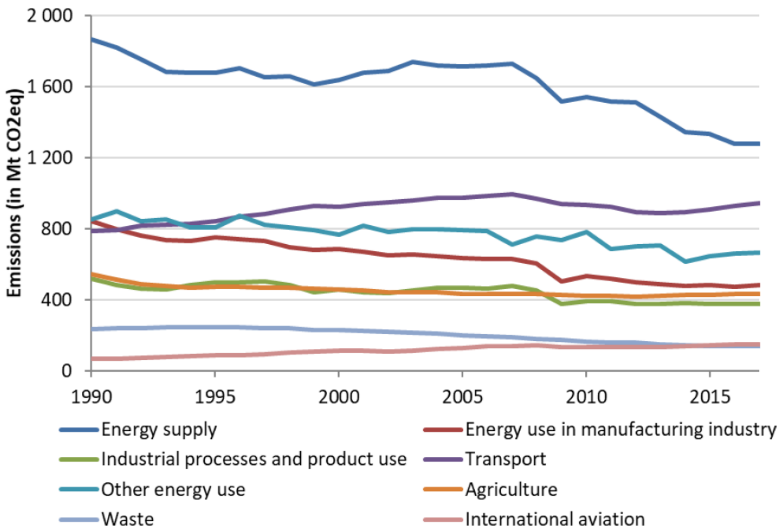
Design

Problem definition

Low uptake of renewable energy sources in industry

The EU industrial sector is a key economic activity, producing a large share of EU GDP and offering employment to a large share of EU population. The industry, and especially Energy Intensive Industries, provides materials and goods that are critical for our economy such as cement and steel, being the basic materials for the buildings sector and plastics being used in many end-use products like cars, appliances or packaging. All these materials are produced from industrial processes requiring significant amounts of energy and emitting, directly or indirectly, a high amount of greenhouse gases. According to the Long Term Strategy (LTS), industrial activity contributes about 16% of EU's GDP and is directly responsible for about 15% of total GHG emissions. In 2015, energy intensive industry sectors emitted approximately 700 million tonnes of CO_2, which represents a reduction by more than 30% compared to 1990 levels (as illustrated by Figure 0-6). This was observed especially in the energy intensive industries.

Figure 0-6 EU GHG emissions per sector 1990-2017[690]



Industry has a leading role to play in the transformation towards a climate-neutral economy. All industrial value chains, including energy-intensive sectors, will be confronted with major challenges.

Industry's emissions, especially the process emissions, have often been considered as difficult to abate. The LTS describes the need of industrial emissions reductions of roughly 95-98% compared to 1990 (from 760 Mt CO_2eq in 2017 to 62 Mt of CO_2eq) in 2050. A large part of the GHG reductions achieved up to date are a result of energy efficiency improvements. Further energy use and process optimisations, for instance through the reduction of heat losses, recovery of process released heat and re-use of energy containing gaseous effluents are achievable, but are insufficient to achieve the long term GHG reduction goals. In many cases, further energy savings would require the replacement of major parts of the existing industrial processes, which may not be preferable compared to more drastic options (for example thanks to technology breakthrough), changing to a radically new production process, such as

[690] European Commission. (2018). Communication A Clean Planet for all – A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. COM(2018) 773 final.

electrification. To reach such reduction, renewable energy sources will be required to be largely mainstreamed using all available technologies in order to replace fossil carriers. Electrification, backed by low-emission fuels and integrated energy-efficiency solutions, are key for many industrial processes. Examples of where industrial processes can become electrified include high-temperature processes (i.e. ore and cement sintering, reheating ore furnaces, steam crackers), and the use of renewable hydrogen for ammonia and iron production.[691] Considering a much wider solution set to decarbonise the "hard to abate" sectors will be needed for deep emission cuts. A more circular economy is also part of the answer. Innovations in industrial processes, digitisation, and renewable energy technologies (e.g. biobased) can also enable deeper reductions over time.

The slow uptake of renewables in the industry (both of industries under the Emissions Trading Scheme (ETS) representing ~70% of the EU emissions & the ones under the Effort Sharing Regulation (ESR) representing ~30%), can be attributed, to a large extent, to the following main root causes:

- Market conditions of RES (not yet competitive):
  - Switching to renewable-based energy sources vis-à-vis fossil fuels is not yet sufficiently attractive for the industry sector at large. More than technology maturity the problem can often be associated with a lack of sufficient incentives for change. For example, although half of the H&C demand in industry is for low-temperature processes (<200°C) for which renewable technology options exist and are cost-competitive, more than 90% of the H&C demand is currently met by fossil fuels. The challenge of introducing renewables for heat in the industrial sector can often be attributed to two reasons: either energy is a minor component in the production cost, and therefore it is considered not worth to invest time and resources to decarbonise it; or conversely energy is a fundamental part of the process and companies are reluctant to take technical and economic risks necessary for change (this could partly be solved via third party financing schemes, or energy performance contracts).

- Lack of awareness/ knowledge:
  - This root cause can be tied to the insufficient availability of incentives to learn about and consider the required changes (power purchase agreements, other RES supply agreements, required production changes, need for connections to relevant infrastructure, or simply the valorisation of local resources, etc.) for decarbonizing the industrial processes. The second dimension is the lack of awareness/knowledge from the consumers' side which again translates into a lack of incentive for the industry to switch to a renewables-based production process. The lack of awareness and knowledge is also considered as an important barrier, and even with the integration of renewables in energy audits to be conducted in compliance with article 8 EED, renewables do not seem to be on the agenda of industries, certainly considering it is out of core business (while energy savings are more related to the process and more easily mainstreamed).

- Barriers regarding the supply (limited solutions, e.g. for high temperature process, or lack of infrastructure, e.g. H_2):

[691] Material Economics. (2019). 'Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry'. Available at: https://www.ies.be/files/Industrial_Value_Chain_25sept_0.pdf

- In order to maximize the options available for industry to switch to RES further planning and infrastructure development will be required. This is important, for example, in the case of hydrogen supply, where infrastructure and regulation are still missing. Similarly, to support the deployment of other options to decarbonize the industry sector such as Carbon Capture and Storage (CCS) infrastructure to transport the captured CO_2 into a safe storage place is a pre-requisite, which is largely missing at present. There are several options for deep decarbonisation of the industry, however, the many diverse subsectors do not allow for a single silver bullet solution, each with its own particularities arising from a variety of reasons, leading to different energy and material needs resulting in different types, mixture, volumes and concentration of industrial effluents containing greenhouse gases. In some hard-to-abate sub-sectors, there is a limited amount of technical options. Moreover, resource availability remains a challenge (e.g. biomethane may be an option for all industries using natural gas, without any conversion/investment required, but producing biomethane to cover the entire industrial demand of gases would not be possible due to resources limit).

Objective setting

In order to further reduce emissions from industry in line with the higher climate target for 2030, major changes need to be made in the way industry consumes energy and produces its products notably via increased material and energy efficiency, greater material recirculation, new production processes, renewable fuels and carbon capture technologies. According to the CTP IA, achieving further reductions in industry will depend increasingly on:

- the deployment of renewable energy carriers, like e.g. hydrogen and e-fuels, and of the infrastructure necessary to deliver those to end-user points;
- proving the technical and economic feasibility of expensive breakthrough technologies, particularly for energy intensive industrial processes, still under development or at the demonstration level.

In addition, it should be recognised that the uptake of renewable fuels in the industry aims at contributing to long-term climate objectives; at providing more stability and security in the long term; at avoiding stranded assets; at contributing & improving energy system integration; at increasing electrification; and at increasing energy efficiency (e.g. via auto-production).

The objective of the policy options is to facilitate the uptake of renewables in industrial processes, by

- Increasing the awareness of the industry, at plant level, to consider options to integrate renewable fuel supply. E.g., energy audits have proven to efficiently identify potential for energy savings, but are not systematically identifying appropriate actions for delivering renewable fuels to the industry;
- Encouraging the use of renewable fuels in industry with the aim to green the image of a company, of a brand or of a product sold on the market, by transparently informing consumers about their renewable footprint. This would increase the attractiveness of using renewable fuels in industry to satisfy a pull from the demand side, even with an increased cost impact;
- Clearly fixing a medium-term objective.

Development of policy options

The purpose of the measures proposed below is to accelerate H&C renewable share in the industry.

Table 0-1 Description of policy options to accelerate H&C renewable share in Industry

Options	Description
Option 0 (baseline)	No specific provision on industry under the revised Renewable Energy Directive
Option 1 (non-regulatory)	Voluntary agreements for the use of renewable fuels and electricity
Option 2	Include RES in energy audits under EED & provisions for energy system integration
Option 3	Creation of a label to provide information to consumers on such RES content (including) Sub-option A: voluntary, according to EU methodology Sub-option B: mandatory and according to EU methodology
Option 4	Voluntary target(s) for the share of renewables consumed in industry to be applied to all industry. Sub-option A: only RES energy all industry Sub-option B: only RES energy targeted sectors/processes Sub-option C: A OR B +include also low carbon
Option 5	Option 4 + Mandatory target(s) for CCS for specific industries Sub-option A: voluntary target, applied to all sectors, at level of XX% in 2040 Sub-option B: voluntary target, applied to just a few sectors, at level of XX% in 2040

Option 0: No specific provision on industry under the revised Renewable Energy Directive

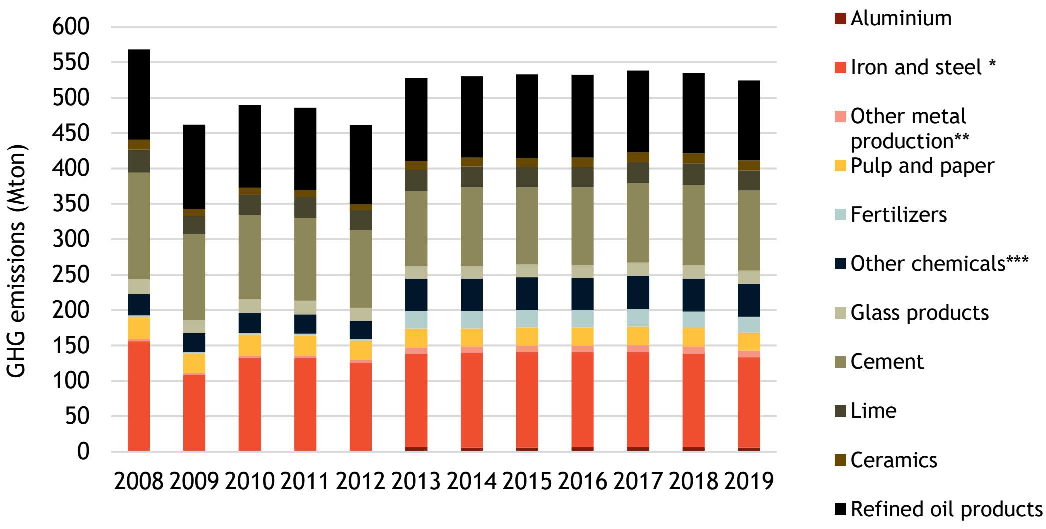
The baseline scenario (Option 0) does not consider any additional measure, relying on the existing framework, comprising the provisions of RED addressing indirectly the industry (e.g. articles 15 & 18), and the revision of the EED.

Currently, the recast Renewable Energy Directive (RED II) does not contain specific provisions on the uptake of renewables in the industry sector. At present, GHG emissions from energy-intensive industries are mainly regulated through the European Emission Trading Scheme (EU ETS), but there is no conflict in addressing the uptake of renewables for EIIs under the RED. Further, the non-ETS industry sector which is covered under the Effort Sharing Regulation and as such can be addressed under the REDII still represents roughly 30% the industrial GHG emissions.[692] Industries have to monitor and report their CO_2 emissions (and other GHGs) and obtain permits for these. Part of the permits are distributed for free to sectors prone to carbon leakage, the rest is sold via auctions. The number of permits distributed decreases yearly according to the "linear reduction factor", currently 2.2%. Permits can be traded to assure a cost-effective compliance to the required reductions.[693]

The figure below shows, that despite the yearly reductions in ETS allowances, CO_2 emissions from industry increased between 2012 and 2013 and have not decreased since.

[692] Own calculations based on EUTL emission data and Eurostat GHG balances.
[693] EP – ITRE. (2020). Energy- intensive industries: Challenges and opportunities in energy transition. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652717/IPOL_STU(2020)652717_EN.pdf

Figure 0-7 CO_2 emissions in the EU ETS from the energy-intensive industries, EU27 2008 -2018[694]



* In the figures for iron & steel all emissions for coking were included; **The category other metal production includes emissions from metal ore roasting and sintering and the production and processing of non-ferrous metals; *** Other chemicals includes: Production of black carbon, glyoxal and glyoxylic acid, bulk chemicals, production of hydrogen and synthesis gas and the production of soda and bicarbonate.

- ***Option 1: Voluntary agreements for the use of renewable fuels and electricity in industry***

Voluntary agreements (VAs) could be a way to incentivise the uptake while allowing for flexibility and limiting the impact on industrial competitiveness associated with other, harder options. Voluntary agreements are a type of self-regulating measure that can take a variety of different forms. A common type of VAs is established between a public body and an industrial association and it includes a collective commitment of the industrial sector to reach a given (in this case renewable energy uptake) objective. Further such Voluntary Agreements can take the form of:

i) Agreement schemes - used as a policy instrument. Such scheme is part of a supranational or national policy and can be seen as a framework for specific voluntary agreements with sector associations.

ii) Single voluntary agreements – concluded either with an industrial sector association or individual companies. These agreements can be part of the broader agreement scheme or exist independently.[695]

Additional characteristics of VAs to consider include[696]:

- <u>Product versus process oriented</u>

The focus of the Voluntary Agreement in this case differs between either a focus on the improvement of the production process by using renewables or more efficient pathways or final-product oriented results (and specific renewable content). In the second case, the companies participating under the VA would be able to come up with different ways for increasing the renewable content of the product and hence would be given more flexibility.

[694] Ibid.
[695] Wuppertal. (2005). Review of Voluntary Approaches in the European Union – Feasibility Study on Demonstration of Voluntary Approaches for Industrial Environmental Management in China. Available at: https://www.econstor.eu/bitstream/10419/59258/1/516277715.pdf
[696] Ibid.

- Target-based versus implementation based

Voluntary Agreements can be either target-based (e.g. pollution abatement or use of renewables) or focus on implementation procedures that should lead to positive outcome achievement.

- Binding versus not binding

The legal form of a Voluntary Agreement has considerable implications on its outcome. An agreement can be considered binding, when it is enforceable though a court's decision and includes sanctions in case of non-compliance. It depends on the national legal system whether the government is allowed to sign a binding contract with industry. The issue of EU harmonisation between MS' systems needs also to be addressed.

- Individual versus collective liability

In case of collective liability, industry or an industry sector is collectively responsible and liable for the implementation of the agreement and any sanctions would also be faced collectively in case of failure. Free riding can be limited in case of an individual agreement as the performance of all participating companies is controlled but likely involves greater monitoring costs and higher administrative burden.

- Open versus closed access to third parties

VAs do not traditionally involve third parties, as they are not part of the legislative process. However, community organisations or environmental groups play an increasing role in VAs.

The most effective combination of characteristics in the context of the Renewable Energy Directive and the industry sector will be analysed under the analysis section of this paper.

Examples of Voluntary Agreements include:

- The Dutch Long Term Agreement on energy efficiency and the benchmarking covenant (analysed as case study in 0)
- The Agreement between the European Automobile Manufacturers Association (ACEA) and the European Commission (analysed as case study in 0)
- The Flemish/Walloon Covenant Energy Benchmarking (and sectoral/branch agreement);
- The Flemish Covenant Energy Auditing;
- VAs under the Eco-design legislation (Complex Set-Top Boxes, Imagine equipment, Games consoles) (See Box below on lessons learned from experience with these VAs).

The Box below provides a description of key considerations in the use and design of VAs based on the experience under the Ecodesign Directive.

Textbox 0-1 Experience of VAs under the Eco-design Directive[697]

Box 3. Experience of voluntary agreements under the Ecodesign Directive

- Directive 2009/125/EC establishes a framework for the setting of ecodesign requirements for energy-related products. Ecodesign aims at reducing the environmental impact of products, including the energy consumption throughout their entire life cycle. Mandatory and voluntary approaches within the same instrument.
- Implementing measures impose legally binding design criteria or recognise voluntary agreements. Two voluntary agreements have been implemented regarding the energy consumption of Complex Set Top Boxes within the European Union; and the environmental performance of imaging equipment on the European Market.
- Self-regulation appears to work best when a broad cross section of the market sector can be included which also lessens the risk of free-riders;
- Transparency is important to monitor performance of the agreement. Reliable and objective information should be available from independent entities.
- A credible system to ensure compliance with commitments is vital and should involve a body outside of the direct control of the parties to the agreement.
- Administrative and other costs of governing a voluntary agreement should be assessed during the IA process so that a fair comparison is made to alternative policy approaches (such costs include independent compliance monitoring, meetings with parties to the agreement, the internal resources in the Commission to manage/update the agreement, etc.)

Note that the description of this option is closely linked and expanded on under option 4.

Option 2: Include RES in energy audits under EED & provisions for energy system integration

An energy audit is a thorough assessment of the energy consumption of a company including its buildings, processes and transport use. Its goal is to identify cost effective ways to save energy.[698]

Article 8 of the Energy Efficiency Directive (EED) (2012/27/EU amended by 2018/2002) requires MSs to require energy audits and promote energy management systems. The Directive required that large companies carry out a first energy audit by the end of 2015 and continue to perform audits every four years. Annex VI of the EED established the minimum criteria to be carried during the energy audits, these are:

a) Be based on up to date, measured, traceable operational data on energy consumption and (for electricity) load profiles.
b) comprise a detailed review of the energy consumption profile of buildings or groups of buildings, industrial operations or installations, including transportation;
c) build, whenever possible, on life-cycle cost analysis (LCCA) instead of Simple Payback Periods (SPP) in order to take account of long-term savings, residual values of long-term investments and discount rates;
d) be proportionate, and sufficiently representative to permit the drawing of a reliable picture of overall energy performance and the reliable identification of the most significant opportunities for improvement.

[697] EC Better Regulation Toolbox #18 – The Choice of Policy Instruments

[698] European Commission. (2016). EU countries have taken measures to boost energy audits in companies, study finds. Available at : https://ec.europa.eu/energy/news/eu-countries-have-taken-measures-boost-energy-audits-companies-study-finds_en

These criteria do not explicitly require an assessment of renewable energy use/uptake as part of the audit. The inclusion of renewable energy as part of such audits, can provide clarity and reliable information as well as serve as an incentive for RE uptake.

Within the scope of this option 2 the following will be assessed:

- Adapt article 8 of EED on energy audits by adding an article 8(1.c) on including the assessment of renewable energy use (and waste heat and cold) in addition to energy savings measures;
- Integrate a provision recommending MS to oblige, under certain conditions, the implementation of identified results of the audits (strengthening EED provisions enforcement);
- Adapt Annex VI of EED on criteria to conduct audits by introducing a criterion to assess the local availability of renewable (and waste heat and cold potential) for buildings and industrial plants;
- Demand- response; in the case of heavy industry and manufacturing, the energy-intensive operations can represent a significant load reduction capability. For slow response (i.e. 4 or more hour notification), production lines can often be fully shut down, or rescheduled. On a more rapid basis, variable speed drives, balers, and even arc furnaces can be both curtailed and remotely controlled. Many industrial facilities also have standby and cogeneration capacity which can be leveraged.[699]
- Process- innovation, through electrification or any other technology breakthrough, even at a low Technology Readiness Level (TRL).

Option 3: Creation of a label to provide information to consumers on RES content (including the creation of the principles of a methodology to calculate the RES content of (certain) industrial products)

Green labelling, also known as 'Ecolabelling', is a recognised approach for businesses to communicate the environmental credentials of products they put on the market.

Ecolabels stimulates the market for green products and services and promotes broader awareness on environmental issues. In the EU and globally there are a number of initiatives that are active in this space, each one of them with their own criteria and focus.[700] Some of these already focus on labelling energy products, including their renewable content. For example:

- EKOenergy (https://www.ekoenergy.org/);
- TUV SUD (https://www.tuvsud.com/en/industries/energy/conventional-power/energy-certification);
- TUV Nord (https://www.tuev-nord.de/en/company/certification/eco-power/);
- Bra Miljöval in Sweden;
- Grüner Strom in Germany;
- NatureMade in Switzerland;
- Svanemærket/EU-Blomsten in Denmark;
- Green-e American in US;
- Windmade was a consumer label for companies, events and products using wind power, established by seven companies and NGOs.

[699] Shen, B. et al. (2012). Addressing Energy Demand through Demand Response: International Experiences and Practices. Available at: https://www.osti.gov/servlets/purl/1212423
[700] Ecolabel index (Accessed on 14/06/2021) Available at: http://www.ecolabelindex.com/.
The index lists over 456 ecolabels globally

Option 3 would add a provision in RED for the creation of a label to provide information to consumers on RES content of the products they are purchasing. The provision would have to define overall principles and, if feasible, specify the methodology to calculate the RES content of (certain) industrial products.

Art. 19 (13) of RED II stipulates that "*The Commission shall adopt a report assessing options to establish a Union-wide green label with a view to promoting the use of renewable energy coming from new installations. Suppliers shall use the information contained in GOs to demonstrate compliance with the requirements of such a label*." This option considers modifying or expanding this article to specify the creation of an industry-specific eco-label.

There are various possibilities for how this option could be implemented in practice. For example, it could mandate a standard EU format and methodology or it may just set overall criteria and allow third-party labels to be officially recognised. The EU Ecolabel (Text box 1) and the experience with its implementation could be used as a model for how to implement option 3.

Identifying the most appropriate design would require a detailed evaluation of the various practical options for implementation, which is beyond the scope of this assessment. However, this assessment considers whether such RES labelling should be mandated or voluntary:

- Sub-option A: voluntary labels but according to EU methodology (possibly under article 15 on Administrative procedures, regulations and codes)
- Sub-option B: mandatory labels and according to EU methodology

Text box 1 - EU Ecolabel, Sustainable Products Initiative

Ecolabel

The EU Ecolabel Regulation[1] sets the legal framework for an EU-wide voluntary public labelling scheme for reporting on the environmental performance of products and services (EU Ecolabel scheme). With the help of the EU Ecolabel, public, corporate and private consumers would be able to identify environmentally-friendly products and services.[1] To be compatible with the EU internal market principles (e.g. non-discrimination, equal treatment, transparency) the Regulation provides general requirements for the development, establishment and revision as well as the award of the EU Ecolabel criteria (cf. Art. 6-9). Moreover, the product criteria of the EU Ecolabel can be used for Green Public Procurement (GPP), for example as environmental technical requirements or environmental award criteria (see Directive 2014/24/EU infra). Additionally, the Regulation provides rules for the governance structure of EU Ecolabels.[1] Main actors are the Competent Bodies (CB) which have to be designated by each MS (cf. Art. 4) and the European Union Eco-labelling board (EUEB) (cf. Art. 5). The CB is, inter alia, responsible for implementing the Ecolabel scheme at MS levels, the CB has to contribute to criteria development, receive applications from companies and it has to award the label after verification as to whether all the criteria have been met. When developing Ecolabel criteria for product groups or service groups the CB must comply with requirements regarding their independence and neutrality to ensure transparency (cf. Art. 4 (2) and Annex V).

Sustainable Products Initiative

This initiative aims to revise the Ecodesign Directive and propose additional legislative measures to make products placed on the EU market more sustainable. Consumers, the environment and the climate will benefit from products that are more durable, reusable, repairable, recyclable, and energy-efficient. The initiative also aims to address the presence of harmful chemicals in products.

The initiatives focus on energy efficiency of products, rather than renewable energy use during their production.

Proposed articulation between JUST initiative on empowering consumers in the green transition ("JUST initiative") and ENV green claims initiative ("ENV initiative")

The respective JUST and ENV initiatives have been both announced in the Green Deal, the Circular Economy Action Plan and the Consumer Agenda as complementary separate actions. Given the close interlinks between them, they are developed in close coordination. The supporting impact assessments have been prepared in parallel by the JUST and ENV teams. They draw, where relevant, on the same data and aim at avoiding contradictions or discrepancies.

ENV initiative

The objective of the ENV initiative is to tackle the proliferation of inconsistent methods and initiatives based on which environmental information about products (goods and services) and organisations is provided, as well as of the many misleading environmental claims on the market. The most ambitious option for the ENV initiative would make it mandatory for companies to undertake an environmental life-cycle assessment.

JUST initiative

It aims at helping consumers to play an active role in the green transition by giving them useful information and protection from certain misleading commercial practices. It tackles identified issues, in particular: the lack of clear, reliable and actionable information for choosing environmentally sustainable products & untrustworthy information or practices such as greenwashing, early obsolescence of consumer goods and the proliferation and limited transparency of sustainability labels and online information tools.

It is also important to distinguish between purely informational labels (EU Energy labelling for energy-using equipment) and labels associated with minimum performance (such as the EU Ecolabel) or limitations to the production processes. Some labels may require the production process to meet a set of criteria that goes beyond the legal obligations, in order for the product or company to be awarded the label. This is the case for the "Organic" label or for forest certification schemes such as FSC. Option 3 concerns the creation of a purely informational label, i.e. a label that every product or organisation would be able to obtain independently from the characteristics of their production processes. Obviously, the information or "rating" presented in the label will rate poorly processes or products that only meet minimum requirements.

Option 4A: Voluntary target(s) for the share of renewables consumed in industry to be applied to all industry concerned by the ETS

A voluntary target is a "soft" policy measure, as it does not impose a set requirement on an entity or a sector. However, voluntary targets are often able to create a commitment that then drives efforts during implementation. Voluntary, self-imposed targets are often used in driving environmental and climate policies, as they force an actor to take action without facing backlash and opposition reserved for harder options, such as mandatory targets.

Under option 4A, RED would include a requirement for all ETS industries to define such a target, but defining some minimum requirement in order for the targe to be compliant. For example, RED may require such target to be set by a certain date, to indicate milestones at different points in time, to define clear reporting periods and to require a minimum level of ambition. For example, the voluntary target must be below the expected trends presented by Member States in their NECPs. The analysis undertaken under option 1 (VAs) is largely applicable here.

This option could be addressed by:

- Integrating in RED II an article similar to article 24(4(a)) of RED II obliging MS to endeavour to increase the share of energy RES sources and from waste heat and cold in different industrial processes by at least a determined percentage as an annual average.

Option 4B: Mandatory target(s) for the share of renewables consumed in industry to be applied to all industry.

Mandatory targets is a "hard" policy measure, which will mean taking for industry an approach similar to the one used in other sectors in RED such as transport. Contrary to a voluntary target, where the legislator has only to identify the main criteria for a voluntary target to be compliant with the directive, a mandatory target requires RED (or its implementing acts) to specify:

- How the target would be measured, including exceptions and flexibilities;
- The value the target is expected to reach at a certain point in time;
- The penalties for missing the target.

Both points will be subjected to intense negotiations between stakeholders (Member States, industry, EU institutions). Assuming that penalties will be designed in broad alignment with other provisions in

RED, and that the targeted milestones will be defined after careful analysis of costs and benefits, this assessment will focus on the scope of the target:

Variant 1: Target specific industries (e.g. energy-intensive). Given their prominence in the share of total emissions from industry (see **Error! Reference source not found.**), we propose to focus on the f ollowing energy intensive industries: cement, iron and steel industries.

Variant 2: specific products (e.g. steel making). In line with the above, we propose to focus on cement and iron and steel. Other products that could be evaluated are listed in the Annex 2 following the list of products being evaluated under the Carbon Border Adjustment Mechanism (CBAM)
Variant 3: specific energy needs (e.g. process and assembly; buildings heating, cooling and lightning; process heat or cold; steam). Under this option, process intensification[701] and circular economy approaches could be evaluated. This variant could be further split as:
Sub-variant 4B.3A: only RES energy all industry
Sub-variant 4B.3B: only RES energy targeted sectors/processes
Sub-variant 4B.3C: A OR B + include also low carbon. Under sub-option C, in addition to renewable energy fuels, recycled carbon fuels will be evaluated.

An important challenge for a minimum RES obligation for industry is that there is a high risk of creating negative interactions with other EU policies, most notably the EU ETS.

The option mandating to use RES fuels or RES technologies for different temperature processes and ways to integrate them into the target implementation framework of the overall H&C obligation could comprise the following alternatives:

- Integrate in article 15 of RED II a provision similar to article 15(4) obliging MSs to require the use of minimum levels of RES fuels or RES technologies for different industrial processes, categorised by temperature levels and considering the existence of RES alternatives. This would leave the opportunity to the MS to establish the most adapted framework to their industry profile.

RES fuels and RES technologies could be integrated into the target implementation framework in function of the overall H&C obligation (article 23(1)) revision and the possible sub-targets. They could be mainstreamed in the revision or mirroring of article 14 of EED (article 14 (1), (2), (3) and annex VIII) on the potential assessment, adopting policies (LT H&C decarbonisation strategy), and cost benefit analysis.

Option 5: Option 4 + Mandatory target (s) for carbon capture and storage (CCS) for specific industries (e.g. hard-to-abate), (With variant: for specific products that are hard to decarbonise via a switch to RES due to process emissions (e.g. steel, cement, some chemicals).)

[701] Process Intensification (PI) is defined as a set of innovative principles applied in process and equipment design, which can bring significant benefits in terms of process and chain efficiency, lower capital and operating expenses, higher quality of products, less wastes, and improved process safety. Definition based on Kiss A.A. (2016). Process Intensification: Industrial Applications. In: Segovia-Hernández J., Bonilla-Petriciolet A. (eds) Process Intensification in Chemical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-319-28392-0_8

Carbon Capture and Storage (CCS) offers a complementary solution to the use of renewable energy and energy efficiency tools for decarbonizing those sectors that are “hard to abate” and where other options are not technically and/or economically feasible. Energy Intensive Industries (EIIs) such as the steel, cement, and chemical industries are examples of sectors where full-decarbonization of input energy based on direct and indirect electrification and energy efficiency would place unfeasibly large demand on renewable electricity. Furthermore, process emissions associated with the standard processes for the production of these commodities cannot be avoided by the electrification of input energy.

Further considerations on the impact of CCS on industry:

- CCS enables carbon-intensive industries to comply with stringent reduction targets.
- CCS would come at a high price in terms of energy use.
- Without CO2 capture increased use of biomass and alternative raw materials are vital.[702]

Policy considerations for implementing mandatory CCS targets

Carbon takeback obligations

Carbon takeback obligations are being considered in the context of fossil fuel producers and importers. Current research defines Carbon Takeback Obligation (CTBO) as a scheme to ensure that hydrocarbons placed on the market are, on balance, employed in a CO_2-free manner by the time net zero needs to be reached (2050).[703] Or in other words, it is an obligation on the producer to permanently store an increasing % of the carbon taken out of the ground/ released into the atmosphere. A modification of the proposed CTBOs could serve as a basis to evaluate a mandatory CCS target for industry.

The option mandating to use CCS for different industrial processes and ways to integrate them into the target implementation framework of the overall H&C obligation could entail:

- Integrating in article 15 of RED II a provision similar to article 15(4), mandating MS to require the use of minimum levels of carbon takeback obligation for different industrial processes where RES alternatives to reduce carbon intensity of energy supply do not exist. This would leave the opportunity to the MS to establish the most adapted framework to their industry profile, and integrate requirements for CCS as a fallback option when renewable is not deemed economically or technically feasible.

Discarded options

Two sub-options (A – voluntary targets and B – mandatory targets) were considered regarding targets for renewable energy in industry. It was decided to focus the assessment on mandatory targets based on the justification that the impact on economy/environment/society can be assumed to be similar if non-binding targets are expected to be voluntarily enforced. In addition, aspects related to a voluntary type of targets is also reflected under option 1 – on Voluntary Agreements.

[702] Rootzen, J. & Johnsson, F. (2015). CO_2 emissions abatement in the Nordic carbon-intensive industry – an end-game in sight? Available at: https://www.researchgate.net/publication/270455726_CO2_emissions_abatement_in_the_Nordic_carbon-intensive_industry_-_An_end-game_in_sight

[703] Kuijper, M. et al. (2021). Carbon Takeback Obligation – A producers Responsibility Scheme on the Way to a Climate Neutral Energy System. Available at: https://gemeynt.nl/bericht/carbon-takeback-obligation-a-producers-responsibility-scheme-on-the-way-to-a-climate-neutral-energy-system

Mapping of potential impacts

- **Direction:** Positive or negative;
- **Magnitude:** limited or significant;
- **Horizon:** Short to long term;
- **Affected parties:** following categorization indicated below.

Table 0-2 Impacts mapping

Options - impacts map	economic	environmental	social
Option 0 **(baseline)**	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A	D: N/A M: N/A H: N/A A: N/A
Option 1 (voluntary agreements)	D: undetermined M: limited H: short term A: Industry (specific sectors or whole), Consumers	D: positive M: limited H: short term A: National Governments, EU, industry	D: positive M: limited H: short term A: National Governments, EU, industry, consumers
Option 2 (include RES in energy audits)	D: positive M: medium to significative H: long term A: individual enterprises meeting the criteria for audits, independent companies conducting the audits energy, SMEs (on voluntary basis)	D: positive M: medium to significative H: long term A: EU, National Authorities (MS),	D: positive M: medium to significative H: long term A: EU, National Authorities (MS), auditors, consumers
Option 3 (product label)	D: positive if voluntary, negative if mandatory M: very limited H: medium term A: industry, individual enterprises, SMEs, consumers (national and international), non-EU competitors	D: positive M: limited H: medium term A: EU, National Authorities (MS), consumers (national and international)	D: positive M: limited H: medium term A: industry, label organisations, consumers (national and international)
Option 4 (voluntary RES target)	D: negative M: depend on the level of ambition H: medium term A: industry, individual enterprises, SMEs, consumers (national and international), researchers, engineers, non-EU competitors	D: positive M: depend on the level of ambition H: long term A: EU, National Authorities (MS),	D: positive M: depend on the level of ambition H: long term A: consumers (national and international), authorities
Option 5 (+mandatory target CCS)	D: negative M: undetermined H: short term A: industry, individual enterprises, SMEs, consumers (national and international), researchers, engineers, non-EU competitors,	D: positive on GHG, negative on other environmental M: medium H: short term A: EU, National Authorities (MS), the wider public	D: negative M: medium H: short term A: consumers (national and international), current and developing CCS projects, the wider public

Analysis

Semi-quantitative and qualitative assessment

Option 1 - Voluntary agreement

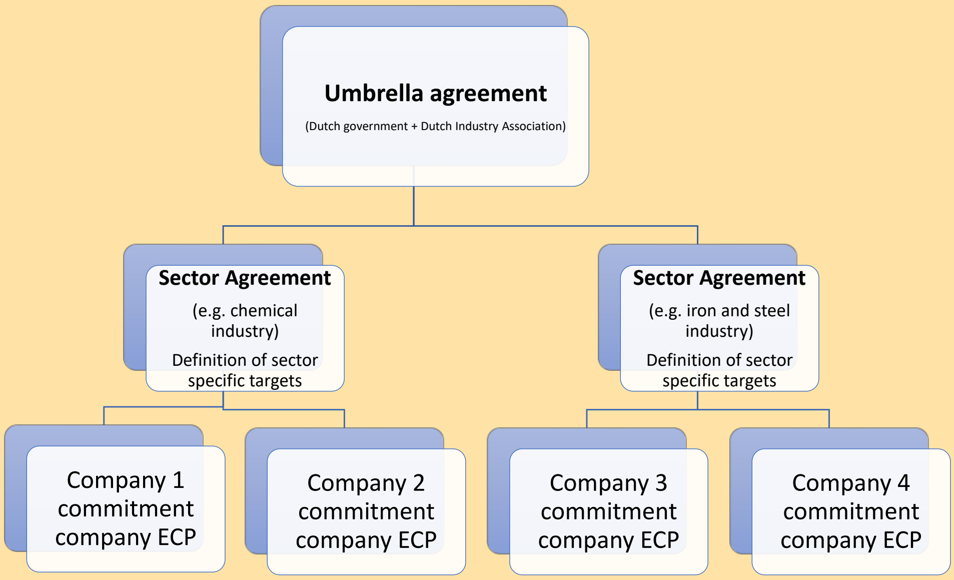
Voluntary Agreements have been used in other areas (eco-design, energy efficiency, industrial symbiosis) to incentivise desirable behaviours/practices/changes. In the boxes below a few examples of VAs are included that exemplify the potential benefits and challenges associated with their implementation.

Textbox 0-2 The Dutch Long Term Agreement on energy efficiency and the benchmarking covenant[704]

The Dutch Long Term Agreement (LTAs) on energy efficiency were signed between the ministry of Economic Affairs and the Confederation of Netherlands Industry and Employers (VNO-NCW) at the beginning of the 1990s. The general goal of the LTS was to increase energy efficiency by 20% by 2000 as compared to 1989. After 2000, the approach was renewed and extended. The most important change was the broadening of the measures towards the whole production chain (e.g. transportation aspects) and the partial incorporation of renewable energy sources. It is designed to head further on towards energy efficiency and guarantee that Dutch companies belong to the ten percent of the most energy-efficient firms in the world. Due to branch specific potentials the targets vary from sector to sector. Thirty-one sector LTAs have been concluded covering around 90 % of the total industry energy consumption in Holland. The structure of the Dutch LTA agreement is depicted below.

The LTA programme was supported by additional policy measures such as monitoring, subsidy schemes, tax reductions and information services.

Figure 0-8 Structure of the Dutch LTA agreement scheme



Own elaboration based on Wuppertal Institute (2005)

Success factors:

- Targets higher than business-as-usual
- Quantified objectives
- Staged objectives
- Reporting procedure in place
- Independent verification of results
- External compliance factors (integration in policy mix) & internal compliance included in agreement
- Legally binding
- Promote dissemination of information
- Institutionalization of environmental working groups and learning effects
- Information of the public and transparency

[704] Wuppertal Institute. (2005). Review of Voluntary Approaches in the European Union – Feasibility Study on Demonstration of Voluntary Approaches for Industrial Environmental Management in China.

Textbox 0-3 Agreement between the European Automobile Manufacturers Association (ACEA) and the European Commission on reducing the CO_2 emissions from European car-fleet[705][706]

In 1998, a Voluntary Agreement was concluded between the European Commission (EC) and the ACEA in relation to environmental problem of CO_2 emissions from passenger cars. VAs at the EU level are legally not binding, as the Commission does not have a formal right to sign agreements with industry. That is why EU-wide VAs have until now been self-commitments from industry, recognised by the EC by an exchange of letters or a Recommendation. The ACEA voluntarily agreed to reduce average CO_2 emissions from new passenger cars to between 165 and 170 g CO_2/km by 2003 and to 140 g CO_2/km by 2008. The ACEA made these commitments subject to the following:

- Availability of sufficiently high-quality fuel to allow further advancements in engine technology.
- Non-ACEA members, particularly those in Japan and Korea, should agree to the same commitments to avoid the European car industry being placed at a competitive disadvantage by imports. The EU Commission responded in 1998 by initiating similar VAs with the Korean and Japanese Automobile Manufacturers Associations.
- EU-wide distribution of new vehicle technologies should be obstructed neither by fiscal nor by other policy measures. In addition, the ACEA retained the right to monitor economic trends and to adapt the reduction target should employment conditions become unfavourable, or a distortion of competition occurs.

The evaluation of the ACEA is that is contained serious weaknesses related to both ecological effectiveness and economic cost-efficiency. The ACEA was not able to effectively target the problem of "free riding" and its negative means on target achievement, further there was no explicitly means of distributing the burden between ACEA members. Moreover, the target of 140 g CO_2/km fell short of what was technically possible. Studies show that the target for 2008 lies in the range of the general downward trend in fuel consumption/km during the 1990s.

Success factors:

- Quantified objectives with clear time horizon
- Intermediate targets
- Public monitoring procedure
- Independent verification of industry data
- Facilitation of data comparison and evaluation
- External threat (EC would introduce legislation if ACEA does not comply with the agreement)
- Awareness rising
- Third party involvement
- Transparency and information – monitoring reports published on the Internet

Effective combination of characteristics

- Product versus process oriented

The focus of the Voluntary Agreement in this case differs between either a focus on the improvement of the production process by using renewables or more efficient pathways or final-product oriented results (and specific renewable content). In the second case, the companies participating under the VA

[705] Michaelis, P. & Zerle P. (2006). From ACEA's Voluntary Agreement to an Emission Trading Scheme for New Passenger Cars.
[706] Wuppertal. (2005). Review of Voluntary Approaches in the European Union – Feasibility Study on Demonstration of Voluntary Approaches for Industrial Environmental Management in China.

would be able to come up with different ways for increasing the renewable content of the product and hence would be given more flexibility.

The high integration of different processes within industry makes it difficult to make individual technology changes, and in most of the cases it requires a full production chain re-design. Alternatives may introduce important changes in the production chain, for which the entire process may need to be re-designed. However, the process re-design might differ from sector to sector and even from plant to plant. A product-oriented approach allows the sector the flexibility to implement whichever process changes will be most efficient and cost-effective. Thus, for the purpose of assessing this option under the RED II, a **product-oriented** (e.g. steel, cement) approach is suggested.

- Target-based versus implementation based

Voluntary Agreements can be either target-based (e.g. pollution abatement or use of renewables) or focus on implementation procedures that should lead to positive outcome achievement.

A product-oriented approach as suggested above would be best combined with a **target-type** of VA to avoid an overly prescriptive approach and maximise flexibility in achieving best results.

- Binding versus not binding

The legal form of a Voluntary Agreement has considerable implications on its outcome. An agreement can be considered binding, when it is enforceable though a court's decision and includes sanctions in case of non-compliance. It depends on the national legal system whether the government is allowed to sign a binding contract with industry. The issue of EU harmonisation between MSs systems needs also to be addressed.

Voluntary Agreements at the EU level are legally not binding, as the Commission does not have a formal right to sign agreements with industry. The case of the agreement with ACEA is not considered successful given that the commitments made by industry were far from ambitious and represented little more than business-as-usual. In contrast, VAs, at national level can become binding. Furthermore, members states are expected to have a better understanding of the national context and industry needs. Based on these considerations, an appropriate design of VAs under the RED could be **at member state level** and **binding** (when applicable).

- Individual versus collective liability

In case of collective liability, industry or an industry sector is collectively responsible and liable for the implementation of the agreement and any sanctions would also be faced collectively in case of failure. Free riding can be limited in case of an individual agreement as the performance of all participating companies is controlled but likely involves greater monitoring costs and higher administrative burden.

It is not possible to unequivocally estimate the trade-off between costs associated with free riding and those related to monitoring as these will depend on particular circumstances. However, given the scale required under the RED, a **collective liability** type of agreement would allow for simplicity and avoid important monitoring and administrative costs. Furthermore, under a collective liability agreement, individual companies within the sector(s) are expected to exercise "peer-pressure" and discourage free-riding, this could function as a peer-based monitoring mechanism.

- Open versus closed access to third parties

VAs do not traditionally involve third parties, as they are not part of the legislative process. However, community organisations or environmental groups play an increasing role in VAs. Access to third parties would add transparency to the process and could avoid monitoring costs and provide greater accountability, if these third parties are willing to engage in voluntary monitoring. Member states could be advised to introduce third parties in the agreements but **this measure could remain at member state discretion**.

Economic impacts

The option on Voluntary Agreements is expected to have the lowest direct cost for industry (together with option 2 on energy audits). In the case of Voluntary Agreements, past research shows that they are most cost efficient in the context of very large, shared uncertainty about (RE uptake) techniques (options), concentrated industrial sectors in which the heterogeneity in (RE uptake) activities and costs are low. Cost efficiency should consider how the potential cost of renewable, if not competitive compared to incumbent fossil fuels, can be passed to final consumers without jeopardising their competitive advantage. Companies should share the economic burden of RE uptake efforts. Studies show that cost minimisation is reached when the allocation results in the equalisation of private marginal uptake costs.[707] Usually, it is assumed that VAs have low transaction and administration costs. However, if too many actors take part in the negotiations (depending on the industry sectors involved, type of agreement, political experience of given Member State with this type of agreements, etc.), it may become difficult to reach an agreement. This results in transaction cost increase since it takes more time to collect all the relevant information and to agree on a common position. One way to bypass this issue is to address one or two very specific sectors, in order to foresee a kind of replication for the other ones. Monitoring can also turn out quite costly.[708] If the VAs is binding at a collective/sectoral level, there is high potential for “free riding” from individual companies. The “free riding” itself can be considered a cost, and additional costs for monitoring and preventing such “free riding” behaviour would need to be considered.

However the most important aspect to consider is whether such VA creates added value for the industry, as this would be demand-driven. Consumers will have to pull the demand for products coming from the industry with VA, assuming the communication is transparent and allows the consumers to distinguish from all “greenwashing” and miscommunication about greening businesses. Such VA has to demonstrate it can make the difference, otherwise it remains of limited use. This is partially address below under the social impacts.

Environmental impacts

The impact of Voluntary Agreements on environmental outcomes should be assessed by evaluating the supplementary effects on energy efficiency and CO_2 reductions compared to the business-as-usual case. A review of five different VAs found that in terms of improvements to material composition, and reduction in material flow, energy related VAs tend to play a minor role as a supporting factor but do

[708] Wuppertal. (2005). Review of Voluntary Approaches in the European Union – Feasibility Study on Demonstration of Voluntary Approaches for Industrial Environmental Management in China. Available at: https://www.econstor.eu/bitstream/10419/59258/1/516277715.pdf

not induce significant achievements on their own.[709] The same study also found that agreements tended to have little impact on investment criteria and planning in relation to energy-efficiency technologies. VAs rarely represent a decisive initial impulse to introduce energy-efficiency management practices, rather they provide an extra impetus to ongoing activities. With regards to speeding up diffusion of efficient technologies within sectors, past VAs utilised pre-existing institutional settings, communication channels, networks and personal relations.

Societal impacts

The evaluation of sectoral agreements in France, Germany and the Netherlands shows that one of the key benefit of these is the support for new forums for discussion within existing frameworks and enhanced intra-branch communication. At company level, VAs can have observable influence on awareness raising and increased motivation, especially for middle-level technical staff.[710]

In the case of VAs, a policy culture of mutual trust between government(s) and the private sector is imperative for the successful implementation. **Option 1** is expected to have a lower, direct impact on the final consumers than the options 3 to 5.

Option 1 would probably lead to a slight positive impact by increasing awareness on both consumer and producer sides, if the required measures are taken to avoid green washing. The balance should be found between the cost of the system (dealing with a certain level of complexity) and the impact it can have on the whole society.

Option 1 would create a limited number of jobs, to operate the agreement scheme (administration), to verify compliance (certifiers), to manage and communicate (industries concerned), to invest in new renewable assets (industries and energy partners).

Option 2 - Energy audits

Article 8 of the EED mandates energy audits for companies with more than 50 employees, or an annual turnover exceeding €50 million and annual balance sheet exceeding €43 million. The most efficient way to implement option 2 is to include a requirement to assesses the potential renewable energy use within the same process. This means the same stakeholders would be affected, minimising the administrative burden. For this assessment, the analysis focusses on impacts in the industrial sector.

Economic impacts

Energy audits have one direct economic impact (the cost of the audit) and a range of indirect economic impacts (which depends to the extent to which the recommendations of the audit stimulate investments in renewable use and generation and provision for system integration). The cost of energy audits should not be considered an administrative cost, given that the audit generates value in the form of an improved understanding of energy-using processes and opportunities for efficiency improvements. Usually, it can be assumed the audit(s) will be paid back with the first measures taken by the industry. Because it is more and more the case (within the ETS sectors) that carbon footprint increases, rather than reduces, the next iteration of energy audits would be more focus- and target-specific. The

[709] Krarup, S. Ramesohl, S. (2002). Voluntary agreements on energy efficiency in industry – not a golden key, but another contribution to improve climate policy mixes. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0959652601000324
[710] Ibid.

amendment of the EED should ensure that the next audit rounds are more attentive to integrating renewables, even when this means including less competitive solutions (e.g. payback higher than 5 years). Some MSs are also partly subsidising these audits, which reduces the upfront cost for the industry.

Costs

The cost of an audit is highly variable depending on the sector, the size of the facility, the qualifications of the energy auditor and/or auditing firm, the type of audit, the accuracy and completeness of information provided by the client, the level of competitiveness in the auditor market and the detail provided by the expert. Certain sectors (such as the food and drink industry) are highly price-sensitive and this may influence the price of energy auditing services provided, depending on the level of detail and the precision they require. Other sectors (such as the chemical industry) are more concerned about quality and process safety, and therefore may value a more comprehensive (i.e. more detailed and hence more expensive) set of energy audit services. Across Member States, other aspects – e.g. tax laws, general cost of living, energy costs, reporting requirements, auditor qualifications, etc. will also vary and affect the price that audited organisations pay.[711] Table 0-3 shows cost ranges in different Member States, with more details available in Annex I.

Table 0-3 Energy audit cost for the manufacturing sector[712]

Occupied area[713]	Cost range €
<2,500 m2	8,000 – 10,000
2,500 – 40,000 m2	10,000 – 27,000
>40,000 m2	23,000 – 32,000
By energy intensity	**Cost range €**
Belgium <1PJ	7,500 – 30,000
Belgium >1PJ	30,000 – 100,000
Czech Republic	5,550 – 6,660
Poland	5,000
Romania	15,000
Spain	18,000
Sweden	8,000

As indicated by the ranges in Table 0-3, costs are relatively small compared to the size of the companies (minimum requirement is an annual turnover exceeding €50 million and annual balance sheet exceeding €43 million). Adding a requirement to assess the opportunity to use renewable fuels and/or to invest in own generation (as well as other measures such as demand-response, fuel switching, and process innovation) could increase the costs of existing audits, as these would require different competences, but the cost increase will be limited.

[711] European Commission (2016) A Study on Energy Efficiency in Enterprises: Energy Audits and Energy Management Systems – Library of typical energy audit recommendations, costs and savings. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/EED-Art8-Implementation-Study_Task12_Report_FINAL-approved.pdf
[712] Own elaboration based on: European Commission (2016) A Study on Energy Efficiency in Enterprises: Energy Audits and Energy Management Systems – Library of typical energy audit recommendations, costs and savings
[713] Ranges for Germany, France, Italy, Denmark, Romania, Sweden,

Including these steps as part of auditing methodology will require auditors and authorities offering audit support to invest in upskilling their staff. Training will be required along the whole chain covering all technologies, also potentially involving the manufacturer of specific equipment (e.g. solar heater to provide process heat at low temperature, backed up with a heat pump).

Macroeconomic impacts and investments

Mandating energy audits is expected to stimulate investments in renewable energy use and generation, as well as other measures such as demand-response, fuel switching, and process innovation. Given the advisory nature of the audit's recommendations, whether the suggested investments will be taken up by audited companies depends on a number of factors, such as availability of finance, market perspectives and whether green credentials are valued in that particular sector.

An analysis produced by the European Investment Bank[714] concludes that energy efficiency audits are a useful tool in overcoming the information barriers and facilitating investments in energy-efficiency measures. Energy audits play a crucial role in the decision of firms to proceed with energy efficiency improvements, with the odds of a company investing in energy-efficiency measures 1.5 times greater for firms with an energy audit than those without one. However, the review also found that information produced by the audit was less useful when looking at production processes, such as replacement of machinery and equipment. This is explained by companies' reluctance to disrupt their production process by changing their machinery and equipment, but also by the high investment costs necessary to implement the recommendations. Therefore, auditors should also be able to provide advice on planning the interventions. In energy-intensive industry, where energy represents a substantial share of production costs, management has already an interest to invest in energy efficiency, but this is balanced by expectations concerning the future cost of energy. It is necessary to consider that the results of the EIB analysis focussed on efficiency, while Option 2 extends the analysis to other measures that may be more attractive for industrial players, such as demand response and process innovation.

Depending on the level competitiveness of the propose renewable options, audits may have a variable positive effects on investments in RES and other measures. Some renewables would be self-supporting and already competitive, therefore audits would play a role of sensitisation and lead to a positive impact (e.g. solar heat for low temperature process may already be competitive, but is probably not well known by industries). Of course, the majority of renewable options still remain uncompetitive and would therefore lead to a limited positive impacts, unless other instruments are promoting the required investments. Therefore, audits may also play an important role in supporting the uptake of other policies and schemes currently incentivising renewables. For example, large energy users such as many industrial consumers are currently exposed to higher energy (particularly electricity) costs because many Member States recoup the cost of subsidies to renewables via their bills. The audit process will support businesses in investigating the overall economic case of investing in renewables, including expectations of further increases to energy prices driven by new policies.

[714] Kalantzis F. & Revoltella, D. for the European Investment Bank. (2019). How energy audits promote SME's energy efficiency investment. Available at:
https://www.eib.org/attachments/efs/economics_working_paper_2019_02_en.pdf

Given the overlap with the measure with the ETS, an increase in the uptake of renewables in industry may also reduce the costs associated with the purchase of carbon permits. Indirectly, this would depress the carbon price.

Administrative costs

There would also be one-time costs of updating auditing methodologies, guidelines and reporting procedures, and operating costs to run the appropriate training on a regular basis, also considering the rapid evolution of technology developments. If the audit process for RES and system integration is included as part of the audit process for energy efficiency, ongoing administrative costs could be limited.

Environmental impacts

The environmental impacts of energy audits depend on the uptake of investments recommended during the audits. The main environmental impact will be the reduction in GHG emissions associated with energy use in industry, but other industrial emissions will be reduced as well when switching fuels, in particular when switching to electricity.

On the other hand, conversion to biomass furnaces in some industrial processes or for CHP may increase emissions of particulate matter, nitrogen oxides, sulphur dioxide, and other hazardous air pollutants. Furthermore, it is important to highlight that bioenergy is not an emission-free source of energy as certain emissions associated with cultivation cannot be avoided. Annex V and VI of REDII provides information on calculating the GHG emissions associated with bioenergy and biofuels.

Social impacts

The direct impacts of option 2 on jobs will be slightly positive, as it is expected that the same auditors currently conducting energy efficiency audits will be able to incorporate the new audit elements in their processes, while also needing additional expertise. The number of audited organisations is expected to increase a little bit to tackle these new areas (if the same criteria for the EED are applied), and the increase in workload due to the additional assessment may create additional jobs.

More significant job creating may happen as a consequence of businesses implementing the actions recommended during the audit process. However, as for environmental and economic impacts, these are highly uncertain.

Option 3 - Eco-labels

Trends and role of green labels

Energy labels for consumer information are now a well-established and understood instrument. They are shown to have a positive effect, albeit limited, and their effectiveness increases with time, as they become more established and known by the general public.

A recent research by the ITC[715] found that sustainable product sourcing has become a top priority for retailers in key European Union markets[716]. Retailers report an increase in sale of sustainable products and expect this trend to continue. Nearly all retailers have created strategies that include provisions to increase the proportion of their sourcing that benefits the environment and the people along their supply chains. Sixty per cent of retailers use their own-label products to meet their sustainability commitments, while others rely on other known labels such as “organic”. However, the commitment to renewable is found only concerning the retailer’s own energy use, rather than energy used as part of production. Some past and current initiatives have focussed on the use of renewables content during operation and production processes (see list in 0); often, these are built on more robust methodologies and provide more credible claims compared to claims made on the basis of own methodologies by the product manufacturer or retailer.

In fact, a lot less has been achieved concerning the production process and products targeted at business customers, either in their final form or as a production input. Companies in some of the most polluting industrial sectors (steel[717], cement) are actively considering options to reduce GHGs emissions by switching to hydrogen or other renewables in their production processes. However, generally each company uses its own method to evaluate the environmental performance of its products.

The problem of the proliferation of inconsistent methods and initiatives used to communicate information about environmental performance of products (goods and services) is recognised by the EU. Currently, two parallel initiatives (ENV and JUST) are attempting to tackle this problem; the former focusses on methodologies and presentation of environmental performance claims, the later aims to help consumers to play an active role in the green transition by giving them useful information and protection from certain misleading commercial practices. The ENV initiative would make it mandatory for companies to undertake an environmental life-cycle assessment in accordance with the Environmental Footprint methods to support any environmental claim which is not yet regulated at EU level and can be substantiated via these methods. The ENV initiative will cover claims both in a B2C and B2B context, both related to products (goods and services) and organisations.

It is possible to envisage that Option 3 would be implemented together with and broadly relying on these ongoing initiatives, so that calculation and audit requirements are consistent and not confusing.

Within the remit of RED II, it would be necessary to devise a methodology that specifies how the renewable energy performance of a particular product or services should be calculated, and this may vary according to whether the calculation is voluntary or mandatory. In the case of mandatory labelling (sub-option b), the methodology will have to be more carefully specified, to avoid the risk of imposing disproportionate requirements on some industries.

While a positive effect of Eco labels is likely, it is extremely difficult to estimate the change they will drive (in terms of shifting production processes and incentivising additional uptake of renewables) in

[715] International Trade Centre. (2019). The European Union Market for Sustainable Products. The retail perspective on sourcing policies and consumer demand. ITC, Geneva. Available at: https://www.intracen.org/uploadedFiles/intracenorg/Content/Publications/EU%20Market%20for%20Sustainable%20Products_Report_final_low_res.pdf
[716] The study covered France, Germany, Italy, the Netherlands and Spain.
[717] Financial Times. (2021). ‘Green steel’: the race to clean up one of the world’s dirtiest industries. Available at: https://www.ft.com/content/46d4727c-761d-43ee-8084-ee46edba491a

isolation. Similar to energy audits, it is reasonable to expect that the effectiveness of this option will depend to a large extent on the availability of complementary policies and programmes (market-based instruments, regulation, mandatory targets, sensitisation campaigns) with similar objectives.

Economic impacts

Similar to Energy Audits, ecolabels have variable direct costs, which are relatively limited, but potentially high economic benefits if these are able to shift consumers/buyer choices towards products with better renewable credentials.

The costs of ecolabelling vary according to a number of factors, often contain flexible and usually volume-dependent elements, and can be broken down into different categories:

- Application fee: usually a one-time, fixed, non-refundable fee;
- Licence fee: usually an annual fee, fixed/dependent on the annual sales volume;
- Certification fee: annual/biennial/5-yearly, depending on the certification validity period;
- Auditing costs: mainly variable costs, charged by the auditing organisation in addition to the other certification costs;
- Additionality funds contribution.

Additional costs may be incurred to gather the necessary information, but these will vary with the organisation and the complexity of the production process and the size of the producer. The cost of applying particular labelling methodologies may also be high due to their complexity, such as is the case for life-cycle assessments in accordance with the Environmental Footprint methods.[718] Annex III provides an overview of the different certification cost elements for select green energy labels. Annex II provides normalisation rules for accounting for electricity generated from hydropower and wind power.

Arriving at robust estimates of the costs and benefits of ecolabels is complex and dependent on the elements listed above. However, several insights are available via extensive research published on the subject, presented below.

The success of an eco-label (**option 3**) relies on consumer awareness and willingness to pay a premium for products produced with a higher renewable energy share. Consumers can contribute to the energy transition by choosing green energy contracts. Although, demand for such energy contracts is rising, it is (still) too low to match the supply of available renewable energy. Results from a recent survey show that labels have limited impact on consumer awareness and that “raising consumer awareness requires other actions than simply labelling the energy. The survey suggests that a full disclosure system is a better way to improve consumer awareness.”[719]

[718] The following 16 impact categories are covered: climate change, (stratospheric) ozone depletion, human toxicity - cancer effects, human toxicity - non-cancer effects, particulate matter, ionizing radiation, (ground-level) photochemical ozone formation, acidification, eutrophication - terrestrial, eutrophication - freshwater, eutrophication - marine, ecotoxicity - freshwater, land use, resource depletion - water, resource depletion - minerals and metals, and resource depletion - fossil energy.
[719] Trinomics et al. (2020). Technical assistance for assessing options to establish an EU-wide green label with a view to promote the use of renewable energy coming from new installations

A study on the economic impact of eco-labels concludes that because of their lack of recognition by consumers with limited recall, eco-labels do not provide perfect information and environmental characteristics are not fully internalized. Eco-labels are most effective when combined with other instruments such as taxes on non-green products or subsidies on green products.[720] From a welfare perspective, the combination of eco-labels and other instruments is socially optimal. Indeed, researchers argued that eco-labels alone are insufficient.[721]

Research also shows that when up-front fees are sufficiently low, labelling increases both firm-level profits and social welfare.[722] Another, relevant study on the subject finds that: a) more rigorous environmental standards represented by labels do not necessarily translate into higher selling prices; b) higher prices commanded by label products do not guarantee higher-profits for the firm through eco-labelling; c) auditing fees paid per product unit is the primary de-facto barrier to business getting involved in eco-labelling and; d) customers' willingness to pay price premiums for labelled products is not a sufficient condition to generate a market premium.[723] Auditing fees and in-house administration costs are generally identified as one of the main barriers to a wider uptake of ecolabels[724], which suggests option 3 may consider whether other provisions already included or considered for RED II may lessen this burden. For example, it may be possible to link labelling with mandatory audit requirements (option 2), although the different foci of the two may pose practical challenges (audit focuses on facilities and production processes at organisational level, while labelling is more appropriate at product or service level).

Impact on international trade

Another important aspect regarding ecolabels is their potential impact on international trade. According to information of the World Trade Organization (WTO), members generally agree that "*labelling schemes can be economically efficient and useful for informing consumers, and tend to restrict trade less than other methods. This is the case if the schemes are voluntary, allow all sides to participate in their design, based on the market, and transparent*."[725] An important issue highlighted by the WTO, is the use of criteria linked to processes and production methods (PPMs). There is a disagreement among WTO members on whether "unincorporated PPMs", which refer to process and production methods which leave no trace in the final product (e.g. products produced using renewable versus fossil-based energy), are consistent with WTO agreements.[726] Option 3 would therefore have to consider these limitations when setting the methodology and requirements of a labelling scheme, in particular concerning sub-option b (mandatory scheme).

Administrative cost

In general, the costs associated with labelling fall entirely within the category of administrative cost. This is because they do not provide any additional value to the company, but they are entirely

[720] Yokessam M. & Marette, S. (2019). A review of Eco-labels and their Economic Impact
[721] Horne, R. E. (2009). Limits to labels: The role of eco-labels in the assessment of product sustainability and routes to sustainable consumption. International Journal of Consumer Studies, 33(2), 175–182
[722] Crespi, J.M. & Marette,S. (2001). How should food safety certification be financed Am. J.Agric.Econ.83,852–861.
[723] Yenipazarli, A. (2015). The economics of eco-labeling: standards, costs and prices
[724] Seebach, Dominik; Stojanovic, Teodora; Wingenbach, Marion (Öko-Institut e.V.); Altmann, Matthias, Schmidt, Patrick; Gleiter, Tabea (LBST). Mapping of existing green labels - Task 1 report for the project "Technical assistance for assessing options to establish an EU-wide green label with a view to promote the use of renewable energy coming from new installations" under framework contract MOVE/ENER/SRD/498-2016 Lot 3; Freiburg, Munich
[725] WTO. (2021). Environment: Issues – Labelling. Available at: https://www.wto.org/english/tratop_e/envir_e/labelling_e.htm
[726] Ibid.

dependent on how the obligations are associated with the labelling process. This is different from option 2 (auditing) where the audits would provide the audited subject with new and valuable information. When the scope of the labelling is limited to a few highly energy-intensive industries with a relatively low variety of product types but large throughput volumes (e.g. iron & steel, aluminium, cement) the expected costs associated with the analyses needed to underpin the information required in the label are expected to remain relatively low.

Environmental impacts

Literature is generally cautiously positive on the environmental impacts of labelling schemes. While it is reasonable to expect a shift to greener production, quantifying the size of this shift is not possible. For example, "*There can be little doubt that some ecolabelling has a positive influence on the environmental impact of production and consumption. Nevertheless, there is no consistent and definitive body of independent evidence to support this claim. Virtually no data is available that could be used to quantify the degree of influence that these programmes have and the reasons*."[727] Another study, evaluating the technical assistance for assessing options to establish an EU-wide green label with a view to promote the use of renewable energy coming from new installations, concludes that "*energy labels have an impact on the promotion of specific energy sources through their eligibility criteria and specific premiums per energy source, though this is limited due to the small market share of labels. There is no information on the share of different RES sources for the different labels*."[728]

As it is the case for economic impacts, environmental benefits of an ecolabel that focusses on renewable generation would probably be limited in size and dependent on the availability of complementary policies that drive renewable generation. If the methodology used to evaluate the product or service relies on simplified assumptions and methods (for example, renewable content depending on the amount of GO or certificates surrendered) it is unlikely that ecolabelling will drive any material amount of additional capacity or generation (for example, due to the overabundance of GOs). A more robust methodology, such as environmental life-cycle assessment in accordance with the Environmental Footprint methods[729] would ensure an actual reduction of GHG emissions compared to a scenario with no labels, but implementation costs would increase and products/services able to be captured will be fewer.

Societal impacts

Globally, only option 3 (eco-label) would have a positive impact on consumers' behaviours leading to possibly more responsible consumption and use of products, if the eco-label is accompanied by awareness raising, to increase consumers' interest.

Option 3 would create a slightly higher number of jobs than option 1 and 2. These would be required to operate the eco-label scheme (administration), to verify compliance (auditors and certifiers), to

[727] United Nations Environment Program - The Trade and Environmental Effects of Ecolabels: Assessment and Response

[728] Trinomics et al. (2020). Technical assistance for assessing options to establish an EU-wide green label with a view to promote the use of renewable energy coming from new installations

[729] The following 16 impact categories are covered: climate change, (stratospheric) ozone depletion, human toxicity – cancer effects, human toxicity – non-cancer effects, particulate matter, ionizing radiation, (ground-level) photochemical ozone formation, acidification, eutrophication – terrestrial, eutrophication – freshwater, eutrophication – marine, ecotoxicity – freshwater, land use, resource depletion – water, resource depletion – minerals and metals, and resource depletion - fossil energy.

manage and communicate (industries concerned), and to communicate in the distribution chain (commerce).

As in the case of auditing, the higher potential for job creation is associated with the additional jobs that may be created if companies decide to invest in new renewable assets with the aim to improve their rating provided by the label.

Since EU-based industries have a relatively high environmental performance compared to their international competitors, they might benefit most from labelling the renewable energy use in industrial processes, thereby specifically increasing the demand for products from European installations. When this effect is large enough it might result in increased production levels and, as a consequence, also increased employment in EU industry at least on the short-term.

Option 4B – Mandatory renewable target

Variant: Targets for renewables uptake in heating across all industries

Given the large variety of industrial sectors and associated production processes the specific industrial needs vary and conditions vary significantly, nonetheless the following three factors are key across industrial sectors:

- **Temperature:** temperature needs can vary significantly from around 200 to almost 2000 C, nonetheless the majority of industrial processed depend on the application of high-grade heat to feedstock.
- **Flux:** industrial head demand requires a high and usually continues heat flux into the system.
- **Reliability:** many industrial facilities operate at high capacity factors, often of between 60 to 95%. Thus, heat supply must be dispatchable and available during daily, seasonal and yearly time-periods.[730]

The above requirements limit the options available for heat decarbonisation in industry given that low-heat technologies (e.g. heat pumps) or intermittent ones (e.g. using variable renewable power directly for heating) are often not appropriate for industrial settings. There are no “one-fits-all” solutions for heat decarbonisation in industry, however a few options based on direct or indirect renewable energy should be considered:

- **Hydrogen** (green – produced from renewable electricity) **combustion;**
- **Biomass and biofuel combustion;**
- **Electrical** (produced from renewables) **heating** – including direct and indirect approaches based in resistive heating, induction heating and dielectric (microwaves) heating;
- **Concentrated solar power.**

The scope of renewable energy sources to be included in the target should consider direct and indirect use of RES based on the four technology areas listed above. In addition low-carbon/none-carbon options available include carbon capture and storage (CCS) (option 5) and conventional and advanced nuclear heat (out of the scope of this analysis). It is also important to consider the temperature ranges provided by each one of these technologies. For example, only biomass (biodiesel) and hydrogen can achieve temperatures of above 2000 Celsius required for the cement industry (indirect process). The maximum

[730] Innovation for Cool Earth Forum. (2019). ICEF Industrial Decarbonization Roadmap. Available at: https://www.icef-forum.org/pdf/2019/roadmap/ICEF_Roadmap_201912.pdf

temperature achieved by resistive electricity is 1800 Celsius. Advance nuclear technologies can reach up to 850 Celsius and non-advanced 300 Celsius. The steel-making, cement and glass industries require temperature process of 1000 degrees Celsius. [731]

Although the above listed options have important drawbacks and associated costs (see analysis below), they are nonetheless implementable in a large variety of sectors. For example, an analysis by McKinsey and Co. estimates that about half of the fuel used by industrial companies for energy could be replaced by electricity using technologies already available, this is illustrated in the figure below.

Figure 0-9 Technology status based on temperature needs of different industrial processes[732]

	Share of total estimated fuel consumption for energy (2017)	Examples of processes	Technology status
Other (potential not assessed)	19%	NA	NA
Very-high-temperature heat (>1000 Celsius)	32%	Melting in glass furnace, reheating of slab in hot strip mill, and calcination of limestone for cement production	Research or pilot phase
High-temperature heat (400 – 1000 Celsius)	16%	Steam reforming and cracking in the petrochemical industry	Available today
Medium-temperature heat (100- 400 Celsius)	18%	Drying, evaporation, distillation, and activation	Available today
Low-temperature heat (</ 100 Celsius)	15%	Washing, rinsing, and food preparation	Available today

To incentivise the very slow uptake of renewable heating technologies in the sector, setting a minimum requirement for RES supply should be considered. The targets could initially be set to low in order to account for concerns related to industrial competitiveness. Nonetheless, the benefit of setting minimum requirements would force industries to start thinking and implementing the solutions required for decarbonising their industrial processes. The targets could be increased gradually over time.

Economic impact

A requirement for a minimum uptake of renewable heating for industries will have an economic impact on the majority of them. The extent of the economic impact will differ for the individual companies based on the extent of modifications they would be required to undertake to meet the target requirements. Based on the key options available for decarbonising heat in industry some general cost estimates can be presented. Production of green hydrogen using purely renewable sources is 3 to 10 times more expensive compared with the standard mode of production via steam methane reforming (SMR). Figure 0-10 shows the levelized costs of hydrogen (LCOH)[733] and costs of heat from hydrogen combustion based on different approaches to producing hydrogen.

[731] Innovation for Cool Earth Forum. (2019). ICEF Industrial Decarbonization Roadmap. Available at: https://www.icef-forum.org/pdf/2019/roadmap/ICEF_Roadmap_201912.pdf
[732] McKinsey and Co. (2020). Plugging in: What electrification can do for industry. Available at: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/plugging-in-what-electrification-can-do-for-industry
[733] "Levelized cost of hydrogen" (LCOH). LCOH estimates the unit cost of producing hydrogen over its economic lifetime, including capital costs, operating and maintenance costs, and capacity factors, as well as calculating different costs as a function of gas costs, power costs, conversion methodology and degrees of decarbonization.

Figure 0-10 Estimated costs for hydrogen production (normalized to natural gas)[734]

Natural Gas Reformation*	Capture Rate	LCHO	Cost of Heat (LHV)
Steam-methane reforming (SMR) without CCS	0%	1.05-1.5/kg	$8.78-12.51/GJ
SMR with CCS	53%	1.32-1.77/kg	$11.02-14.75/GJ
	64%	1.46-1.91/kg	$12.19-15.91/GJ
	89%	1.71-2.15/kg	$14.22-17.92/GJ
Electrolysis of Water#	**Cost of Power**	**LCOH**	**Cost of heat (LHV)**
US avg, grid + PEM (90% capacity factor)	60-90/MWh	4.50 – 6.04/kg	$37.52-50.34/GJ
Solar PEV (20% capacity factor)	36-46/MWh	7.1-8.3/kg	$59.2-69.2/GJ
Wind unsubsidized (35% capacity factor)	29-56/MWh	6.02-7.25/kg	$50.17-60.46/GJ
Hydropower unsubsidized (40% capacity factor)	30-60/MWh	4.80-6.34/kg	$40.01-52.83/GJ

*All natural gas capture cases assume 90% capacity factor 3.5/million BTU and 20/ton for CO2 compression, transportation and storage.

#All electrolysis cases assume 1,000,000/ MW electrolyzer cost.

The production cost for solid biomass has are in the range of 11-50 $/GJ using current technologies, which is at least four times as expensive as coal and twice as expensive as natural gas.[735]

Variant: Targets for specific industries

Target for the cement industry

The current available renewable or low-carbon solutions for the cement industry include:

- **Biomass;**
- **Electrification of heat;**
- **Use of hydrogen for heat;**
- Carbon capture and storage/utilisation (CCUS);
- The use of low-carbon cement processes.

Critically, with the exception of CCUS (analysed under **option 5**), all other solutions are focused on the decarbonisation of fuels to heat cement kilns, which are responsible for about 35% of the clinker's carbon footprint, are not able to address the remaining 65% of process emissions. Based on the above-listed options, the use of biomass constitutes a direct use of renewable energy and the electrification of heat and use of green hydrogen for heat constitute an indirect use of renewable energy. Thus, renewable energy targets would encourage the uptake of biomass and/or electrification/hydrogen use for heat.

Target for the steel industry

Decarbonization strategies for the steel industry include:

- Carbon capture and storage/utilization (CCUS);
- Smelting reduction using one production unit, and thus concentrating CO_2 emissions;

[734] Own elaboration based on McKinsey and Company Plugging in: What electrification can do for industry. Available at: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/plugging-in-what-electrification-can-do-for-industry
[735] Innovation for Cool Earth Forum. (2019). ICEF Industrial Decarbonization Roadmap. Available at: https://www.icef-forum.org/pdf/2019/roadmap/ICEF_Roadmap_201912.pdf

- Using electric arc furnaces can reduce CO_2 emissions to zero if **renewable electricity** is used, but the increased use of electric arc furnaces requires a sufficient level of scrap availability;
- Replacing coke by charcoal, provided **biomass** availability;
- Use of **hydrogen** for direct reduction of iron ore, where natural gas is often used as reducing agent.

The figure below provides a summary of these options, as well as examples and a summary of the current outlook. As in the case of cement, renewable integration options include the direct renewable uptake through biomass and/or indirect renewables uptake through electrification/the use of green hydrogen. Unlike in the case of cement, green hydrogen can be used in the process production itself, thus addressing more than the heat requirements of the process. Green hydrogen in steel can be used in two ways:

- As an alternative injection material to the pulverized coal injection. This use of hydrogen can reduce carbon emissions by 20 % but it does not address the need for coking coal and thus it is not a carbon-neutral production method.
- Alternatively, H_2 can be used as a reductant to produce direct reduced iron (DRI) that can be further process using the electric arc furnace. When this method is done using green hydrogen and renewable electricity the production is nearly carbon-neutral.[736] It should be noted however, that this production route depends on a different production process than the conventional BF-BOF process. Only plants that already produce steel with a gas-based DRI products can switch to hydrogen relatively easily without the need for very far-reaching changes to the production process itself.

Figure 0-11 Overview of strategies for low-carbon steel production[737]

	CO_2 reduction			**Full decarbonisation possible**		
	Blast furnace efficiency	**Biomass reductants**	**CCU**	**Electric arc furnace**	**DRI plus EAF using natural gas**	**DRI plus EAF using H_2**
Strategy	Make efficiency improvement to optimize BF/BOF operations	Use biomass as an alternative reductant or fuel	Capture emissions from fossil fuels and create new products	Maximize secondary flows and recycling by melting more scrap in EAF	Increase usage of DRI in the EAF	Replace fossil fuels in DRI process with renewable energy or H2
Examples	Optimized BOF inputs (DRI, scrap) increased fuel injection in BF (e.g. hydrogen, PCI)	Tecnored process	Bioethanol production from CO_2 emissions	EAF - usage to melt scrap	Current DRI plus EAF plants using natural gas	MIDREX DRI process running on H2 HYL DRI process running on H2
Current outlook	Technology readily available at competitive cost	Process possible in South America and Russia due to biomass availability	Not available on an industrial scale	Technology readily available at competitive cost	Technology readily available	Technology available at high cost

[736] McKinsey & Company. (2020). Decarbonization challenge for steel – Hydrogen as a solution in Europe. Available at: https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel
[737] Ibid.

Economic impacts

The option on mandatory renewable targets is expected to result in higher direct costs for the industries affected. Key economic barriers for implementation of new processes based on renewable energy for both the steel and the cement industries are:

- Both industries operate with very low profit margins in very competitive markets. Companies cannot generally pass on costs without losing market share.
- Steel and cement have also traditionally been operated as relatively undistinguished commodities (but niche markets are emerging).
- Capital costs are very focussed and upfront, resulting in increased investment risk and conservatism. For these kinds of investments to be made there must be a very robust long-term business case.[738]

In a world without an effective international carbon pricing mechanism, ambitious industrial decarbonisation targets need to go hand in hand with financial support mechanisms (and additional trade considerations including carbon border adjustment mechanism) in order to protect the domestic industry and prevent carbon leakage. In this context, it would be good to expand the policy toolbox for providing financial incentives to industry in the form of tax benefits or direct subsidies to promote a shift to renewable energies, while safeguarding against excessive state aid hurting the EU internal market. Furthermore, an analysis of renewable targets for energy should consider the possible impacts of industry relocation to MS with cheaper/more abundant renewable energy. This impact is expected to be limited given the already multi-national/global character of many of the EII companies and the fact that other characteristics are expected to play a bigger factor (labour costs, existing infrastructure including the presence of existing facilities). Concerns about resource availability in a given country, can further be addressed through cross-border virtual Power Purchasing Agreements (PPAs), the case study below provides a good example of this. Although heat is a more localised commodity, a forthcoming roadmap on decarbonisation of the H&C sector in the EU27[739], suggests that member states may take different approaches to decarbonise their heat supply and demand but this should be possible at a reasonable cost for all countries.

[738] OECD, Financing Climate Futures. (2019). Low and zero emissions in the steel and cement industries: Barriers, technologies and policies. Available at: https://www.oecd.org/greengrowth/GGSD2019_IssuePaper_CementSteel.pdf
[739] Forthcoming: Trinomics. (2021). Policy Support for Heating and Cooling Decarbonisation – Roadmap

Textbox 0-4 Use of virtual cross-border PPAs to decarbonise chemical company Novartis[740]

Structure: Virtual cross-border PPA

Generation market: Spain

Offtake markets: Austria, Germany, Spain, France, UK, Italy, Sweden, Romania, Poland, Czechia, Ireland

Power Producer: Enel Green Power

Capacity: 78.5 MW via wind power

Tenor: 10 years

In November 2020 Novartis, the global pharmaceutical company, announce a set of virtual cross-border PPAs accounting for 275 MW of renewable electricity. This move was part of the company's global efforts to become carbon neutral in its operation by 2025. One of the virtual cross-border PPAs was set up between Novartis and Enel Green Power and support from Schneider Electric. The PPA is for 78.5 MW of electricity delivered from the Tico wind farm in Spain. The 10-year contract will result in guarantees of origin (GOs) for Novartis that can be applied on a pan-European basis. A key consideration to opt-in for a PPA structure was the company's need for a 'fluid European footprint' given the numerous locations where it operates. This mode allows for both aggregation of demand from multiple counties and flexibility in the case of changes to the size or location of facilities. By choosing to produce electricity from the Spanish wind project, Novartis can leverage one of the largest onshore wind load factors in Europe and thus obtain lower levelized costs and more cost-effective renewable electricity production.

It is likely that option 4 would have a more significant economic impact compared to the previous options (1 to 3), by imposing to the industry the use of renewable energies which are less competitive than their fossil-based counterparts. It should also be recalled that the decarbonisation efforts of heavy industries already drive the deployment of renewable where their carbon abatement is cost effective. Setting a target could also be used as a kind of awareness signal. Therefore, a mitigation variant could be to set a low threshold, just to oblige all industries to start thinking about renewable options, and possibly explore further and invest in own production assets.

Economic impact of renewable targets in the cement sector

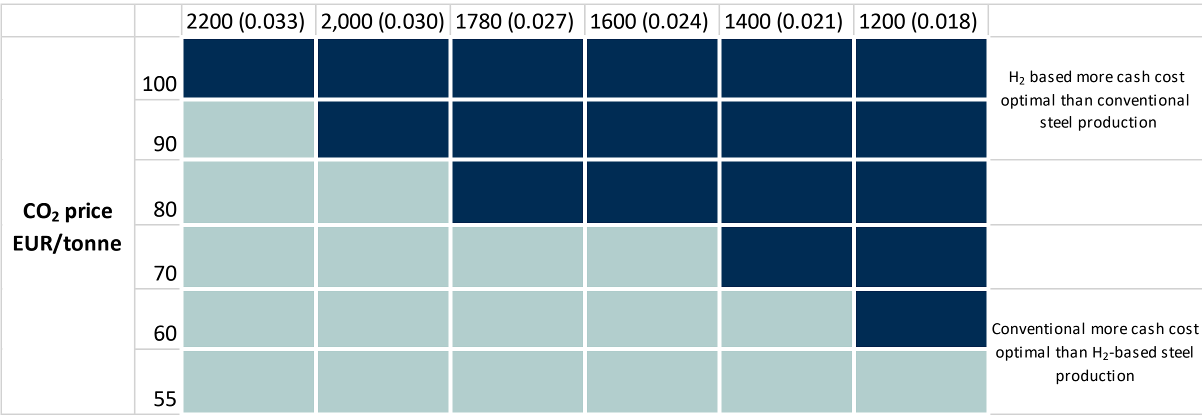
The abatement costs for different decarbonisation options in the cement industry differ per technology. A negative abatement cost, as in the case of clinker substitution options (slag, fly ash, pozzolan and others) indicates benefits to the producer rather than a reduction in cost. [741] Given that the abatement costs for most of these solutions are above the current CO_2 prices (currently below 40 EUR/ton), the industry has little economic incentive to decarbonise. Nonetheless, pressure from the public and financial investors to abate quickly is mounting to invest in abatement technologies. For example, in early 2020, Redburn, an equity research house, downgraded the rating of HeidelbergCement and LafargeHolcim, two major European cement producers, based on "the seismic level of extra pricing that the industry is going to have to unlock over time to make returns".[742]

[740] WBCSD. (2020). Cross-border renewable PPAs in Europe: An overview for corporate buyers. Available at: https://www.wbcsd.org/Programs/Climate-and-Energy/Energy/REscale/Resources/Cross-border-renewable-PPAs-in-Europe-An-overview-for-corporate-buyers
[741] McKinsey & Company. (2020). Laying the foundation for zero-carbon cement. Available at: https://www.mckinsey.com/industries/chemicals/our-insights/laying-the-foundation-for-zero-carbon-cement
[742] Financial Times. (2020). Decarbonisation to drive 'dramatic' rise in cement prices, says Redburn. Available at: https://www.ft.com/content/04314b8e-412d-11ea-a047-eae9bd51ceba

Economic impact of renewable targets in the steel sector In the case of the steel sector all the options for decarbonising steel, except for recycling, are associated with at least 30% cost increases. However, these numbers are only applicable to bulk steel costs; metal parts will be perhaps 10 % more costly, and it will only add $300-400 to a car.[743]

Given that in the case of steel (more so than in the cement case) green hydrogen combined with renewable electricity represents a promising option for decarbonised steel production, the cost of hydrogen (and green electricity more generally) represents an important economic factor. Figure 0-12 below shows an analysis of the prices of carbon and hydrogen needed for hydrogen-based steelmaking to become competitive. Analysis by McKinsey & Co. finds that at an expected CO_2 price of ~ 55 EUR/ton and a hydrogen price of 1.78 EUR/ton (implied electricity price of 0.027 EUR/kwh) in 2030 would not be sufficient to make the hydrogen-base steelmaking cost competitive. However, any increased in CO_2 price or decrease in H_2 price above/below this threshold would give the green steelmaking process a cash cost advantage.[744] Thus, the results suggest that without further incentives, the pure hydrogen-based steel production is expected to be cash cost competitive between 2030 and 2040 in Europe. It is necessary to highlight that the above analysis excludes capex implications (depreciation) given that conventional steel production assets are already largely written off.[745]

Figure 0-12 Cost competitiveness of hydrogen based steel production in comparison to conventional production based on price of CO_2 and H_2[746]



Dark blue: cash cost conventional >/ cash cost H2-based

Light green: cash cost conventional </ cash cost H2-based

Environmental impacts

Iron & steel represents around 6-8% and cement & concrete about 6% of global energy system combustion and industrial process CO_2 emissions.[747] Thus, decarbonising them is imperative for ensuring carbon-neutrality by 2050. The emission-savings are the primary climate benefit of decarbonising these industries.

[743] OECD, Financing Climate Futures. (2019). Low and zero emissions in the steel and cement industries - Barriers, technologies and policies.
[744] This analysis does not take into consideration any further policy based-incentives.
[745] McKinsey & Company. (2020). Decarbonization challenge for steel – Hydrogen as a solution in Europe
[746] Own elaboration based on: McKinsey & Company. (2020). Decarbonization challenge for steel – Hydrogen as a solution in Europe
[747] International Energy Agency. (2018). World Energy Balances Database.

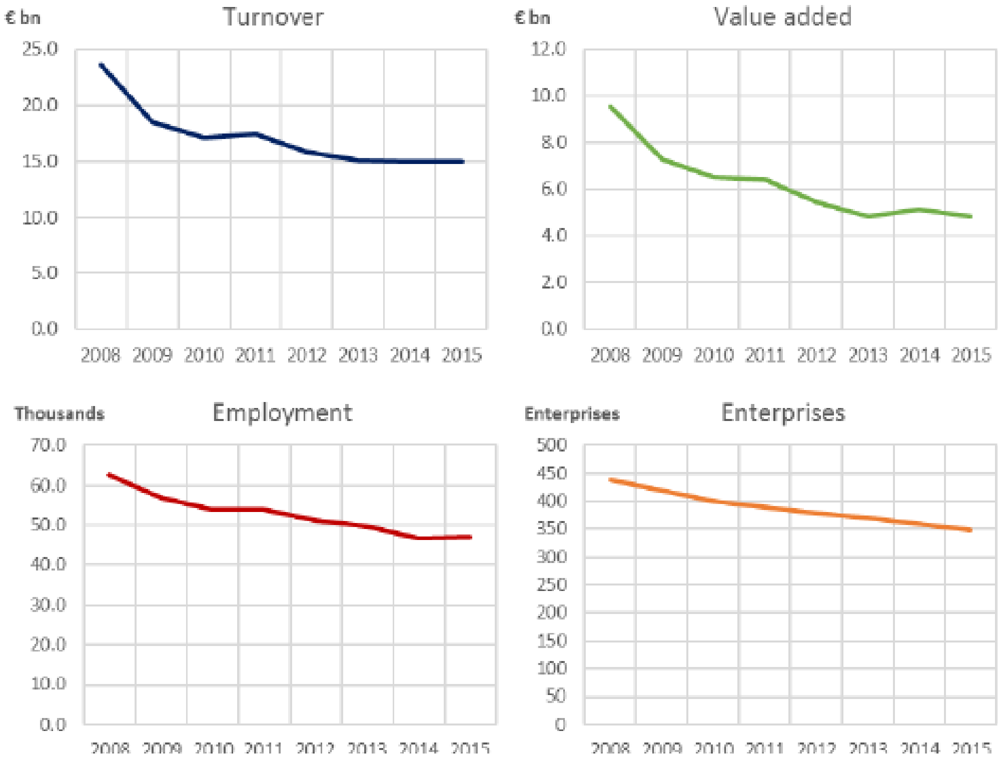
The global, direct CO_2 emissions from the steel industry in 2019 were a little above 2.5 $GtCO_2$. Those from the cement were slightly below 2.5 $GtCO_2$. The Chemical industry emitted a little less than 1.5 $GtCO_2$ in 2019. In the case of the chemicals and steel industries the emissions came largely from energy sources, in the case of the cement sector, more than half of the emissions were process emissions. [748] Currently, the majority of this demand is satisfied by fossil fuel based sources (coal, oil, gas) in the case of all three sectors. As mentioned throughout this analysis, the substitution of fossil-based energy would require ramping up renewables very significantly. Although the positive impact of renewables on reduced GHG emissions and thus positive climate outcomes is the *raison d'être* of the Renewable Energy Directive, renewable energy technologies also have important environmental and biodiversity related drawbacks. Care should be taken that such targets do not result in high bioenergy increase without very stringent sustainability checks. Given that bioenergy is expected to be the most accessible solution to meet targets an expected consequence is increased demand for bioenergy sources, this in turn could have very negative consequences on biodiversity loss and afforestation. Issues related to increased demand for biomass and sustainability aspects are presented in Annex I of this analysis under “Bioenergy analysis options”.

Societal impacts

Iron & steel and cement & concrete are essential materials for the Global and European economy and industrial development. They provide key materials for buildings, infrastructure, industry and almost all structures. Thus, any changes to their production and impact on costs (see above) will also have an impact on society. The iron and steel sector employs (direct jobs) around 300,000 employees and generates around 23.7 billion euros in value added, although these have been falling since 2008.[749] Information on employment, turnover, value added and enterprises in the cement sector are presented in the figure below.

[748] IEA. (2020). The challenge of reaching zero emissions in heavy industry. Available at: https://www.iea.org/articles/the-challenge-of-reaching-zero-emissions-in-heavy-industry
[749] Agora Energiewende and Wuppertal Institute. (2021). Breakthrough Strategies for Climate-Neutral Industry in Europe: Policy and Technology Pathways for Raising EU Climate Ambition

Figure 0-13 EU28 cement manufacturing - key variables over time (2008-2015)[750]



Option 4 would have a limited impact on jobs, unless a broad communication campaign able to substantially shift purchasing choices is undertaken to raise awareness about the new obligations of the industry. However, the efforts of the industry over the past 3 decades to decrease substantially its carbon emissions, and to decouple growth and energy use, decreasing energy/carbon intensity, is not broadly recognised beyond the small circle of professionals. The industry is perceived by many citizens as responsible of most of the carbon emissions, and should be the first to hurry up efforts to decrease its carbon footprint. Unless this option is accompanied by an adequate communication campaign, it would have limited impact.

Option 4 would create a high number of jobs, to manage and carry out the required investments (for the concerned industries), to set up the scheme, verify and follow up (administration), and to invest in renewable assets (RES investors).

Trade and competitiveness

Many of the energy intensive industrial products are traded in highly competitive global markets (e.g. steel, aluminium, primary chemicals). This represents a challenge for producers wanting to turn to the currently more expensive low-carbon production pathways without being undercut on price. Thin profit margins also make it difficult to fund the large upfront investments that are currently required for near-zero emission technologies.[751]

[750] European Commission. (n.d.). Competitiveness of the European cement and Lime Sectors. Available at: https://ec.europa.eu/growth/content/competitiveness-european-cement-and-lime-sectors_en
[751] IEA. (2020). The challenge of reaching zero emissions in heavy industry. Available at: https://www.iea.org/articles/the-challenge-of-reaching-zero-emissions-in-heavy-industry

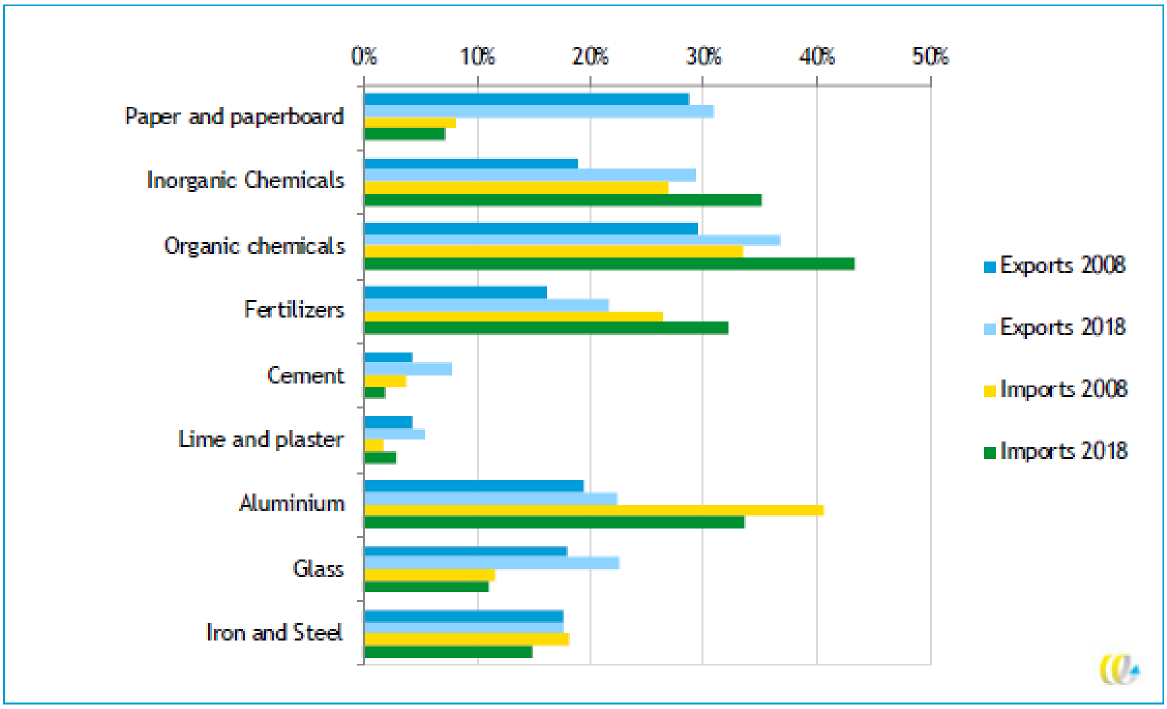
A very recent analysis of the global heavy industry shows that only 14% of publicly listed companies in the steel, cement, aluminium, paper and mining sector are on track to meet the Paris Agreement's 2°C climate target.[752] Research by the Transition Pathway Initiative (TPI) reports that the aluminium and paper sector have a particularly poor performance. Only Rio Tinto – specifically for aluminium, is aligned with a 2°C or below pathway by 2050 across both sectors. Whereas only five companies in the steel sector were in line with the Paris goals for 2030 last year, this year there are eight. However, when looking at the 2050 Paris targets, only five companies still meet this threshold. European steel producers perform relatively well with Acerinox, Arcelor Mittal, Thyssen Krupp and Voestalpine, four Europeans companies among the top 5, and the Dutch-Luxembourg company Arcelor Mittal being the world's biggest steel producer.

In the case of cement only five out of 33 companies assessed were on track with decarbonisation plans compatible with the Paris Agreement.[753] This assessment is important because, since the industries operate with very low profit margins in very competitive markets, without the majority of the sector committing to decarbonising its production, those companies that do will be at a competitive disadvantage. Thus, there is clearly a need for a global approach. This is also the case due to the multi-national character of many of the large companies, for example, ArcelorMittal, is active in 60 countries. Some of the largest cement companies, are also multinationals (LafargeHolcim, Cemex and Heidelberg). Anhui Conch and 3rd China National Building Materials are Chinese companies active globally.[754]

A recent study by the European Parliament discusses competitiveness aspects related to more stringent climate-requirements in EU for energy intensive industries. Trade imports and exports in key sectors (See Figure 0-14) can be used as proxies to provide general commentaries on competitiveness. The figure below shows the share of imports and exports to production for select energy-intensive industrial sectors between 2008 and 2018. Based on the figures it is possible to observe that for aluminium, iron, and steel, the relative share of imports has been falling indicating that these industries are better able to compete on the domestic EU market than in 2008. In the case of cement and lime, there is little competition on world markets given the localised nature of the business due to difficulty in transporting material. Based on the figures below, the conclusion of study is that there is no overall sign of deteriorating completeness in relative import or export positions.[755]

[752] Scheid, L. for Euractive. (2020). Only fractions of global heavy industry are aligned with Paris climate goals. Available at: https://www.euractiv.com/section/energy-environment/news/only-fractions-of-global-heavy-industry-are-on-track-to-hit-the-2c-target/
[753] Transition Pathway Initiative. (2021). Management Quality and carbon Performance of Industrials and Materials Companies: February 2021
[754] OECD, Financing Climate Futures. (2019). Low and zero emissions in the steel and cement industries.
[755] European Parliament – ITRE committee. (2020). Energy-intensive industries: Challenges and opportunities in energy transition. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652717/IPOL_STU(2020)652717_EN.pdf

Figure 0-14 Share of value of EU exports and imports in the production value of 9 sectors (2008 to 2018)[756]



Variant: Target across all ETS and non-ETS industries

The analysis above already shows that there are substantial differences in the methods available for the cement and steel sector and in the particularities associated with the emissions to be tackled in each. A key difference is that in the case of the cement, more than two thirds of the emissions are process emissions which cannot be addressed though replacing the energy needs by renewables. For this reason, especially in the case of the cement industry, instruments related to efficiency, circularity, material substitution and CCS (see below) might be more appropriate/effective than renewables. Thus, an approach targeted at all industry sectors in the ETS should consider these differences and potentially set different targets per sector.

Option 5 - Renewable + CCS targets

The analysis above shows that substitution of fossil fuels for renewable energy has its limits. One unsurmountable limitation of a strategy based on retaining the same processes and substituting energy by renewables are the associated process emissions. In the case of the cement sector, process emissions constitute ~ 60 % of the total emissions (see **Error! Reference source not found.**). Thus, a full d ecarbonisation of the current processes to make the key industrial materials requires either changes in the process making and associated technologies (e.g., Hisarna ironmaking process) or the use of Carbon Capture and Storage (CCS). Note that the analysis of this option goes beyond a focus on renewable energy. Looking at low-carbon options beyond renewables is justified based on the specificities and needs of the industry sector and to provide a better understanding of the benefits and limitations of renewables as compared to other solutions.

[756] Ibid.

Textbox 0-5 The LEILAC cement manufacturing process and relevance for CCS[757]

> The LEILAC process concentrates the CO_2 chemical process gases (which are ~60% of all emissions from cement production) in the calciner portion of cement plant. The higher concentration of CO_2 allows for the direct use of already commercialised oil and gas technology for geological disposal of highly concentrated (>=80-85%) CO_2. Thus, the process avoids the need to use the more technically difficult and not yet commercialised technology for separating CO_2 from combustion flue gas streams that are highly diluted. This production process allows for the CO_2 capture to become more efficient and cost effective. The first pilot plant is hosted by Heidelberg Cement at Lixhe in Belgium.

Economic impacts

Cost considerations remain one of the biggest problems to wide-spread CCS deployment. The costs associated with the CO_2 capture technologies and transport and storage infrastructure are high, especially for the first projects, which face additional barriers related to uncertainty. Subsequent projects may reuse the same infrastructure, which will make the projects less risky and less capital intensive. The cross-value chain risks that are built-in across the capture, transport and storage/utilisation parts of the CCUS value chain remain a high business risk. No compensation mechanisms are currently available to mitigate the business exposure for any party in a CCS/CCU value chain in the event of underperformance of one of part in the value chain. This is preventing the optimal use of resources to create shared transport and storage infrastructure. The current carbon price is too low to make for a market driven business case. Hence, in the absence of a stable carbon price of ~ 50 to 60 EUR/t CO_2[758], investments in CCS will be dependent on public funding and policy incentives. Currently, some projects have had access to funding, for example, via the Connecting Europe Facility (in case of Projects of Common Interest (PCI) designation) or the Innovation Fund, but it is necessary to identify further instruments able to support the deployment of infrastructure at scale. Furthermore, at present, there is no market for materials produced by means of low-carbon technology processes such as, for example, cement, steel, chemicals, or fuels produced using either CCS processes of via CO_2-reutilization. Given the higher costs associated with producing such materials, policy intervention, in the form of, for example, public procurement contracts would be required.

Given these considerations, a mandatory target for industry sectors, would help to provide a level-playing field for the European companies (although it would have an effect vis a vis international ones), and could drive technology cost reductions by driving up usage up at scale.

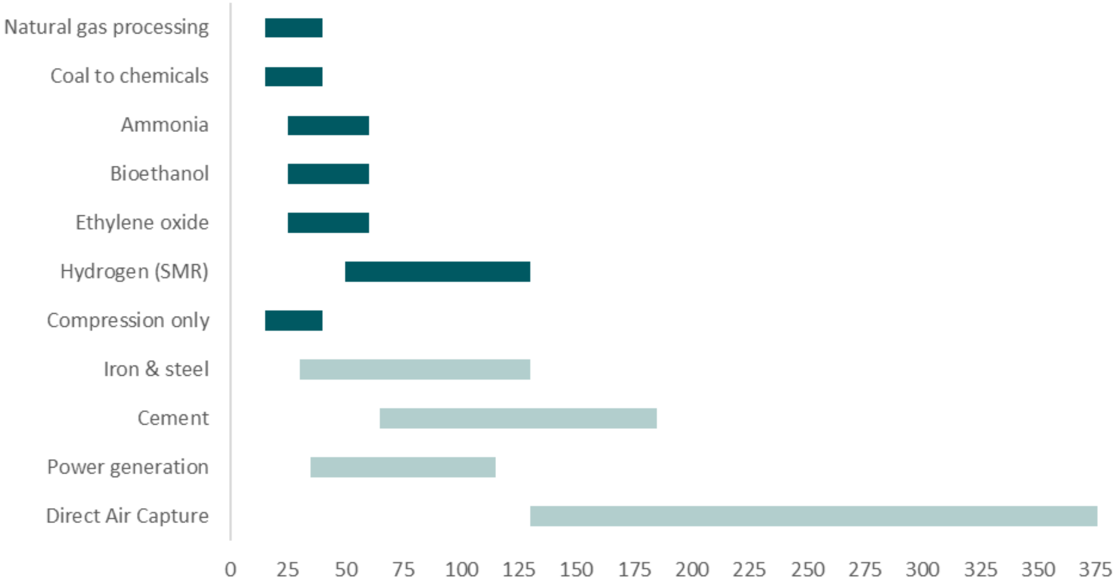
The costs of carbon capture vary significantly per sector and are highly dependent on the purity and concentration of the carbon dioxide stream. For industrials processes emitting concentrated CO_2 streams (ethanol production, natural gas procession) costs can be as low as 15-25 USD/t of CO_2, in the case of more dilute streams such as in the cement industry costs range from 40 to 120 USD/t CO_2.[759] The concentration of CO_2 in the air is very dilute and thus associated with the highest costs. Finally,

[757] Leilac - Low Emissions Intensity Lime & Cement. (n.d.). Available at: https://www.project-leilac.eu/
[758] IOGP. (2019). The Potential for CCS and CCU in Europe. Available at: https://ec.europa.eu/info/sites/default/files/iogp_-_report_-_ccs_ccu.pdf
[759] IEA. (2021). Is carbon capture too expensive? Available at: https://www.iea.org/commentaries/is-carbon-capture-too-expensive?utm_content=bufferccd81&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer

Error! **Reference source not found.**, also incorporates information on the costs of different capture technologies.

Figure 0-15 and **Error! Reference source not found.** provide a range of costs associated with CO_2 capture based on two different studies. Finally, **Error! Reference source not found.**, also incorporates i nformation on the costs of different capture technologies.

Figure 0-15 Levelised cost of CO_2 capture (USD/tonne) by sector and initial CO_2 concentration, 2019[760]



Based on existing and planned CCUS projects in Europe, the two main options for CO_2 transport are pipelines and shipping. Repurposed offshore oil and gas pipelines could be used for carbon dioxide transport to store the gas in depleted oil and gas fields or saline aquifers. Reusing offshore oil and gas pipelines is estimated to cost 1 to 10 % of the costs of building new pipelines. However, the total cost savings of reusing infrastructure which would otherwise be decommissioned depend on a number of factors and are difficult to estimates. The factors include the condition of existing pipelines, and required technical upgrades/intervention (e.g. repairing corrosion). Costs of offshore CO_2 pipelines range between EUR 2-29/t CO_2. Costs of shipment vary between EUR 10 and 20/t CO_2.[761]

The estimated costs of CO_2 storage depend on the formation type and location. The costs of offshore saline aquifer which include exploration, seismic acquisition, drilling and geological data processing are high, amounting potentially to several tens of millions of euros (€6 – 20 per tonne of CO_2).[762] In depleted oil and gas fields, these costs are lower (~ 1 and 11 EUR per tonne) but the storage capacity is also lower.

[760] Own elaboration based on: IEA. (2021). Is carbon capture too expensive? Available at: https://www.iea.org/commentaries/is-carbon-capture-too-expensive?utm_content=bufferccd81&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer
[761] IOGP. (2019). The Potential for CCS and CCU in Europe. Available at: https://ec.europa.eu/info/sites/default/files/iogp_-_report_-_ccs_ccu.pdf
[762] Ibid.

In spite of the relatively high costs associated with it, CCUS it can be more cost-effective to retrofit CCUS to existing facilities than building new capacity with alternative technologies.

The most recent article on capture costs by the IEA finds that "in the case of cement production, where two-thirds of emissions are from chemical reactions related to heating limestone CCS is currently the only scalable solution for reducing emissions. And in the iron and steel sector, production routes based on CCS are currently the most advanced and least-cost low-carbon options. Incorporating CO_2 capture raises estimated costs by less than 10%, while approaches based on electrolytic hydrogen can raise costs by 35-70% compared with today's conventional production methods".[763]

Furthermore, in the case of ammonia production, CCS is currently the cheapest option for reducing emissions. The estimated costs of CCS-equipped ammonia and methanol production based on natural gas are around 20-40% higher than their unabated counterparts, while the cost of electrolytic hydrogen routes is estimated to be 50-115% higher.[764]

Price effects of mandating CCS on select products

If CCS targets are to be implemented on a mandatory basis, a key consideration, will be the effect of this mandate on final prices of products (from sectors) covered under the obligation and their competitiveness vis-à-vis products produced outside of the EU27.

Cement

Cement production is emission intensive given that emissions are a result not only of fossil fuel use but also the chemical production process itself. Process emissions make up to 60% of the sectors' emissions. Currently, production of one tonne of cement emits nearly one tonne of CO_2. Use of less carbon-intensive fuels (e.g. waste, biomass) could reduce overall cement emissions by 18-24%. However, for traditional cement production CO_2 emissions from the production process can only be substantially reduced with CCS.[765]

Producing low-carbon cement will require additional manufacturing processes (e.g. investments in CCS infrastructure), consequently, the production costs are expected to increase. It is estimated that low-carbon cement could be about 70%-95% more expensive than today's climate intensive cement.[766] However, since cement and concrete represent a small fraction of the total production costs of buildings and other construction projects, the final cost increases could be small. Research estimated that an average residential building using zero carbon concrete would add around 1% to the final cost, assuming the cost of cement doubles compared to traditional processes.[767]

Steel

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[763] IEA. (2021). Is carbon capture too expensive? Available at: https://www.iea.org/commentaries/is-carbon-capture-too-expensive?utm_content=bufferccd81&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer
[764] Ibid.
[765] Bellona Europa. (2018). Building with Low Carbon Cement is Affordable. Available at: https://bellona.org/news/ccs/2018-04-building-with-low-carbon-cement-is-affordable
[766] UNT. (2018). Gör betongen klimatneutral. Available at: http://www.unt.se/asikt/debatt/gor-betongen-klimatneutral-4872542.aspx (via Bellona)
[767] Rootzen, J. & Johnsson, F. (2016). Managing the costs of CO_2 abatement in the cement industry. Climate Policy. Available at: https://www.tandfonline.com/doi/abs/10.1080/14693062.2016.1191007?journalCode=tcpo20

Research on the impact of low-carbon steel production on downstream supply chain for passenger cars shows that investing in low-CO_2 processes have marginal impacts in end-user stage. Increase in the retail price of a mid-sized passenger car would be well below 1%.[768]

Other sectors

Costs of carbon capture vary significantly based on the percentage of volume of CO_2 in the flue gas from which it is captured, the higher the purity of the flue gas the lower the capture costs. Thus, capture costs can range from 12 EUR/tonne CO_2 avoided in the chemicals industry to 98 EUR/tonne CO_2 avoided for non-metallic minerals – lime.[769]

Environmental impacts

Under **option 5**, carbon capture and storage technologies, require additional consideration in relation to environmental impacts. The main environmental challenge with CCS is the accidental release from the pipeline and spillage when the pipelines are being constructed into the water. Carbon Capture plants also release some wastewater, which is considered as being harmful and toxic to aquatic life. The water can also become acidic due to CO_2 leakage; when these spillages and leakages eventually get to the groundwater, they become contaminated.[770] Further, the authors of a recent paper state that air quality is likely to be negatively affected during the operational and construction stages of CCS projects due to dust suspension, fuel utilized by the machines from the project and the shipping. Moreover, the release of CO_2 into the soil causes an increment in the soil's pH which leads to the mobilization of heavy metals. Finally, aspects related to induced seismicity need to be considered.[771]

Societal impacts

Estimates show that the sum of European jobs linked directly and indirectly to the emergence of a market for CCS may approach 150,000 in 2050.[772]

Industries in Germany support over half a million direct jobs, and millions more indirect and induced jobs, which would be at risk without the availability of CCS infrastructure to enable them to decarbonise. A study on the value of CCS to employment in Norway, which found that a CO_2 management industry could retain 30,000 process industry jobs.[773] In the UK, the Trades Union Congress (TUC) found that more than 800,000 people worked in energy intensive industries and their supply chains and that 160,000 jobs could be retained through the deployment of CCS .[774] In addition to

[768] Rootzen, J. & Johnsson, F. (2016). Paying the full price of steel – Perspectives on the cost of reducing carbon dioxide emissions from the steel industry.
[769] IOGP. (2019). The Potential for CCS and CCU in Europe. Available at: https://ec.europa.eu/info/sites/default/files/iogp_-_report_-_ccs_ccu.pdf
[770] Wilberforce, T. et al. (2020). Progress in carbon capture technologies. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048969720367346
[771] Ibid.
[772] IOGP. (2019). The Potential for CCS and CCU in Europe. Available at: https://ec.europa.eu/info/sites/default/files/iogp_-_report_-_ccs_ccu.pdf
[773] Størset, S. Ø., Tangen, G., Wolfgang, O. & Sand, G. (2018). Industrial opportunities and employment prospects in large-scale CO_2 management in Norway (Industrielle muligheter og arbeidsplasser ved CO2-håndtering i Norge), ISBN 978-82-14-6865-8. Available at: https://www.nho.no/contentassets/e41282b08ceb49f18b63d0f4cc9c5270/industrial-opportunities-ccs_english.pdf
[774] TUC. (2012). TUC in association with the Energy Intensive Users Group, Building our low-carbon industries: The benefits of securing the energy-intensive industries in the UK. Available at: https://www.tuc.org.uk/sites/default/files/tucfiles/buildingourlowcarboninds.pdf
TUC (2014), TUC and CCSA, The Economic Benefits of carbon capture and storage in the UK. Available at: https://www.tuc.org.uk/sites/default/files/carboncapturebenefits.pdf

retaining jobs, several studies[775] highlight the job creation opportunities associated with deployment of CCS, for example, one of them states that “establishing a European CCS industry in Norway could generate up to 40,000 additional (direct and indirect) jobs in 2030, and up to 90,000 by 2050, due to a growing demand for storage services as more industrial sites deeply decarbonise.”[776]

Public Acceptance

Public acceptance for CCS remains low among the public. This can be attributed, in part, to low levels of technology awareness amongst the general public and key stakeholders. Acceptance is also hampered by misleading perceptions of the technology, including lack of trust of the businesses leading the project, and/or of the decision-makers, such as regional or national governments; fear of the risks associated with transport and storage and of environmental damage caused by the project; impact on local livelihoods; lack of belief in climate change and/or objections to the use of public money for CCS.[777]

[775] Turner, K., Katris, A., Race, J., and Stewart, J. (2020). How is Planned Public Investment to Enable CCS Likely to Impact the Wider UK Economy? Available at: https://strathprints.strath.ac.uk/72886/;
Vivid Economics. (2020). Capturing Carbon at Drax: Delivering jobs, clean growth and levelling up the Humber. Available at: https://www.drax.com/wp-content/uploads/2020/11/Capturing-Carbon-at-Drax-Delivering-Jobs-Clean-Growth-and-Levelling-Up-the-Humber.pdf
Summit Power. (2017). Clean Air – Clean Industry – Clean Growth: How Carbon Capture Will Boost the UK Economy - East Coast UK Carbon Capture and Storage Investment Study. Available at: http://industriamundum.com/wp-content/uploads/2017/10/Summit-Power-Clean-Air-Clean-Industry-Clean-Growth.-Oct-2017-FULL-REPORT.pdf
[776] Størset, S. Ø., Tangen, G., Wolfgang, O. & Sand, G. (2018). Industrial opportunities and employment prospects in large-scale CO_2 management in Norway (Industrielle muligheter og arbeidsplasser ved CO2-håndtering i Norge), ISBN 978-82-14-6865-8. Available at: https://www.nho.no/contentassets/e41282b08ceb49f18b63d0f4cc9c5270/industrial-opportunities-ccs_english.pdf
[777] CCUS Projects Network. (2020). Public perception of CCS: A Review of Public Engagement for CCS Projects. Available at: https://www.ccusnetwork.eu/sites/default/files/TG1_Briefing-Report-Public-Perception-of-CCS.pdf

Synthesis

Summary

Energy audits integrating renewables

Energy audits are key to:

- Support/help industry identify the appropriate technologies/options to decarbonize;
- Build the required knowledge and mainstream energy efficiency measures.

Industry has already addressed many of the potential energy efficiency improvements and is slowly moving towards (or at least considering) integrating RES to further decarbonize. At present, the main motivation to decarbonize is based on the carbon price under the ETS, but the price has historically been too low to motivate industry to decarbonise. Currently the carbon market price under the EU ETS is above 50 EUR/tonne (56.4 EUR/tonne as of 17/05/2021). If this price level continues or keeps increasing, this is expected to incentivize at least some industries to invest in renewable energy technologies and CCS. The Market Stability Reserve (MSR) mechanism which began operating in January 2019 has improved the system's resilience to shock by adjusting the supply allowances being auctioned. The revised EU ETS Directive is designed to provide more predictable and robust price signals. Further reforms to the EU carbon market scheduled for the summer are expected to lead to greater demand for CO_2 permits and to make them scarcer leading to high prices. On the other hand, some industries say higher CO_2 costs are diminishing their ability to find cash to invest in renewable and low-carbon technologies.[778] However, this is expected to be a short-term problem which could be addressed using Third Party Financing. The long-term perspective and perceived price stability are crucial to provide investment certainty, and support the decarbonization of the sector. If high carbon prices are maintained and remains stable over the years, the EU ETS would be the optimal mechanism to incentivize decarbonization of industry in a cost effective way. It is important to note that with the increased ambition of GHG emission reduction targets, much less free allocation under the ETS is expected to take place, in consequence the importance of a carbon border adjustment mechanism increases strongly.

However, guidance and expertise are required to identify the most cost-effective solutions, as RES is not traditionally a core-business area (on the other hand energy efficiency is closer to core-business and mainstreamed in industrial processes). RES would often be a completely new activity (be it the purchasing of renewable energy via Pawer Purchase Agreements (PPAs), heat purchase agreements (HPA), or the on-site installation of PV, wind, geothermal, bioenergy or biogas plants).

To push the industry to increase the decarbonization efforts, some MSs (at least BE & NL, see Textbox 4-1 for the Walloon case) have set up schemes based on two basic steps:

- an audit (external) identifies decarbonization options (EE & RES);
- the results of the audit (measures with payback < 5 years as in the case of Wallonia) can serve as basis to determine a binding GHG reduction goal at sectoral-level, and ensure that it is a realistic one. Requiring MSs to specify a minimum GHG reduction target (binding or indicative) for their industries (with a minimum RES uptake sub-target) in this way ensures that the target is designed based on realistic expectations and on a case-by-case basis. This is because this

[778] Reuters. (2021). EU carbon price hits record 50 euros per tonne on route to climate target. Available at: https://www.reuters.com/business/energy/eu-carbon-price-tops-50-euros-first-time-2021-05-04/

option will allow the RES solutions to vary from one industry sector to another, from one plant to the other. Annex I of this document illustrates the case in Wallonia (BE), which has integrated renewables into industrial audits since 2012.

Auditors have EE expertise, but should strengthen and deploy their RES expertise which would have additional cost, estimated to be marginal as update of audits is required. This additional expertise is needed to ensure bankability of the projects/solutions recommended by the auditors and correct risk management. More control and verification by the authorities (via sector federation e.g.) would also be necessary to guide and push ambitions. Energy audits integrating renewables would address mainly the lack of awareness and the barriers regarding renewable fuel supply as root causes. The advantage of this option is that it fully supports the logic of addressing renewable uptake and energy efficiency at the same time, taking into account all local parameters and potentials. In addition, the administrative costs would be relatively low based on the fact that energy audits are already required under the Energy Efficiency Directive. Information from audits can also support a better understanding of the planning and infrastructure needs (see cause 3) vis a vis the local resources and opportunities.
The only way to address the lack of market competitiveness and level playing field is the strengthening of the existing market mechanisms, ETS with an increased price, and Energy Taxation Directive (ETD) for the non-ETS industries. This is key to ensure the appropriate RES options are considered bankable.

Product labels

Products labels are key to:

- Provide a “pull” for the market from the consumer’s side.
- Differentiate “green” products on the market.

Labels do not change the behaviour of customers; they just provide the required information to the consumer to make a more informed choice if the consumer requests so - a label does not create the demand, it only satisfies consumer’s expectation. This means that for a label to be successful the consumers should already have an awareness of environmental issues and be interested in purchasing the “green” version of a given product.

Product labelling should ideally be simple, broad (large environmental concerns) and targeted (e.g.to specific products that can make a substantial difference in terms of decreasing GHG emissions by increasing the uptake of renewables). For the ease of application, the establishing of RES labels for industrial products should probably focus first on basic products like steel and cement. In this context, public procurement could play an important role in incentivizing the purchasing of, for example, bulk, construction products. This would allow to secure a market for products produced by using renewable energy while avoiding any complications of tracking and calculating the share of RES in more refined, final retail products. In the case of further refined retail products sold on the market, the tracing of the final renewable energy content could become complex and create high compliance and administrative costs.

Given the potential for complexity in tracking the final share of renewable energy in a product through labelling, a simpler approach could consist of ensuring that companies commit to using renewable energy as input (an input oriented approach rather than output). The RE100 initiative constitutes an interesting example where companies voluntarily pledge to increase renewable electricity uptake based on specific criteria.[779] In this case, the company rather than a product is able to gain customer support through a branding based on a green, sustainable image. Depending on the ambition of the commitments a company can earn a “Gold” designation. This approach is not only simpler to set up and could be verified through audits, but also supports a general culture of transparency. Furthermore, this approach would be less intrusive than a label with regards to trade rules. As such, this approach could potentially have broader and faster impacts in promoting renewable energy uptake by industry.

The RE100 initiative 2019 report[780] presents data disclosed by 261 members, including geographical breakdown of companies’ electricity consumption and their sourcing strategies. Alongside, the CDP disclosure reveals companies' broader climate change risks and impacts. RE100 members belong to many sectors, although services remain the most represented area, and they report a total of 278 TWh/yr in aggregated electricity demand. Most of them member have ambitious commitments in place that go above and beyond legal requirements and opportunities offered by policy incentives, with 75% of RE100 members set to be running on 100% renewables by 2030. 142 members are also setting science-based targets (SBTs[781]) to reduce GHG emissions, and 62 have a verified 1.5°C-aligned target.[782]

The renewable content of energy used to produce a car, a wash machine, or other consumer goods, is only one of many other elements/indicators which could interest the final consumer. These include aspects such as environmental footprint, recyclability, or secondary material content, pollution and hazards. Labels encompassing all environmental aspects are already being developed, and as such it is necessary to consider if developing a parallel scheme is a cost-efficient option. At present, there are 231 different ecolabels in Europe.[783] With this overwhelming amount of information the consumer might end up feeling more disoriented than informed.

Setting up a labelling scheme is costly and would require time and efforts. It would only make sense if a mass market for “renewable” products would already be developed. However, there is n opportunity to consider this at a later stage, building on environmental (or sustainable) labels and including renewable content, if demand increases as more consumer awareness is generated.

The risk for green washing perception is high. Without a well-developed and clear methodology to quantify the share of RES in the final product there is a risk that industry will claim to use RES, to enhance its green, global image and Corporate Social Responsibility, without necessarily fully complying with the requirements, as tracing the RES share of the products could be complicated or unfeasible. Further, these estimates may impose significant administrative costs. This dees not preclude continuing to support awareness raising, in order to demonstrate how the industry is contributing to the climate efforts.

[779] RE100, Climate Group & CDP. (n.d.). RE100 Joining Criteria. Available at: https://www.there100.org/sites/re100/files/2020-11/RE100%20Joining%20Criteria.pdf
[780] RE100, Climate Group & CDP. (2020). Growing renewable power: Companies seizing leadership opportunities. Available at: https://www.there100.org/growing-renewable-power-companies-seizing-leadership-opportunities
[781] Science Based Targets. (n.d.). Ambitious Corporate Climate Action. Available at: https://sciencebasedtargets.org/
[782] RE100, Climate Group & CDP. (n.d.). RE100 Joining Criteria. Available at: https://www.there100.org/sites/re100/files/2020-11/RE100%20Joining%20Criteria.pdf
[783] Ecolabel Index. (n.d.). All ecolabels in Europe. Available at: http://www.ecolabelindex.com/ecolabels/?st=region%2Ceurope

A renewable product label could help to address the lack of market competitiveness and level playing field, but given the length of some supply chains, the complexity setting up the scheme, and the hope on consumer's willingness to change its behaviour, this impact would remain quite hypothetical, at least for the time being. It would have a small impact on the lack of awareness, as only the industry willing to participate in the labelling efforts would take the required time and put work into identifying and deploying the appropriate solution. This option could have a limited impact on the barriers regarding renewable fuel supply as root causes.

Indicative target

An indicative target (as a % of energy consumption) per sector or MS is good to:

- Force the industry to use renewable directly (on-site) or indirectly (via PPA, HPA);
- Globally identify the expected contribution of each responsible party (e.g. industrial sectors, or plants) to the overall GHG/RES target.

An indicative general annual increase of RES-share target per MS is good to:

- Force MS to define the most appropriate approach to increase the share of RES in the industry (via obligations, incentive schemes, voluntary schemes built in the audit, …);
- Give a limited impetus (the level of the annual increase would certainly remain low).

Setting up a 2030 renewable target for the industry (overall, per industrial sector, or at MS level) would require a one-size-fits-all formula able to grasp all industrial/national/local specificities in order to determine the adequate level of ambition. Otherwise, the risk is high that:

- The target is too low and easy to reach. In this case, a first level of sensitization (addressing the lack of awareness) would be reached, by at least forcing the industry to think about solutions to incorporate renewable energy in their processes. However, it is likely that industry reaches the target with minimal effort, far from being enough to significantly support the overall renewable energy target. This would also send a bad political signal outside the arena, even with efforts made to communicate the idea behind the approach;
- The target is too high, not cost-effective or even impossible to reach for the industry. This would lead to long discussions with industry (delaying the start of the programme), or may end up imposing a high burden on industrial plants. This option could also simply push the industry to replace fossil fuels with sources that are not-optimal such as, for example, natural gas by biomethane, raising the issue of its cost (biomethane costs 70-100eur/MWh, compared to natural gas currently ~20eur/MWh in large industry), and the issue of resource availability and sustainability. Thus, the "gap filler" approach (to accommodate the ambition gap between the targets and the physical constrains) could run the risk of not being based on an appropriate assessment and opt for options cheaper on the short term. Greening the gas supply is a relatively easy fallback option, and can technically supply most of the industry; however, in practice, such an option is not feasible at scale, given resources limitation. Further, high targets would significantly lower the flexibility for industry to choose other pathways to decarbonization based on, e.g., carbon capture and storage or switching to processes which emit less GHG.
- The formula determining the adequate target level would be complex to agree and depend on the scope:
    - At sector-level, this would require determining what is technically feasible for a process to integrate renewables or use renewable fuels, also considering the national renewable

potential (e.g. producing biomethane, biofuels, or hydrogen), even if import still remains an option. PPA (or HPA) can be an alternative to on-site production and use, but could also depend on national circumstances.
  - At national-level, this would require to first determine the national profile of the industry to precise the demand and technical feasibility of using renewables, and then the potential of renewables to be supplied by PPA/HPA.

In both cases, national and sector specific parameters are required to calculate the most adequate level of ambition, but these would probably not be able to integrate all local constraints and conditions (local resources such as land area, biomass, wind/sun, geothermal heat, … but also the infrastructure to deliver alternative renewable fuels).

In addition, it should be recalled that MSs and their industry are already bound by overarching targets:

- The Effort Sharing Regulation imposes an overall GHG target to all non-ETS sector, with transport and buildings being the two most important sectors (although the Commission announced this could change[784]). For a more ambitious GHG plan, more will be expected from all sectors, and certainly from the non-ETS industry to contribute to the target. With a higher GHG target, the non-ETS industry would have no other choice than combining at the same time EE & RES, in order to be able to comply to the target (renewable would deploy progressively without additional need for a push, leaving to the MS to decide the efforts the non-ETS industry would need to achieve);
- A global RES target (at MS, or at EU with a national contribution). Here too it would be to the MS to allocate the efforts to each sector, according to their national context (demand profiles, and RES potential).

<u>Indicative annual increase of RES-share in industry - target at MS level</u>

An alternative option is to establish an indicative annual increase of RES-share in the industrial sector, at MS level, mirroring RED article 23 (yearly increase of RES-share). With a fixed indicative target for all MS (it could be a sub-target under art 23), determining the yearly increase would be more straightforward than defining a middle term target, as this would set the same target for all MSs. However, to ensure the target is set at an achievable level for all MSs (and politically acceptable), it is likely this target would be set at a rather low level. Given that the proposed target would be indicative in nature there is scope for making it slightly more ambitious than if a binding one was being considered. The annual increase should be seen as a gentle push for MSs to develop the appropriate set of instruments, and in most cases, ensure these instruments fit together and are compatible and complementary. The key instruments which should be integrated and linked are:

- Market and price signal related instruments, with the ETS and any additional, possibly transitional, measure (such as carbon pricing on top of the ETS, support schemes such as Contract for Difference, subsidies, loans, etc.);
- Accompanying instruments, with energy audit's recommendations on RES as a mainstreamed decarbonisation roadmap tool, ideally with a binding target based the results of the audit and on a clear long-term objective to decarbonize (the move to renewable fuels in the industry can imply important changes, including in the process, therefore a long tern perspective is

[784] Euractiv. (2021). EU carbon market will be extended to buildings and transport, von der Leyen confirms. Available at: https://www.euractiv.com/section/energy/news/eu-carbon-market-will-be-extended-to-buildings-and-transport-von-der-leyen-confirms/

required). The tool could remain voluntary but making its results binding would require appropriate incentives for the industry;

- For the non-ETS industry, the ESR GHG target should guide MSs to integrate renewable stimuli (via the low annual increase RES-share in industry) and the ambition to fully decarbonise the non-ETS sectors.

Such instrument would leave to MSs sufficient flexibility in choosing on the best way to pass on the national target to their industry. This could be achieved by incentivising, by setting nationally allocated targets for each industrial sector, or via bilateral dialogues between the industry and the authorities on the best approach to accelerate the decarbonization of the industry.

The purpose of the target would primarily focus on incentivizing industry to think about the processes through which renewable uptake can be achieved. However, the target by itself would be too low by itself to meaningfully contribute to the new EU GHG reduction ambitions by 2030 and climate neutrality by 2050. The Commission should take into account these risks during the negotiation/trialogue, to avoid a kind of lock in. This is why the combination of instruments is key, to ensure the deployment of renewable counts in the decarbonization efforts. Also, the bad political signal outside the arena should be a point of attention.

This variant is expected to address to some extent the lack of awareness, especially if properly linked to the audits. If appropriately combined with other instruments, it could also strengthen the efforts to address the lack of market competitiveness, by forcing MSs to set up appropriate market instruments. Per se, this variant would address the barriers regarding renewable fuel supply to a limited extent, but its combination with the audit scheme reinforces their dynamic and have a strong positive impact on renewable fuel supply. On the other side, this variant would have a very limited administrative cost impact, unless lengthy discussions about the right level ambitions are required.

An additional alternative option “Create targets for RFNBOs in hard to decarbonise sectors such as maritime, aviation and industry” is considered under the paper B on Energy System Integration, to promote the use of renewable and low carbon fuels across transport and H&C (in the sector integration paper).

Conclusion

We strongly recommend strengthening the current industrial efficiency audit scheme, with the explicit inclusion of renewables, and using the audit as a base to set up a Decarbonisation Roadmap at plant level in line with the 55% target, and possibly with a view to fully decarbonize by 2050. The best way (would be to recommend MSs to use these audits to define binding carbon targets on a voluntary basis, also adding a specific renewable (sub)targets which would be defined at plant level.

We do not recommend setting up renewable industrial products labelling, as these would only add to an already extensive list of green labels, with the risk of further confusing consumers. Options to progressively integrate renewable content of the products within the frame of these green labels should be explored, when the evidence that the pull from the consumers would make a difference and there is willingness to pay a premium for labelled products. However, communications about the efforts made by the industry to decarbonize and use renewable remains important.

It is unlikely that any of the options considered would have an important impact on the market conditions of RES, given the current competitiveness gaps of renewables in the industrial sector. The ETS remains the appropriate instrument to significantly contribute to a level playing field, but supports from other sides is necessary until the carbon prices reaches sufficient levels.

Summary table

Table 0-4 Summary table of the impact of measures for various options

	Impact of measures			
	Effectiveness (economic, social, environmental)	**Subsidiarity**	**Coherence**	**Administrative burden**
Option 0 - baseline	/	/	/	/
Option 1 - Voluntary Agreements	The economic impact of this option is expected to be low. Given the voluntary nature of the agreements, industry is expected to implement this option only if a business case can be made for it. The economic effects on consumer (e.g. increased final price) are also expected to be low given that participating industry would still be competing in a market with industries not implementing the voluntary agreements. Regarding social impacts, voluntary agreements lead to a slightly positive impact by increasing awareness on both consumer and producer sides, if the required measures are taken to avoid green washing. This option is expected to have the lowest positive environmental impacts of all options other than the baseline. Energy related voluntary agreements tend to play a minor role as a supporting factor but do not induce significant achievements on their own.	This option is compatible with the EU's subsidiary principles. Enforcement would be likely more efficiently implemented at member state level.	This option is a stand-alone option which would not contradict other policy and regulatory instruments established under e.g. the ETS, the ESR	The administrative burden is expected to be medium to large in comparison to the effectiveness offered by this option. Enforcement/compliance costa are expected to also be medium to large as monitoring mechanisms would have to be established to ensure industry complies with the agreements made.
Option 2 - RES in energy audits under the EED	This option is expected to be effective based on the foreseen environmental outcomes as compared to the low economic costs associated with implementation. The economic costs are expected to be low given that this option involves building on audits which are already in place. The social benefit of this option include a higher alignment of renewable energy and energy efficiency mechanisms leading to learning and most efficient resource use. The main environmental impact will be the reduction in GHG emissions associated with energy use in industry, but other industrial emissions will be reduced as well when switching fuels, in particular when switching to electricity.	Energy audits are already established under the Energy Efficiency directive. Article 8 of the Energy Efficiency Directive (EED) (2012/27/EU amended by 2018/2002) requires Members States to require energy audits and promote energy management systems.	Several options to amend the Energy Efficiency Directive (E.g. Adapt article 8 or adapt Annex IV) are possible in order to ensure coherence.	The administrative costs would be relatively low based on the fact that energy audits are already required under the Energy Efficiency Directive

Impact of measures				
Option 3 – Creation of a label	Economic costs of introducing an ecolabel will vary based on a number of factors. Experience from previous ecolabels shows that t because of their lack of recognition by consumers with limited recall, eco-labels do not provide perfect information and environmental characteristics are not fully internalized. The effectiveness of this option is highly reliant on consumer awareness, receptivity and demand for the label. This option is the most demand-side driven one. Putting too much focus on consumers to drive the transition towards greater renewables uptake could place a high burden on citizens. As is the case for economic impacts, environmental benefits of an ecolabel that focusses on renewable generation would probably be limited in size and dependent on the availability of complementary policies that drive renewable generation.	The label option must ensure that the products labelled do not distort the functioning of the EU single market.	This option needs to be considered in the context of the functioning of the EU single market as well as internationally established trade rules to avoid distortions in competition.	The tracing of the final renewable energy content especially in highly refined products could become complex and create high compliance and administrative costs
Option 4 – Targets for share of renewables consumed in industry	The extent of the economic impact will differ for the individual companies based on the extent of modifications they would be required to undertake to meet the target requirements. Mandatory targets are expected to have a higher economic impact than voluntary ones. This option is expected to have highly positive environmental impacts especially in the case that the targets are mandatory. High GHG emission reductions are expected as a consequence of increased renewables uptake. However, care should be taken that such targets do not result in high bioenergy increase without very stringent sustainability checks. Given that bioenergy is expected to be the most accessible solution to meet targets a consequence of a target could result in an increased demand for it, this in turn could have negative consequences on biodiversity loss and afforestation. Option 4 is expected to create a high number of jobs, to manage and carry out the required investments (for the concerned industries), to set up the scheme, verify and follow up (administration), and to invest in renewable assets (RES investors). On the other hand, with the increased ambition, much less free allocation is expected to take place under the ETS, and the importance of a carbon border adjustment mechanism increases strongly if job	A renewable share target would need to be implemented and enforced by member states. The ambition and nature of the target are expected to be subject to high political sensitivity given the different national contexts. A mandatory target would be especially sensitive.	Other policies, regulations and instruments should be considered including to ensure coherence between these and the targets under REDII. These include: the ETS, the ESR, the European Industrial Strategy and the Circular Economy Action Plan	The administrative costs are difficult to estimate due to a number of variables. Compared to the environmental and social effectiveness expected to result from this option they are relatively low.

Impact of measures				
	losses are to be avoided based on the potential of companies relocating out of the EU.			
Option 5 – Option 4 + CCS targets	The conclusions under option 4 are also relevant for this option. On top to these: Additional economic impacts are expected from the deployment of CCS. New investments in infrastructure to capture, transport and store CO_2 would be required. However, the impact on the final price of goods produced from renewable energy and CCS is not expected to be large. This option is expected to have the highest environmental impacts are is would have the largest potential of substantially reducing GHG emissions from industry. CCS could also be used in some cases to achieve negative emission reductions. Social acceptance of CCS is currently low.	A renewable share target would need to be implemented and enforced by member states. The ambition and nature of the target are expected to be subject to high political sensitivity given the different national contexts. A mandatory target would be especially sensitive. Given that in many cases CO_2 transport infrastructure is expected to be trans-European, the EU should play an important role in ensuring that member states have equal access to transport infrastructure and storage sites.	Other policies, regulations and instruments should be considered including to ensure coherence between these and the targets under REDII. These include: the ETS, the ESR, the European Industrial Strategy and the Circular Economy Action Plan and the CCS Directive	Administrative and regulatory costs are expected to be substantially higher than in the case of option 4 given that CCS is not yet a technology that is highly deployed and developing a better regulatory framework would be required.

Annex I: Indicative energy audit costs for manufacturing

Figure 0-16 Energy audit costs for manufacturing[785]

Occupied area (m^2) or energy intensity (PJ)	Member State	Energy audit cost (€)
< 2,500 m^2	Germany	€ 10,000
< 2,500 m^2	France	€ 9,000
< 2,500 m^2	Italy	€ 8,000 - € 9,000
< 2,500 m^2	Denmark	€ 8,000
< 2,500 m^2	Romania	€ 9,000
< 2,500 m^2	Sweden	€ 9,000
2,500-7,000 m^2	Germany	€ 12,000
2,500-7,000 m^2	France	€ 10,000 - € 11,000
2,500-7,000 m^2	Italy	€ 10,000
2,500-7,000 m^2	Denmark	€ 10,000
2,500-7,000 m^2	Romania	€17,000 - 18,000
2,500-7,000 m^2	Sweden	€ 11,000
7,000-15,000 m^2	Germany	€ 14,000
7,000-15,000 m^2	France	€ 13,000 - € 14,000
7,000-15,000 m^2	Italy	€ 12,000 - € 13,000
7,000-15,000 m^2	Denmark	€ 15,000
7,000-15,000 m^2	Romania	€ 21,000 - € 22,000
7,000-15,000 m^2	Sweden	€ 16,000
15,000-40,000 m^2	Germany	€ 18,000
15,000-40,000 m^2	France	€ 17,000
15,000-40,000 m^2	Italy	€ 15,000 - € 16,000
15,000-40,000 m^2	Denmark	€ 25,000
15,000-40,000 m^2	Romania	€ 22,000 - € 23,000
15,000-40,000 m^2	Sweden	€ 27,000
> 40,000 m^2	Germany	€ 23,000
> 40,000 m^2	France	€ 24,000 - € 25,000
> 40,000 m^2	Italy	€ 22,000 - € 23,000
> 40,000 m^2	Denmark	€ 29,000
> 40,000 m^2	Romania	€ 25,000 - € 27,000
> 40,000 m^2	Sweden	€ 32,000
< 0.1 PJ primary energy consumption	Belgium	€ 7,500 - € 10,000
0.1-0.5 PJ primary energy consumption	Belgium	€ 10,000 - € 20,000
0.5-1 PJ primary energy consumption	Belgium	€ 20,000 - € 30,000
> 1 PJ primary energy consumption	Belgium	€ 30,000 - € 100,000
0.015 PJ primary energy consumption	Czech Republic	€ 6,660
0.023 PJ primary energy consumption	Czech Republic	€ 5,550
0.063 PJ primary energy consumption	Poland	€ 5,000
0.021 PJ primary energy consumption	Romania	€ 15,000
0.017 PJ primary energy consumption	Spain	€ 18,000
0.019 PJ primary energy consumption	Spain	€ 18,000
0.022 PJ primary energy consumption	Spain	€ 18,000
0.035 PJ primary energy consumption	Sweden	€ 8,000

[785] EC (2016) A Study on Energy Efficiency in Enterprises: Energy Audits and Energy Management Systems - Library of typical energy audit recommendations, costs and savings. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/EED-Art8-Implementation-Study_Task12_Report_FINAL-approved.pdf

Annex II: Proposed list of sectors to be considered following the sectors considered under the CBAM

Table II-5: Description of the proposed aggregated sectors which are referred to in this report.

Number of installations with open registry account at the end of 2018, average emissions 2017-18, number of PRODCOM categories according to PRODCOM 2019 (unless noted differently in the footnotes). The table also shows which product benchmarks (if any) apply under the EU ETS, and whether indirect emissions play a role (indicated by the fact that there exist indirect cost compensation benchmarks for use by the environmental state aid guidelines.

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[786]	Remarks
Iron & Steel	24.10	Manufacture of basic iron and steel and of ferro-alloys	396	156,358	97	Hot metal EAF carbon steel EAF high alloy steel Iron casting (sintered ore) (Coke) Fall-backs	Basic oxygen steel EAF carbon steel EAF high alloy steel FeSi FeMn SiMn	Benchmarks in brackets may need to be considered for value chain purposes Fall-back approaches for hot rolling and several other processes etc.
	24.20	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	32	1,304	31			
	24.51	Casting of iron	28	1,705	15			
	25.50	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	29	495	1*			
Refineries	19.20	Manufacture of refined petroleum products	130	132,164	10**	Refinery products (Hydrogen, synthesis gas, aromatics, high value chemicals) Fall-backs		Benchmarks mentioned in brackets are derived from the refinery BM Fall-back approaches relevant e.g. for heat imports and exports.
Cement	23.51	Manufacture of cement	214	118,164	3	Grey cement clinker White cement clinker Fall-backs		Fall-back approaches relevant e.g. for heat imports and exports.

786 Indirect cost compensation benchmarks are taken from the 3rd EU ETS phase, as new ones not available yet.

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[786]	Remarks
Organic basic chemicals	20.14	Manufacture of other organic basic chemicals	331	64,877	168	Adipic acid Steam cracking Aromatics Styrene Phenol/acetone Ethylene oxide/ethylene glycols Synthesis gas Vinyl chloride monomer (Refinery Products) Fall-backs	Sector not eligible in 4th phase anymore. However, the following BM were applied in the third phase: Steam cracking (HVC) Aromatics Styrene Ethylene oxide/glycols	Sector can be simplified by including only products directly covered by benchmarks (i.e. by putting the other products into the sector “other chemicals”). Otherwise very high number of very different processes and products, high number of application of fall-back approaches. Refinery products benchmark mentioned, because there is often high integration of processes into refineries, and some benchmarks are derived from the refineries BM.
Fertilizers	20.15	Manufacture of fertilisers and nitrogen compounds	99	36,995	30	Ammonia Nitric acid Fall-backs	Ammonia (not eligible in 4th phase anymore)	
	17.11	Manufacture of pulp	56	1,722	4	Short fibre kraft pulp		

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[786]	Remarks
Pulp & Paper	17.12	Manufacture of paper and paperboard	616	25,510	53	Long fibre kraft pulp Sulphite pulp Thermo-mechanical and mechanical pulp Recovered paper pulp Newsprint Uncoated fine paper Coated fine paper Tissue Testliner and fluting Uncoated carton board Coated carton board Fall-backs		Several products outside the BM definition, hence fall-back approaches relevant.
Lime & Plaster	23.52	Manufacture of lime and plaster	193	26,151	6	Lime Dolime Sintered Dolime (Plaster, Dried secondary gypsum, Plasterboard) Fall-backs		BM products in brackets have significantly lower specific emissions and could therefore be treated separately. Several products outside the BM definition, hence fall-back approaches relevant.
Crude petroleum	06.10	Extraction of crude petroleum	132	23,492	2†	Fall-backs		
	20.11	Manufacture of industrial gases	36	6,438	1	Carbon black	Carbon black	

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[786]	Remarks
Inorganic chemicals	20.13	Manufacture of other inorganic basic chemicals	113	16,045	105	Hydrogen Soda ash (Refinery Products) Fall-backs	Chlorine (not in EU ETS) Si metal hyperpure polysilicon SiC (Silicon Carbide)	Very high number of very different processes and products, high number of application of fall-back approaches Refinery products benchmark mentioned, because the hydrogen benchmark is derived from it. Indirect emissions in some cases more important for CL than direct emissions (Chlor-Alkali).
Food & drink	10.31	Processing and preserving of potatoes	38	1,162	2*	Fall-backs		
	10.39	Other processing and preserving of fruit and vegetables	100	855	1*			
	10.41	Manufacture of oils and fats	95	2,622	30			
	10.51	Operation of dairies and cheese making	133	3,372	5*			
	10.62	Manufacture of starches and starch products	53	4,052	15			
	10.81	Manufacture of sugar	135	8,503	7			
	10.89	Manufacture of other food products n.e.c.	16	618	1*			
	11.06	Manufacture of malt	19	328	2			
Glass	23.11	Manufacture of flat glass	53	5,847	8	Float glass Bottles and jars of colourless glass		Many products outside the BM definition, hence fall-back approaches relevant.
	23.13	Manufacture of hollow glass	197	10,684	18			
	23.14	Manufacture of glass fibres	45	1,149	8			

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[786]	Remarks
	23.19	Manufacture and processing of other glass, including technical glassware	31	547	13	Bottles and jars of coloured glass Continuous filament glass fibre products Mineral wool Fall-backs		Proposal: Include "mineral wool" here instead of under "other mineral products"
Aluminium	24.42	Aluminium production	89	13,755	14	Pre-bake anode Primary Aluminium Fall-backs	Primary Aluminium Alumina (Aluminium Oxide)	Fall-back approaches for forming processes, alloying,… Indirect emissions more important for CL than direct emissions.
Ceramics	23.20	Manufacture of refractory products	47	981	12	Facing bricks Pavers Roof tiles Spray dried powder Fall-backs		Many products outside the BM definition (in particular "normal building bricks", tiles, table and sanitary ware, etc., hence fall-back approaches relevant.
	23.31	Manufacture of ceramic tiles and flags	303	6,829	1			
Coke	19.10	Manufacture of coke oven products	16	5,833	1	Coke Fall-backs		Coke by-products (aromatics) *not* covered by aromatics benchmark (see organic chemicals)
Polymers	20.16	Manufacture of plastics in primary forms	112	4,789	48	S-PVC E-PVC	(Chlorine, Steam cracking)	Potentially very high number of very different processes

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[786]	Remarks
	20.17	Manufacture of synthetic rubber in primary forms	9	866	2	(Steam cracking, Vinyl chloride monomer, Adipic acid, Synthesis gas, Refinery Products) Fall-backs		and products, high number of application of fall-back approaches. Benchmarks in brackets added for the production of the monomers (i.e. pre-cursors of the polymers), as those are the emission-intensive processes, while the polymers are the trade-intensive ones. Refinery products benchmark mentioned, because there is often high integration of processes into refineries.
Non-ferrous metals (except Al)	24.43	Lead, zinc and tin production	20	1,903	11	Fall-backs	Zinc electrolysis	Indirect emissions often more important for CL than direct emissions.
	24.44	Copper production	21	2,040	13			
	24.45	Other non-ferrous metal production	-††	190	42			
Other mineral products	23.99	Manufacture of other non-metallic mineral products n.e.c.	212	3,691	15	Fall-backs		
Other chemicals	20.12	Manufacture of dyes and pigments	22	1,779	31	Fall-backs		
	20.30	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	18	377	2			
	20.60	Manufacture of man-made fibres	19	1,101	24			
Mining	07.10	Mining of iron ores	-††	682	2	Sintered ore Fall-backs		
	08.12	Operation of gravel and sand pits; mining of clays and kaolin	7	156	1*			
	08.91	Mining of chemical and fertiliser minerals	-††	52	4			

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[786]	Remarks
	08.99	Other mining and quarrying n.e.c.	16	1,703	7			
Wood-based panels	16.21	Manufacture of veneer sheets and wood-based panels	108	1,919	18	Fall-backs		
Textiles	13.10	Preparation and spinning of textile fibres	-[††]	28	42			
	13.95	Manufacture of non-wovens and articles made from non-wovens, except apparel	-[††]	68	5			
Other installations			18	1,020				

[†] Number of CN codes given, as there is no PRODCOM code

†† For reasons of confidentiality, these installations have been grouped under "other installations".

** In case of sectors indicated by an asterisk, only a limited number of PRODCOM sectors are on the Carbon Leakage List (CLL)*

*** Number of PRODCOM 2004 codes (no codes in current PRODCOM system); There are 46 corresponding CN codes.*

Annex III: Overview of certification costs breakdown per label

Table III - 1 Overview of certification costs per label

	Label name	Application fee	Licence fee	Certification fee	Auditing costs	Other costs
		1 one-time 2 fixed 3 variable 4 extra fees per each additional product/plant	1 annual 2 biennial 3 fixed 4 sales-related fee 5 options 3 & 4 offered 6 options 3 & 4 required	1 annual 2 biennial 3 five-yearly 4 fixed 5 variable	1 fixed costs 2 variable costs 3 included in the licence fee 4 charged separately by the auditor	1 membership fees 2 additionality funds contribution 3 other
Electricity	Bra Miljöval	1 2 4	1 3		2 4	2
Electricity	EKOenergy		1 4		1 3	2
Electricity	Milieukeur	1 2	1 5		2 4	
Electricity	Grüner Strom Label		1 4	2 5		2
Electricity	Naturemade basic		1 6	3 4	2 4	1
Electricity	Naturemade star		1 6	3 4	2 4	1 2
Electricity	TÜV Süd EE01		1 4	1 5	2 4	3[787]
Electricity	TÜV Süd EE02		1 4	1 5	2 4	3[788]
Electricity	TÜV Nord A75-S026-1	No information available				
Electricity	ok-power			5	2	2
Electricity	Österreichisches Umweltzeichen	1 3 4	1 4			
Heat	Bra Miljöval	1 2 4	1 6		2 4	2
Heat	EKOenergy		1 4			2
Heat	Naturemade basic		1 6	3 4	2 4	1
Heat	Naturemade star		1 6	3 4	2 4	1 2
Gas labels	CertifHy	1 4		1 5	2 4	
Gas labels	EKOenergy		1 4			2
Gas labels	Grünes Gas Label		1 4	2 5		
Gas labels	Bra Miljöval	1 2 4	1 6		2 4	2
Gas labels	TÜV Nord Climate Neutral Gas	No information available				
Gas labels	TÜV Süd Green Hydrogen		1 4	1 5	2 4	
Gas labels	"VSG/GazEnergie Clearinghouse Renewable Gases"			1 5		
Gas labels	Naturemade star		1 6	3 4	2 4	1 2

[787] Variable fee for delivery attestations dependent on the quantity delivered per year and the term of validity of the attestation
[788] Naturemade has a Board which consists of various members, partly being market participants with own market interests

Annex H - Bioenergy Options Analysis

Annex H to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

Acronym	Full name
AGB	Above ground biomass
BAT	Best available technology
BAT-AEEL	Best available technology associated energy efficiency levels
BREF BAT	Best Available Techniques Reference Document
CHP	Combined heat and power
CO2	Carbon dioxide
CoC	Chain of Custody
DG ENV	European Commission's Directorate General for Environment
DH	District heating
EC	European Commission
EEA	European Environment Agency
EU	European Union
FW	Fuelwood
GDP	Gross domestic product
GHG	Greenhouse gases
GW	Gigawatt
GWh	Gigawatt-hour
HCVF	High Conservation Value Forests
JRC	Joint Research Centre
JRC-PPDB-OPEN	JRC Open Power Plants Database
KBA	IUCN Key Biodiversity Areas
ktoe	Kilo ton oil equivalent
FSC	Forest Stewardship Council
ha	hectares
IFCC	Integrated gasification combined cycle
ILUC	Indirect land use change
IRW	Industrial round wood
IUCN	International Union for Conservation of Nature
LULUCF	Land Use, Land-Use Change and Forestry
Mm3	Million cubic meters
MS	Member State of the European Union
Mt	Mega ton
Mtoe	Mega ton oil equivalent
MW	Megawatt
MWh	Megawatt-hour
NAI	Net annual increment
NDC	Nationally determined contribution
NECP	National Energy and Climate Plans
NGO	Non-governmental organization
ODT	Oven-dried ton
OPC	Open public consultation
PEFC	Programme for the Endorsement of Forest Certification
PJ	Peta joule
PM	Particulate matter
RE	Renewable energy
RED (RED I)	Renewable Energy Directive (Directive 2009/28/EC)
RED II	Recast Renewable Energy Directive (2018/2001/EU)
RES	Renewable energy sources
RES-E	Electricity from renewable energy sources
RoW	Rest of the world
SBP	Sustainable Biomass Program
SITC	Standard international trade classification
SME	Small and medium enterprises
TWh	Terawatt-hour
VOC	Volatile organic compound

Background

Introduction

Bioenergy is the energy produced from biomass, either directly or after this is refined into other fuels. Compared to solar and wind, bioenergy is more flexible as it is available in solid, liquid and gaseous forms. **Biomass** is the biodegradable fraction of products, waste and residues from biological origin from agriculture (including animal substances), from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin.

Directive 2009/28/EC on renewable energy (RED) introduced a set of harmonized sustainability criteria only for biofuels and bioliquids. Bioenergy sustainability is a central element of the recast renewable energy directive (RED II), further reinforcing and expanding the sustainability criteria in RED (Article 29), in order to ensure robust GHG emission savings and minimize unintended environmental impacts. RED II extended the EU sustainability framework to also cover the large scale usage of biomass and biogas in heat and power, but differently from biofuels. MSs are allowed to introduce more stringent national measures. RED II aims to protect ecologically valuable lands including lands with high biodiversity, lands with high carbon stock, forests, etc. Furthermore, land use changes that would lead to substantial carbon emissions cannot be used to produce biomass, in order to avoid the significant GHG emissions related to such land use change. Sustainability criteria relate to land use as indicated above, to GHG saving criteria, and to energy efficiency requirements.

Textbox 0-1 Bioenergy sustainability in RED II

In particular, the following Articles address sustainability of bioenergy:

- **Article 26**: Rules for biofuels, bioliquids and biomass fuels produced from food and feed crops;
- **Article 29:** Sustainability and GHG saving criteria for biofuels, bioliquids, and biomass fuels;
- **Article 30:** Verification of compliance with the sustainability and GHG saving criteria;
- **Article 31:** Calculation of the HG impact of biofuels, bioliquids and biomass fuels.
- **Annex V:** Default GHG emission values and calculation rules for liquid biofuels;
- **Annex VI:** Default GHG emission values and calculation rules for power and heat production

The implementation of sustainability criteria is necessary to ensure the Renewable Energy Directive works alongside other key EU strategies, such as the recently relaunched Biodiversity Strategy and the EU Forest Strategy, that is currently being developed. Forests in particular play a complex role, being a source of renewable energy and at the same time a necessary instrument to absorb carbon emissions and ensure biodiversity.

This document presents an analysis of some options considered during the review of the Renewable Energy Directive in early 2021. By drawing from a number of sources, it aims to support the European Commission's assessment of the options in their impact assessment. Rather than providing a complete analysis, the paper focusses on aspects of each option that have been identified as a priority and more in need of new evidence. The early decision to focus on woody biomass was driven by stakeholder feedback on the current implementation of the sustainability criteria. The feedback concerned mainly the need to ensure better coverage of biomass installations and the need to better protect forests from unsustainable and excessive exploitation driven by bioenergy. The European Commission has complemented the findings presented in this report with evidence coming from the public consultation, consultations with other EU actors, such as the JRC, and the results coming from the modelling analysis.

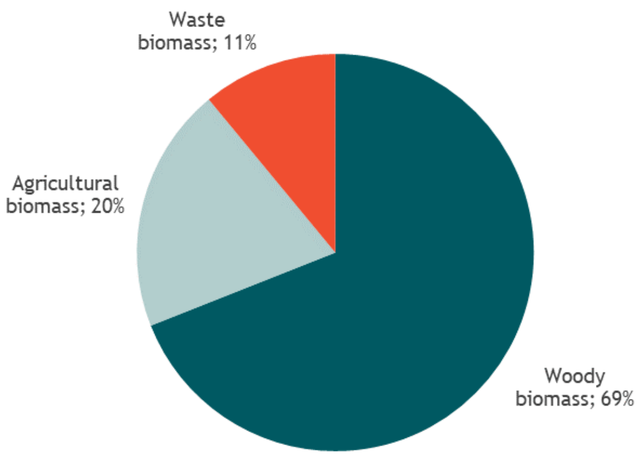
Trends and Projections

Bioenergy

Bioenergy use in heat, electricity and transport fuels is the main source of renewable energy in the EU, contributing to 128 Mtoe (60% of all renewables and 10% of all energy sources) in the EU28 or 8% of gross inland consumption in 2018 and 105 Mtoe (10%) of final energy consumption. Heat is still the largest sector of final bioenergy consumption, representing 75% of total final bioenergy in the EU28 and with its main end-use in the residential sector, followed by electricity (13%) and transport fuels (12%). Solid biomass, mainly from forest resources, represents the largest share (90.8 Mtoe gross inland renewable energy consumption), followed by liquid biomass (14.4 Mtoe), biogas (13.5 Mtoe) and organic waste (9.1 Mtoe).[789]

Targets for renewable energy set by the EU may have resulted in a surge in the consumption of woody biomass. In 2018, the share of woody biomass was 69% (see Figure 0-1) [790]. Wood pellets have experienced a stronger relative consumption growth, reaching 26.1 Mt in 2018 for EU28 compared to 17 Mt in 2013. During the same period, EU production of wood pellets increased from 12 Mt to 16.8 Mt. Hence, imports have been growing rapidly, although Brexit will have a major effect on total pellet consumption, as the UK is responsible for a third of EU pellet consumption and less than 2% of pellet production. [791] Imported solid biofuels, mainly composed of pellets, are only a marginal part of the supply after Brexit (net import of 1.09 million tonnes of wood pellets to the EU-27 in 2018).[792]

Figure 0-1 Distribution of biomass feedstock for energy in 2018 (Source: Bioenergy Europe based on Eurostat data)



[789]PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020, Annexes of the Final Report https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_annexes_final.pdf
[790]Based on Calderón C., Avagianos I., Jossart J.M. (2020). Statistical Report 2020, Bioenergy Europe
[791]Calderón C., Colla M., Jossart JM., Hemeleers N., Cancian G., Aveni N., Caferri C. (2019). Statistical Report – Pellet, Bioenergy Europe.
[792]Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S. (2021). The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

Biogas production is based on the use of various waste products and residues, landfill gas and energy crops (energy grasses, silage maize, etc.). The EU is the world leader in biogas electricity production (where more than 10 GW and 17,400 biogas plants were installed in 2015) as well as in biomethane production for use as a vehicle fuel or for injection into the natural gas grid (with 459 plants producing 1.2 billion m^3).

Employment in the bioenergy economy is most significant in the solid biomass sector, where 360,600 Europeans had a job in 2018. In addition, 248,200 people were employed in the biofuels sector, 68,800 in the biogas sector, and 31,000 in the renewable urban waste sector.[793]

Role and status of forests

From 2000 to 2015, forest area in EU28 has been expanding at a rate of 0.26% per year (413,000 ha), although growth has slowed down since 2010. The increase in forest areas has been accompanied by an increase in the stock of above ground biomass (AGB) by 223 Mt per year on average, corresponding to an annual rate of increase of 1.3%. AGB stock is what determines the potential of forests to act as a sink of GHG emissions. Countries in Central-West Europe account for a large share of AGB (36% of EU28), while southern Europe has much lower biomass stock per hectare, due to ecological factors and forest management practices.[794]

The net annual increment (NAI) is defined as the wood produced in the forest annually minus losses due to natural mortality of trees and indicates the amount of woody biomass added to the AGB per year. Estimates of NAI across EU suggest an EU harvesting ratio below 100%, resulting in a steady increase of forest biomass stock, although with significant differences among MS and from year to year. Because of the increase in biomass stock, EU forests are overall acting as a carbon sink.

Energy accounts for almost half (49%) of total reported uses of woody biomass on EU28 level, but it is important to consider that energy uses are often underreported. Trends indicate a steady increase in production and consumption of fuelwood, although data is only available with several years of delay. Reported fuelwood removals increased from around 70 Mm^3 to about 99 Mm^3 between years 2000 and 2015, while consumption increased from about 69 Mm^3 to around 99 Mm^3. At the same time, imports, especially pellets, have also increased substantially.[795] It is important to clarify that, while the growth in pellets consumption and use has been substantial in the last few years, this has been driven by few countries in EU27, chiefly by Denmark with almost 4 Mtonnes imported in 2018 (double its imports compared to 2016. Following Brexit, import of pellets in the EU block will however decrease—in 2018, the UK was responsible for 43% of pellets imports (almost 8 Mtonnes) and 17% of commercial (>50 kW) consumption. [796]

[793] EurObserv'ER consortium (2020), The State Of Renewable Energies In Europe, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/2020/The-state-of-renewable-energies-in-Europe-2019.pdf
[794] JRC (2018), Biomass production, supply, uses and flows in the European Union https://publications.jrc.ec.europa.eu/repository/bitstream/JRC109869/jrc109869_biomass_report_final2pdf2.pdf
[795] The UK was the EU's large importer of pellets, so imports will register a drop after Brexit.
[796] Calderón C., Colla M., Jossart JM., Hemeleers N., Cancian G., Aveni N., Caferri C. (2019) *Statistical Report - Pellet*, Bioenergy Europe.

While statistical reports do not allow to gauge trends on forest exploitation covering more recent years, recent analysis[797] examined fine-scale satellite data to observe the evolution of forests in Europe. The analysis found an increase in the harvested forest area (49%), an increase in biomass loss (69%) and an increase in the average patch size of harvested area (34%) for the period of 2016–2018 relative to 2011–2015. Largest losses occurred on the Iberian Peninsula and in the Nordic and Baltic countries. This is driven by a number of factors such as the recent expansion of wood markets, wood-based bioenergy and international trade. In recent years, a significant increase in extreme weather events and natural mortality has also been observed. Other studies dispute the size of the increment.[798]

In 2017, the total output of forestry and logging (and related secondary) activities in the EU27 was valued at EUR 55.8 billion.[799] In 2017, the largest contributions were generally made by the growth of forest trees (net increment) in managed forests or by the output from logging activities (industrial roundwood). According to Eurostat, there were 511,000 persons employed in the EU27's forestry and logging sector in 2018, making forests an important source of employment and economic diversification[800] for many rural areas.

The primary products from forestry and logging are industrial roundwood and fuelwood. In 2018, total roundwood production in the EU27 was an estimated 490 Mm^3 (20% higher than in 2000).[801]

Projections

The increased EU ambition with regard to the RES target will have a major impact on the MSs' plans for reducing emissions and promoting renewable energy. It is overall unclear what implications this may have for biomass use for energy purposes, but it is likely to add to pressure for its expansion, alongside growth in all other renewable energies.[802]

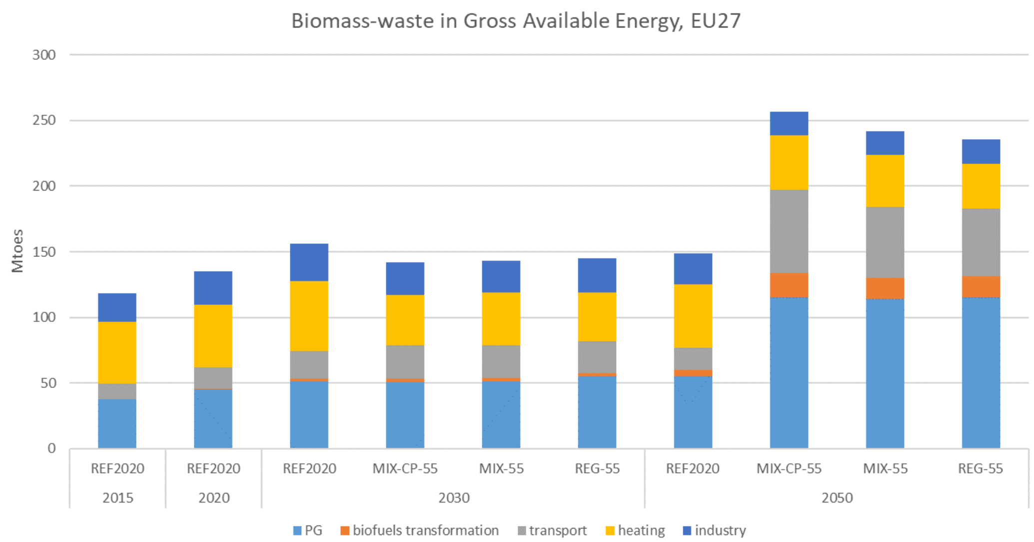
According to information presented in the MSs' National Energy and Climate Plans (NECPs), electricity and heat produced from biomass is expected to increase overall but to decline in proportion to other renewable energy sources by 2030. For biomass used for both power as well as heating & cooling, the planned trajectories suggest a relatively small growth in total EU energy from biomass in the coming decade, while other renewable technologies will grow faster. Nevertheless, in the heating and cooling sector, biomass, and especially solid wood-based biomass, is still planned to provide the majority of renewable energy produced. The planned growth in use of biomass, although small, could have significant impact on increasing the need for biomass inputs. However, there is no assessment of the associated impacts in the NECPs (see section 0).[803]

According to the Commission modelling (PRIMES), projected bioenergy use by 2030 will increase moderately, up to 16% depending on the scenario considered. However, post-2030 bioenergy is set to gain increasing importance with the view to deliver major contribution to that carbon neutrality goal by 2050. Figure 0-2 shows projected use of biomass according to modelling carried out with PRIMES. The

[797] Ceccherini, G., Duveiller, G., Grassi, G. *et al.* Abrupt increase in harvested forest area over Europe after 2015. (2020). *Nature* 583, 72–77). https://doi.org/10.1038/s41586-020-2438-y
[798] Palahí, M., Valbuena, R. et al. (2021). Concerns about reported harvests in European forests. Nature.https://doi.org/10.1038/s41586-021-03292-x
[799] Eurostat pocketbook 2020 - Chapter 5 Forestry activities
[800] Forests provide forestry and logging, wood-based industries, tourism, environmental activities, as well as hunting.
[801] Eurostat pocketbook 2020 - Chapter 5 Forestry activities
[802] Trinomics. (2021). Analysis on biomass in National Energy and Climate Plans
[803] Trinomics (2021) Analysis on biomass in National Energy and Climate Plans

three scenarios (REG, MIX, MIX-CP[804]) include different policy options to reach a 55% reduction in emissions in 2030. Modelling shows that the three scenarios that reach the 55% target reduce the expected use of biomass and waste compared to the baseline, in 2030. As a result, consumption in 2030 is expected to be just above the level it was in 2020 (+7% on average across the three scenarios). On the other hand, post 2030, biomass and waste use is expected to grow by 81% compared to 2050 (+64% compared to baseline).

Figure 0-2 Biomass and waste in gross available energy EU27. Source: PRIMES modelling[805]



National plans

This section is based on a report published in March 2021 that was prepared by Trinomics which was commissioned by FERN[806]. This report assessed the future of biomass use in MSs by reviewing 24 NECPs.

NECP requirements with regard to biomass

As set out in Annex I of the Governance Regulation, the general framework for the integrated NECPs should include:

- (Section A: National Plan, 2.1.ii) estimated trajectories on bioenergy demand, disaggregated between heat, electricity and transport, and on biomass supply by feedstock and origin (distinguishing between domestic production and imports). For forest biomass, an assessment of its source and impact on the LULUCF sink is also required;
- Additionally (in 3.1.2.i or 3.1.2.vii) where applicable, specific measures on the promotion of the use of energy from biomass need to be detailed, especially for new biomass mobilisation, taking into account:
    - Biomass availability, including sustainable biomass: both domestic potential and imports from third countries;
    - Other biomass uses by other sectors (agriculture and forest-based sectors), as well as measures for the sustainability of biomass production and use.

[804] Scenarios names. REG = regulatory approach; MIX = mixed regulatory/market approach; MIX-CP = Mix approach with changes to carbon price
[805] Data from PRIMES
[806] Trinomics (2021). Analysis on biomass in National Energy and Climate Plans. Available at: https://www.fern.org/fileadmin/uploads/fern/Documents/2021/Fern_-_Biomass_in_NECPs_-_Final_report.pdf

- Finally, (under 5.1.i) impact assessments of planned policies and measures, as described in section 3, projections of development of the energy system and GHG emissions and removals as well as air pollutants under the planned policies and measures for at least until 10 years after the period covered by the plan are required, as are policy interactions at national and EU level.

The following table provides an overview of the extent to which each of these requirements have been addressed in the final NECPs of 24 MSs applying a “traffic light” system based on the results of the study performed by Trinomics, which was commissioned by FERN, an NGO.

Table 0-1 Assessment of NECP compliance with Governance Regulation requirements for biomass. ***Source: Trinomics (2021)***

Country	NECP compliance							
	2.1.ii	2.1.iv		2.1.iv	3.1.2.vii			5.1.i
	Trajectories	Biomass supply		Forest biomass source and LULUCF impact	Specific measures on the promotion of the use of energy from biomass	Biomass availability taken into account	Other biomass uses taken into account	Impact of planned measures
		Feedstock origin	Domestic/imports					
Austria	🟡	🔴	🔴	🔴	🟢	🔴	🔴	🟢
Belgium	🟢	🔴	🟢	🟡	🟢	🟢	🟢	🟢
Bulgaria	🟢	🔴	🟢	🟡	🟢	🟢	🟢	🟢
Czechia	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟢
Germany	🟢	🟢	🟢	🔴	🟢	🟢	🔴	🟢
Denmark	🟢	🟢	🟢	🟡	🔴	🔴	🔴	🔴
Estonia	🟢	🔴	🟢	🟡	🟢	🟢	🟢	🟡
Greece	🟢	🔴	🔴	🔴	🟢	🟢	🟢	🟢
Spain	🟡	🔴	🔴	🔴	🟡	🔴	🔴	🟢
Finland	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
France	🟢	🟢	🔴	🟡	🟢	🔴	🔴	🟢
Croatia	🟢	🔴	🔴	🔴	🟢	🔴	🔴	🟡
Hungary	🟢	🟢	🟢	🟢	🟢	🔴	🔴	🟢
Ireland	🟢	🟢	🟢	🟡	🟢	🟢	🟢	🟢
Italy	🟢	🟡	🟢	🔴	🔴	🔴	🔴	🟢
Lithuania	🟢	🔴	🟢	🟡	🟢	🔴	🔴	🟢
Latvia	🟢	🔴	🔴	🔴	🔴	🔴	🔴	🟢
Netherlands	🔴	🔴	🔴	🔴	🟢	🟢	🔴	🟡
Poland	🟢	🟢	🟢	🟡	🟢	🔴	🟢	🟢
Portugal	🟢	🔴	🔴	🔴	🟢	🔴	🟢	🟢
Romania	🟢	🟢	🔴	🔴	🟢	🔴	🔴	🟡
Sweden	🟡	🔴	🟢	🔴	🟢	🔴	🔴	🟡
Slovenia	🟢	🔴	🟢	🟢	🟡	🔴	🔴	🟢
Slovakia	🟢	🟢	🔴	🟢	🔴	🔴	🔴	🟢
Counts								
🟢	20	10	14	5	18	9	8	18
🟡	3	1	0	8	2	0	0	5
🔴	1	13	10	11	4	15	16	1

🟢 Fully complied 🟡 Partially complied 🔴 Not complied

Key findings of the analysis of NECPs are:

- Most MSs provide some information on the planned trajectories of the production of electricity and heat from bioenergy, although only around half specify the amount of (solid) biomass, with many also encompassing bioenergy more broadly. Only the Netherlands was totally deficient in detailing quantified biomass or bioenergy trajectories.
- In contrast, there are significant deficiencies in the information MSs provided on biomass supply and feedstocks and, especially, on the sourcing of forest biomass and its LULUCF impact, where fewer than half of the NECPs provided sufficient information.
- In terms of planned measures for biomass, consideration to, and information on whether biomass availability and its uses, and sustainability measures were taken into account was assessed to be generally poorly addressed. Whilst 18 of 24 MSs had planned measures for biomass, only 9 clearly took into account biomass availability and sustainability. This appears to be a significant gap in policy development.
- The impact of planned measures was modelled in the NECPs but it is usually not possible to separate out the impacts of specific technologies or policies to assess the specific impact from biomass or biomass-related measures. Separating these dimensions would be particularly useful to identify potential positive or negative impacts of biomass, e.g. potential negative impacts on air quality.

Trajectories of biomass use in electricity

A review of the trajectories for biomass use for electricity generation based on the NECPs is summarised in **Table 0-2** below. Trajectories for biomass electricity production are presented by only 10 of the 24 MSs, and a further 13 MSs provide trajectories for bio-electricity (also electricity from both solid biomass and biogas) as a whole. Considering NECPs for which projections are available, MSs plan a total increase in RES-E production of around 58.5% by 2030. At the same time, a smaller increase in biomass for electricity of 18% is planned, driven to a very large extent by the high growth planned in Spain[807]. The relatively small increase in biomass for electricity may be caused by relatively high costs compared to other renewable power technologies. Other studies suggest that the cost of electricity from solid biomass, whilst expected to decrease a little over the next decade, will be amongst the most expensive electricity generation technologies.

[807] In the NECP target scenario for Spain a growth in Biomass capacity from 613MW in 2020 to 1 408MW in 2030 is foreseen, leading to this more than doubling of the production of electricity from biomass.

Table 0-2 Summary of biomass, bioenergy and renewable energy trajectories for electricity in NECPs to 2030

Country	NECP provides trajectory for solid biomass?	NECP Provides trajectory for bioenergy?	Biomass electricity production [GWh]			Bioenergy (including biomass) electricity production [GWh]		
			2020	2030	Change [%]	2020	2030	Change
AT	No	Yes				5,000	6,000	20.0%
BE	Yes	*Yes*	5,430	3,395	-37.5%	*5,430*	*3,395*	*-37.5%*
BG	No	Yes				1,113	1,627	46.2%
CZ	Yes	Yes	2,194	2,497	13.8%	4,825	4,167	-13.6%
DE	No	Yes				46,520	34,890	-25.0%
DK	No	Yes				7,257	6,269	-13.6%
EE	Yes	*Yes*	1,150	1,200	4.3%	*1,150*	*1,200*	4.3%
EL	No	Yes				425	1,575	270.6%
ES	Yes	Yes	4,757	10,031	110.9%	5,570	11,235	101.7%
FI	No	Yes				14,000	16,000	14.3%
FR	No	Yes				9,000	9,000	0.0%
HR	No	Yes				508	1,223	140.7%
HU	No	Yes				2,332	3,229	38.5%
IE	Yes	Yes	337	384	13.8%	523	861	64.4%
IT	No	Yes				19,300	15,700	-18.7%
LT	Yes	Yes	292	583	99.6%	502	950	89.1%
LV	No	Yes				1,000	650	-35.0%
NL	No	No						
PL	Yes	Yes	9,560	11,642	21.8%	11,293	15,875	40.6%
PT	No	Yes				2,750	2,160	-21.5%
RO	No	Yes				900	900	0.0%
SE	Yes	Yes	15,000	16,000	6.7%	16,000	17,000	6.3%
SI	Yes	Yes	151	407	169.2%	291	582	100.0%
SK	Yes	Yes	1,045	1,100	5.3%	1,981	2,540	28.2%
Total	**10**	**23**	**39 917**	**47 238**	18.3%	**157 671**	**157 027**	-0.4%

Legend:
Blue - negative percentage change;
Yellow - positive percentage change.
Source: Own elaboration based on NECPs. Note: Italicised values e.g. for Belgium and Estonia, represent values listed as biomass with no other bioelectricity sources noted, therefore the bioenergy total is assumed to be the same as for biomass.

Trajectories of biomass use in heating and cooling

Table 0-3 provides an overview of planned developments in the use of solid biomass and total bioenergy (including solid biomass) for heating and cooling for the 24 Members States. 18 out of the 24 in-scope MSs presented trajectories for biomass-heat in their NECPs. Overall biomass use for heating and cooling is planned to increase by around 10% by 2030. Nevertheless, biomass is planned to continue to contribute to more around 70% or more of all renewable heat in 2030.

The NECPs provide further information regarding the development of specific heating systems, such as district heating (DH) and combined heat and power (CHP). With regard to DH, the aim of all countries is to increase the share of renewables by 2030. Whilst it was not possible to analyse the role of DH in the NECPs of all countries, examples of the approach from a handful of MSs include: Denmark (an 80% renewable share in DH, mainly through the use of biomass and heat pumps), France (5-fold increase of renewable share in 2030 compared to 2012 values), and Lithuania (90% of the DH from renewables by 2030). Furthermore, several countries, such as France and Slovakia, will set in action additional regulatory and economic measures in order to optimize and develop DH systems.

CHP technologies also contribute significantly to the achievement of MSs targets for 2030, with several mentioning their intention to further develop high efficiency CHP systems both for electricity and heating purposes, and to implement additional measures to promote CHP use. For instance, Austria uses high-efficiency CHP plants based on solid biomass to meet the 100% renewable target, while in Finland, 70% of the DH production is based on CHP, which also accounts for one third of Finland's electricity production. However, it is projected that electricity generation from DH CHP plants will probably decrease. Ireland, by implementing additional measures, expects to increase its biomass CHP electricity generation for the period 2021-2023 to up to 60 ktoe, although a decline to 33 ktoe is planned for the period between 2030-2040.

- **Table 0-3 Summary of biomass, bioenergy and renewable energy trajectories for heat in NECPs to 2030**

Country	NECP provides trajectory for solid biomass?	NECP Provides trajectory for bioenergy?	Biomass heat production [GWh]			Bioenergy (including biomass) heat production [GWh]		
			2020	2030	Change	2020	2030	Change
AT	No	*Yes*	-	-	-	*52,500*	*56,111*	*6.9%*
BE	Yes	*Yes*	16,202	19,367	19.5%	*16,202*	*19,367*	*19.5%*
BG	Yes	*Yes*	12,898	17,538	36.0%	*12,898*	*17,538*	*36.0%*
CZ	Yes	Yes	28,321	35,877	26.7%	31,178	41,476	33.0%
DE	Yes	Yes	118,056	116,944	-0.9%	170,833	179,722	5.2%
DK*	No	Yes	-	-	-	3,281	3,129	-4.6%
EE	*Yes*	*Yes*	*9,000*	*9,600*	*6.7%*	*9,000*	*9,600*	*6.7%*
EL	*Yes*	Yes	*12,037*	*13,281*	10.3%	12,037	13,281	10.3%
ES	No	No	-	-	-	-	-	-
FI	Yes	*Yes*	87,000	97,000	11.5%	*87,000*	*97,000*	*11.5%*
FR*	Yes	*Yes*	145,000	157,000	8.3%	145,000	157,000	8.3%
HR	Yes	*Yes*	12,879	13,743	6.7%	*12,879*	*13,743*	*6.7%*
HU	No	Yes	-	-	-	3,105	6,559	111.2%
IE*	Yes	Yes	2,816	4,860	72.6%	2,928	5,645	92.8%
IT*	No	Yes	-	-	-	84,492	86,411	2.3%
LT	Yes	Yes	14,738	15,619	6.0%	15,086	16,084	6.6%
LV	Yes	*Yes*	3,500	4,300	22.9%	3,500	4,300	22.9%
NL	No	No	-	-	-	-	-	-
PL	Yes	Yes	65,093	84,759	30.2%	66,663	88,725	33.1%
PT	Yes	*Yes*	11,200	11,083	-1.0%	*11,200*	*11,665*	*4.2%*
RO	*Yes*	*Yes*	40,486	46,828	15.7%	40,486	46,828	15.7%
SE	Yes	Yes	106,000	106,000	0.0%	114,000	120,000	5.3%
SI	Yes	Yes	5,989	4,501	-24.9%	6,606	5,599	-15.2%
SK	Yes	Yes	6,978	7,560	8.3%	7,734	8,723	12.8%
Total	**18**	**21**	**698 192**	**765 862**	**9.7%**	**908 609**	**1 008 508**	**11.0%**

Legend:
Blue - negative percentage change;
Yellow - positive percentage change.
** The countries indicated with a star have different starting and ending dates: Denmark: starting date 2021, France: starting date 2021/ending date 2028, Ireland: starting date 2018, Italy: starting date 2017*
Note: Italicised text represents biomass or bioenergy values with no other sources noted, therefore the assumption has been made that totals are the same for both biomass and bioenergy.

Biomass availability and feedstock origins

Almost all MSs provide an indication of their biomass supply up to 2030, often disaggregated per energy use, i.e. district heating, decentralised, etc. Only 14 of 24 of the MSs also refer to their domestic potential for biomass production and, when applicable, about the expected imports from third countries. Of those countries that did report on this issue, most claim to be independent in terms of biomass production since their resources are sufficient to fulfil their energy needs. Ireland, Lithuania, Denmark, Finland, Italy, and Slovenia all indicate they produce solid biomass domestically in volumes large enough to meet part or all of their demand, whilst the Czech Republic and Estonia have large biomass sectors which export biomass to other MSs. Contrarily, Sweden, Belgium, Hungary, and Bulgaria plan to meet their future demand for biomass through imports, either because of low domestic biomass production or potential (e.g., Belgium) or because of increasing biomass needs that cannot be satisfied from the domestic production (e.g. Bulgaria). However, Sweden does not fall under any of those two categories since it has significant potential of biomass feedstocks, but still imports significant quantities of biomass for energy purposes due to the relatively low costs compared to domestic production[808]. The Swedish NECP suggests this will continue.

However, for the reporting of the feedstock origins, only 10 countries detailed their sources for biomass, while 13 countries failed to mention it at all.

Forest biomass and impact on the LULUCF sink

Only 5 countries (Czechia, Finland, Hungary, Slovenia, Slovakia) discussed both forest biomass and the impact on LULUCF sink in their NECPS, while 8 countries partially complied, usually reporting the forest biomass potential but not the feedstocks and the LULUCF impact. Overall, Finland and Hungary fully complied with the specifications of Governance Regulation regarding the biomass availability, forest biomass and its impact on LULUCF. Both countries relied significantly on biomass, and specifically on forest biomass, for electricity and heating purposes and this trend will continue, as the projections suggest. However, their NECPs indicate in both cases that the impact on the LULUCF sector will remain small.

Policies and measures

An overview of the number of current and planned policies covered by the NECPs aiming to boost the use of biomass is provided in **Table 0-4**.[809] This shows policies classified into five main categories, namely energy, air quality, forest management[810], transportation/biofuels and other (innovation, awareness/information, circular economy, waste management) depending on the specific aim of the policy. The table also includes the number of policies that can be identified as subsidies or financial supports. Key highlights are:

- Around 50 current and 60 planned policies for biomass were identified in the NECPs, with the main focus of the measures being to increase energy production from biomass, accounting for more than 60% of all measures. By taking a closer look into specific policies, most of them revolve around 4 main pillars:

[808] Svebio (2014). IEA Bioenergy, Task 40- Country report Sweden. Available at: https://www.bioenergytrade.org/wp-content/uploads/sites/17/2013/09/iea-task-40-country-report-2014-sweden.pdf
[809] In some cases there were no specific references to biomass policies. In those cases, policies aimed at a range of renewable energy sources were recorded, as these were expected to also cover biomass as well (i.e. Germany, Croatia for current policies and Latvia and Czech Republic for planned policies).
[810] The considered policies related to the forest management aim at increasing biomass mobilisation for renewable energy production.

1. Setting up sustainability criteria for biomass used for energy purposes;
2. Funding the expansion of biomass as renewable energy source;
3. Increasing the efficiency of biomass power or heating plants; and
4. Increasing the share of sustainable biofuels in the total fuel mix for transportation.

- Most countries will either apply no additional measures or very few targeting the LULUCF sector (between 1 and 3 policies). The only exceptions are Lithuania with 16 planned policies, Sweden with 6, and the Flemish region of Belgium with 9. However, those policies were not taken into account in the summary table, since they did not target the promotion of biomass and typically focused on agricultural improvements, such as reduced fertiliser use and no tillage techniques;
- Despite a large number of new policies being identified, the planned trajectories for biomass growth in the NECPs do not suggest a major shift in biomass growth rates compared to the last 5 years, i.e., overall there does not appear to be a strong policy push to grow electricity and heat production from biomass. Policies do show a focus, amongst other goals, on improving biomass sustainability criteria;
- The planned measures in the NECPs typically do not quantify the level of subsidy or financial support they provide, if any. This is common to all technologies, not just biomass.

The additional policies and measures that most of the EU MSs are planning to implement are expected to have immediate impacts on the development of the energy system, for example enhancement of the renewable share in the energy mix, as well as on the GHG emissions. However, NECPs typically consider impacts in their entirety, and do not provide significant breakdowns by fuel/technology or by individual policy measures.

- **Table 0-4 Summary of the number of current and planned renewable energy policies aiming at boosting the use of biomass purposes per target for 24 EU MSs**

Countries	Targets													
	Energy (sustainable production, efficiency, security of supply)		Air quality		Forest management		Other (innovation, awareness/information, circular economy, waste management)		Transportation / biofuels		Total		Total of which are financial measures or subsidies	
	Current	Planned	Current	Planned	Current	Planned	Current	Planned	Current	Planned	Current	Planned	Current	Planned
Austria	2	4	-	-	-	-	-	-	-	1	2	5	1	1
Belgium	3	2	-	-	-	-	-	-	-	-	3	2	-	-
Bulgaria	-	3	-	-	1	1	-	-	1	-	2	4	-	-
Croatia	-	-	-	1	-	-	-	1	-	-	-	2	-	-
Czech Republic	5	7	-	-	-	-	-	-	-	-	5	7	1	2
Denmark	4	1	-	-	-	-	-	-	-	-	4	1	1	1
Estonia	1	3	-	-	-	-	-	-	-	2	1	5	1	1
Finland	1	1	-	-	1	-	-	-	1	1	3	2	-	1
France	4	2	-	-	-	-	-	-	-	-	4	2	1	1
Germany	-	1	-	-	-	-	-	1	-	1	-	3	-	1
Greece	-	2	-	-	-	-	1	1	1	2	2	5	-	1
Hungary	1	2	-	-	-	-	-	-	-	-	1	2	1	1
Ireland	1	1	-	-	-	-	-	-	1	-	2	1	-	1
Italy	-	-	-	-	-	-	-	-	2	3	2	3	-	-
Latvia	-	-	-	-	-	-	-	-	-	1	-	1	-	-
Lithuania	3	2	-	-	-	-	-	-	-	-	3	2	2	1
Netherlands	-	2	-	-	-	-	-	-	1	1	1	3	-	1
Poland	-	2	-	-	-	-	-	-	-	-	-	2	-	1
Portugal	1	3	-	-	-	1	-	-	-	1	1	5	-	3
Romania	1	-	-	-	-	-	-	-	-	-	1	-	-	-
Slovakia	-	3	-	-	-	-	-	-	-	-	-	3	-	-
Slovenia	2	1	-	-	-	-	1	-	-	-	3	1	2	2
Spain	2	-	-	-	2	1	-	-	1	-	5	1	1	-
Sweden	1	-	-	-	1	-	-	-	5	-	7	-	3	-
Total	**32**	**42**	**-**	**1**	**5**	**3**	**2**	**3**	**13**	**13**	**52**	**62**	**14**	**19**

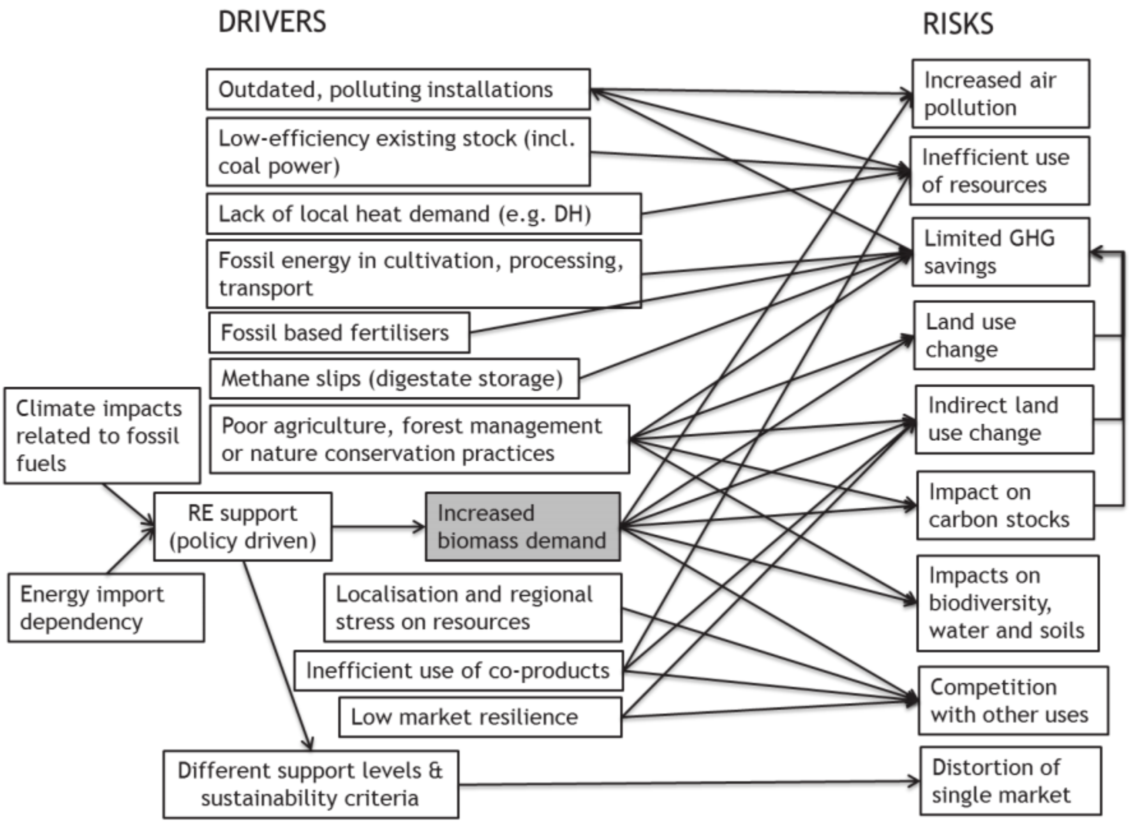
Note: the measures indicated in the table account for those described only under the section 3.1.2. “Renewable Energy” of the NECPs. They do not reflect the totality of the current and planned measures that each country considers. This simple count and classification does not provide a full basis for drawing deep insights on the potential impacts of policies. Nevertheless, it provides an overview of the volume of effort planned by MS, if not its expected effectiveness.

Design

Problem definition

The EU faces an important dilemma: it is impossible to reach the ambitious climate targets without resorting to biomass, but there is a risk that biomass use will lead to further pressure on biodiversity.[811] The problems and policy gaps associated with bioenergy sustainability were extensively examined in the Biosustain report[812] in 2016. Figure 0-3 depicts the key problems and respective drivers associated with bioenergy sustainability, considering both the production of biomass and its use.

Figure 0-3 Problem tree for sustainability risks related to solid biomass and biogas for heat. (PWC, 2017)[813]



The analysis, including the model simulation, that was carried out in 2016 expected an increase in energy demand from biomass from 124 Mtoe in 2020 to 147 Mtoe by 2030 (19% increase). MSs' current plans and forecast, presented in Background, suggest an increase in bioenergy generation of 11% for heat and no increase compared to 2020 for electricity. However, not all MSs have sufficiently developed their plans, which means upwards revisions are possible. Current projections from the EC suggest energy from biomass and waste in 2030 will remain broadly at the same level it was in 2020, even after accounting for the revised target.

[811] PBL. (2020). Availability and application of sustainable biomass. Report on a search for shared facts and views. Available at: https://www.pbl.nl/en/publications/availability-and-applications-of-sustainable-biomass-report-on-a-search-for-shared-facts-and-views
[812] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf
[813] Ibid, page 109

In response to the expected trends for biomass use, and the risk these pose to the environment, human health, and the single market, RED II put in place a series of criteria to ensure biomass production and its use are sustainable and efficient. The European Commission and the JRC[814] maintain that the 2016 analysis and response to the risks identified is broadly correct and sufficient to address the risks.

However, the new EU ambitions and its associated higher target requires to re-evaluate the conclusions reached in 2017 and to consider whether significantly more strict criteria concerning forest biomass should be introduced. The majority of EU civil society (NGOs, environmental organisations, citizens) has repeatedly expressed its opposition to the use of biomass, in particular the use of forests, for energy generation (see analysis of OPC responses in Annex I). Further, the JRC warns that: "*compliance with the RED II criteria for sustainable forest management relies, in the first instance, on the existence of national forest legislation or on management systems at the level of the sourcing area. […] the effective implementation will depend on the fitness of national legislation and guidelines, as well as their effective implementation. […] both EU and national legislations should strive to create the right incentives to promote the win-win pathways and good practices highlighted in this report.*" [815] While these are relevant considerations, it is also important to note that this re-evaluation takes place before RED II is fully transposed[816], and as such there are data and information gaps.

It is possible to consider risks and possible interventions and to address them in three broad categories:

- Improve implementation guidance for MSs;
- Fine-tuning the current approach. RED II sustainability criteria include some exemptions, in order to limit the administrative burden and avoid regulating aspects with relatively little impact overall, such as biomass use in small installations and forests extensions into sensitive areas;
- Abandoning the risk-based approach. Adopting an alternative to the risk-based approach would ensure stricter adherence to the criteria.

Table 0-5, extends the analysis presented in the Biosustain report[817] and introduces a link to the options developed in the following sections of this document.

[814] "…we are of the opinion that several negative impacts associated with the pathways reviewed in this study could be effectively minimised through swift and robust implementation of the RED II sustainability criteria related to forest biomass, which will be further operationalised through the upcoming EU operational guidance on the evidence for demonstrating compliance with the forest biomass criteria." (JRC, 2021, page 10). Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf.

[815] Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S., (2021).The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

[816] Article 36 of RED II requires Member States to adopt the necessary measures by 30 June 2021.

[817] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf

Table 0-5 Risks and policy gaps

Problem/risk	Current approach	Policy gap	Targeted option
Implementation and application of sustainability criteria complex and uneven	MSs allowed to interpret the directive and set their own criteria	Further guidance on new requirements	Option 1
Differences in implementation and application of sustainability criteria	MSs allowed to set stricter criteria	Lack of harmonisation	Option 1
Supply chain related greenhouse gas emissions	New heat and power installations to comply with GHG criteria	Existing heat and power installations are exempt from meeting the criteria	Option 2
Greenhouse gas emissions related to indirect land use change (ILUC)	No go areas for energy crops	Forest biomass is exempted from ILUC rules mandated for crops	Option 2
Biomass conversion is inefficient	CHP compulsory when feasible, minimum 36% efficiency level for large power-only plants	Higher efficiency levels may be desirable	Option 2
Biomass used in heat and power installations comes from unsustainable sources	All plants above 20 MW (solid) and 2 MW (biogas) to comply with sustainability criteria	A substantial share of biomass (25%) is used in smaller installations	Option 3
Unsustainable harvest puts extreme pressure on forest ecosystems leading to adverse impacts on biodiversity, soil and water	Addressed by compliant national legislation If national legislation not present, certification at sourcing area/forest level	Forest biomass is exempted from ILUC rules mandated for crops, which means high biodiversity areas may be used for forest plantations	Option 2
		Cascading use of forest wood not respected, which means too many stems of large diameter may be used in bioenergy rather than used in products with longer carbon sinks (e.g. as industrial wood).	Option 4
		There seems to be an increase in harvest for fuelwood, which could continue in the coming years. RED currently has no mechanism to limit overall quantities.	Option 5

Some risks identified in 2016 are not further considered:

- Distortion of the single market;
- Greenhouse gas emissions related to changes in biogenic carbon stocks;
- Competition with non-energy end-use markets;
- Impact on air quality. Several studies[818,819] suggest that increasing biomass consumption can lead to substantial environmental and health impacts through poor combustion and emissions controls, releasing particulates and other pollutants into homes or the local environment. More

[818] Solarin, S. A., Al-Mulali, U., Gan, G. G. G., & Shahbaz, M. (2018). The impact of biomass energy consumption on pollution: evidence from 80 developed and developing countries. *Environmental Science and Pollution Research*, *25*(23), 22641-22657.
[819] NRDC. (2016). Health Groups to Congress: Burning Biomass is Bad for Health. Available at: https://www.nrdc.org/experts/sasha-stashwick/health-groups-congress-burning-biomass-bad-health

specifically, a 2019 study[820] suggests that the increased consumption of biomass since 2005 resulted to a respective increase in air pollution ($PM_{2.5}$, PM_{10} and VOCs).

Below, the risks underlying the three areas of actions are elaborated further in light of the links identified in Table 0-5.

Implementation guidance

Ensuring the sustainability of biomass production, in particular forest residues, relies on MSs and third countries having appropriate policies in place and enforcing them. Further, RED II adds new monitoring and enforcement requirements on MSs, which are complex and may be totally new for some MSs. These criteria have to be adopted at national level by June 2021, but it may take some time before all MSs are able to implement them correctly. For this reason, options to speed up and improve the uptake of current criteria should be considered.

Fine-tuning the current approach

Considering that it has not been fully implemented yet, the current approach seems broadly sufficient to ensure a sustainable use of biomass. However, there are aspects that could be strengthened or improved:

- The EU Biodiversity Strategy commits to "*strictly protect at least a third of the EU's protected areas, including all remaining EU primary and old-growth forests*". Some MSs have not yet in place legislation that ensures protection to more sensitive areas, such as old-growth forests or endangered ecosystems;
- The current Article 29 treats differently the risk of indirect land use change when it comes to energy crops versus forests (for example, it allows forest plantations in areas of high biodiversity or high-carbon stock, forbidden to energy crops). It also sets different requirements between sectors (liquid biofuels mostly used in transport compared to biomass and biogas for heat and power);
- In order to limit administrative burden, the current Directive excludes from sustainability criteria:
  - Existing bioenergy installations from the application of the GHG saving criteria, meaning they may be using feedstock with high supply-chain emissions;
  - Small installations (below 20 MW for biomass and 2 MW for biogas) from sustainability criteria.
- This leaves a substantial share of biomass supply currently exempt from the criteria. Given the current popularity of small installations, there is a risk that a growing share biomass use is not captured by the criteria;
- The conversion efficiency of biomass installations should be as high as possible to limit the overall quantities of biomass needed. While the majority of biomass installations are medium/small and efficient CHP plants (reaching usually over 70% efficiency), in the EU there are few very large plants producing only electricity that are responsible for using a very large share of total biomass supply. There are also plans for more installations (either as new or conversions) as MSs move to ban coal. These plants are substantially less efficient compared to CHP. RED current approach to limiting the use of biomass in inefficient plants requires:
  - demonstrating that a CHP installation is not viable;

[820] Capizzi, Das, et al. (2019). Renewable energy in Europe - 2019, recent growth and knock-on effects. (European Topic Centre on Climate Change Mitigation and Energy, 2019/8)

    - a power only installation should reach a minimum efficiency level of 36%.
- Therefore, it could be possible to increase the threshold of efficiency required for these plants.

Abandoning the risk-based approach

In the past years, there has been a significant increase in the harvested forest area which is – at least partially – attributed to the existing policy framework which promotes the use of wood in the context of the bioeconomy, in particular for renewable energy generation.[821] According to the risk-based approach, compliance with sustainability criteria can either be demonstrated through effective national or regional legislation, or through management systems at the sourcing area level. This means that, for the purpose of bioenergy to be counted towards the RED target, compliance does not have to be demonstrated at forest level, which leaves open the risk that some fuelwood derived from unsustainably-managed forest is used if that particular forest (or unsustainable practice) is not stopped by national authorities. Essentially, the risk-based approach relies on MSs and third countries' national legislation and its robust implementation. However:

- There are gaps in MSs' legislation ensuring protection to primary forests, but also limits of LULUCF accounting for the protection of production areas located outside the EU. The risk-based principle currently applied recognises the issue, but it assumes that these gaps and limitations are non-material;
- Inadequacy of the limits to the exploitation of forests set by national legislation. For example, MSs may allow logging practices that are not considered sustainable in light of new evidence, or enforcement in some countries may be too lax compared to others;
- A broader issue concerns the use of stemwood for bioenergy production. While there is evidence that a large share of fuelwood is made up of tops, branches and other residues, large amounts of stems are currently used directly for bioenergy; for example, roundwood is the primary source for the production of pellets. Usually, roundwood used for bioenergy is of lower quality, as selling stems as industrial round wood is much more profitable. However, using large amounts of roundwood as fuelwood does not respect the principle of cascading use of biomass and RED targets may be pushing MSs to use more roundwood than it is desirable.

The options

Table 0-6 presents an overview of the six options considered for amending the treatment of bioenergy in the Renewable Energy Directive. Options are analysed in order of departure from current approach, with:

- Option 0 is the current approach (baseline);
- Option 1 considers a series of soft measures (guidance);
- Option 2 considers a number of provisions to strengthen Article 29 and 30;
- Option 3, evaluates extending the number of installations that have to comply with the criteria;
- Options 4 and 5 are additional to option 3 (therefore further strengthening sustainability requirements) and can be considered alternative to each other.

[821] Ceccherini, G. et al (2020), Abrupt increase in harvested forest area over Europe after 2015. Nature 583, 72-77 (2020). Available at : https://www.nature.com/articles/s41586-020-2438-y

Table 0-6 Summary of options considered

Option	Description
Option 0 (baseline)	This option is the baseline and consists in confirming the **current treatment of bioenergy** as set in Article 29 and Article 30. These Articles require some further pieces of legislation to become fully operational, such as: • the Implementing Act on forest biomass (Article 29.8); • the Implementing Act on standards for voluntary schemes (Article 30); and • the new Forestry Strategy. At the time of writing, while RED II is currently in force, these implementing acts and supporting guidelines are not yet completed
Option 1 (non-regulatory)	This option concerns the implementation of a series of **non-regulatory measures**: • new guidance on harmonised implementation of the new sustainability criteria (e.g. Article 29.2 on soil management for agriculture biomass); • new guidance on implementation of Article 3.3 on support schemes for bioenergy; • developing a European tool for harmonised calculations of GHG emissions from biomass in heat and power; • updated guidance on cascading use of forest biomass.
Option 2 (mix)	This option includes **strengthening** the reach of some aspects of Article 29: • application of the existing no-go areas for agriculture biomass to forest biomass (Article 29.3 -5) + new no-go area for 'old-growth forests'; • application of the GHG saving criteria (Article 29.10) also to existing heat and power installations; • stricter energy efficiency criteria for large scale electricity installations (Article 29 para 10).
Option 3 (small installations)	• Application of the **sustainability and GHG saving criteria** to small installations.
Option 4 (certification)	• **National caps on the energy use from stemwood** (above a certain diameter size). This option includes also ○ Sub option 4.1: involving **the full exclusion of stemwood** (excluded coppice), by limiting forest bioenergy use only tops and branches of trees felled for industrial roundwood, and by-products of timber processing such as sawdust and black liquor.
Option 5 (feedstock limits)	• **National caps on the energy use from forest biomass** (based on 2019-2020 values). Forest bioenergy above the cap level would not be eligible for subsidies or accountable for the European/national renewable targets/mandates.

The rest of this chapter provides a full description of these options, the following estimates the effect of these options on bioenergy production and on the supply chain. The last section provides a summary of economic, social and environmental impacts.

Option 0

Articles 29, 30, and 31 of RED II are the key reference text for dealing with bioenergy sustainability. These articles expand sustainability considerations included in RED I and introduce a series of rules and thresholds for the production and use of bioenergy to be considered for the targets set by the directive. The directive came into force on 24 December 2018, with a transposition deadline of 30 June 2021. By January 2021, less than half of MSs had transposed it in national legislation.

Option 0 assumes that all MSs will transpose and apply the current directive, and that further national rules follow the main provisions and various implementing acts which may be adopted by the Commission. These concern areas such as criteria by which to determine which grassland are to be covered by Article 29.3(d), operational guidance for demonstrating compliance with the criteria in Article 29.6 and Article 29.7, and other aspects.

Option 1

Option 1 is a combination of non-regulatory measures to support the way in which MSs and sector operators implement RED II provisions concerning bioenergy sustainability. RED II and subsequent targeted legislation (for example, Directive to reduce indirect land use change for biofuels and bioliquids ((EU)2015/1513[822])) introduced a series of provisions covering aspects such as indirect land use change, bioenergy from waste and residues derived not from forestry but from agricultural land. These add to previous sustainability criteria set in RED I, such as conditions concerning land with high biodiversity value and land with high-carbon stock. Rules surrounding sustainability criteria are in some cases complex to implement, also demonstrated by the fact that they are currently applied unevenly across MSs. RED II also allows MSs to establish additional or stricter sustainability criteria for biomass fuels, which means implementation may diverge substantially. There are opportunities to streamline and improve this process and to ensure only bioenergy with limited environmental and GHG impacts is used to produce energy. Guidance could focus on a number of key areas, described below.

New guidance on harmonised implementation of the new sustainability criteria.

The 11 paragraphs of Article 29 set out the sustainability criteria for eligible biofuels, bioliquids and biomass fuels. Besides a reorganisation of criteria previously included in the first directive, RED II introduces a new approach to address the issue of ILUC. It sets limits on high ILUC-risk biofuels, bioliquids and biomass fuels with a significant expansion in land with high carbon stock. These limits consist of a freeze at 2019 levels for the period 2021-2023, which will gradually decrease from the end of 2023 to zero by 2030. The directive also introduces an exemption from these limits for biofuels, bioliquids and biomass fuels certified as low ILUC-risk.

Other amended provisions include reporting on soil management (Article 29.2)[823], which has become a requirement for biofuels, bioliquids, and biomass fuels produced from waste and residues derived from agricultural land. While monitoring was also required in RED I, the new nature of the plan, including the importance of the monitoring and management aspects of it, requires a much more robust implementation from the MSs and operators.

New guidance on implementation of Article 3.3 on support schemes for bioenergy;

RED II foresees that in designing national policies and support schemes promoting bioenergy, MSs measures have to avoid distortive effects on the raw material markets and respect the waste hierarchy

[822]Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015L1513

[823] *"Biofuels, bioliquids and biomass fuels produced from waste and residues derived not from forestry but from agricultural land shall be taken into account for the purposes referred to in points (a), (b) and (c) of the first subparagraph of paragraph 1 only where operators or national authorities have monitoring or management plans in place in order to address the impacts on soil quality and soil carbon. Information about how those impacts are monitored and managed shall be reported pursuant to Article 30(3)."*

(art 3.3)[824]. MSs have to ensure that the production of energy from biomass is not promoted at the expense of uses higher up in the waste hierarchy. EU guidelines[825] foresee that MSs would assess:

1. Whether there are other uses for that raw material than the production of bioenergy;
2. The raw material's available sustainable supply; and
3. The impact of the national measures on the demand for the raw material.

If it is determined that the national measures result in, or risk resulting in, demand exceeding available sustainable supply, MSs will have to:

a. Determine what level in the waste hierarchy each of the uses of the waste material concerned corresponds to; and
b. Ensure that the national measures incentivising the use of that raw material for bioenergy generation do not result in, or risk resulting in, a shortage of supply of the raw material for the industries using it for it for purposes higher up in the hierarchy.

The assessments required to comply with this provision are complex, which means some MSs may not have the sufficient know-how and availability to determine whether they comply with it. Therefore, as part of option 1, a revised RED II would set the elements to provide further guidance and tools to guide MSs with this assessment.

Developing a European tool for harmonised calculations of GHG emissions of biomass in heat and power

Article 30 (Verification of compliance with the sustainability and greenhouse gas emissions saving criteria) specifies how MSs can ensure compliance with sustainability criteria for biofuels, bioliquids and biomass fuels used in transport. Most of the requirement of the articles are to be adopted via implementing acts.

From January 2021, MSs will also have to ensure compliance with the GHG criteria for new heat and power installations. Annex V provides the rules for calculating *Greenhouse Gas Impact Of Biofuels, Bioliquids And Their Fossil Fuel Comparators*, including default values, methodology, and disaggregated values for part of the process (e.g. cultivation, processing). Annex VI provides the equivalent for *biomass fuels and their fossil fuel comparators*. This element of option 1 consists of developing a tool that Member States and operators can use to evaluate emissions of heat and power from biomass. This would be particularly important to incentivise the use of local biomass sources, as it would allow even small operators to calculate their own specific emissions without excessive administrative burden. The tool itself could be an update to Biograce II[826].

[824] *Article 3.3: "Member States shall ensure that their national policies, including the obligations deriving from Articles 25 to 28 of this Directive, and their support schemes, are designed with due regard to the waste hierarchy as set out in Article 4 of Directive 2008/98/EC to aim to avoid undue distortive effects on the raw material markets. Member States shall grant no support for renewable energy produced from the incineration of waste if the separate collection obligations laid down in that Directive have not been complied with."*
[825] *Guidelines for the implementation of Article 3(3) of the REDII as regards to raw material market distortions https://zerowasteeurope.eu/wp-content/uploads/2019/06/zero_waste_europe_guidelines-for-the-implementation-of-article-33-of-REDII_en.pdf*
[826] See online tool at https://www.biograce.net/biograce2/

Updated guidance on cascading use of forest biomass

In 2018, the EC published the ***Guidance on cascading use of biomass with selected good practice examples on woody biomass***[827]. Biomass cascading use refers to the maximization of resource effectiveness by using biomass in products that create the most economic value over multiple lifetimes. This approach to production and consumption states that energy recovery should be the last option, and only after all higher-value products and services have been exhausted. This option considers updating the guidance in light of new experience, particularly in relation to forestry practices.

Option 2

Option 2 consists in a series of changes, largely applying to Article 29, which would strengthen the requirements associated with sustainability criteria and their application.

No-go areas and 'old-growth forests' (29.3 – 29.5)

RED II (81) expands the criteria protecting land with high biodiversity value and land with high-carbon stock (part of Directive 2009/28/EC) to include ILUC, which "*occurs when the cultivation of crops for biofuels, bioliquids and biomass fuels displaces traditional production of crops for food and feed purposes. Such additional demand increases the pressure on land and can lead to the extension of agricultural land into areas with high-carbon stock, such as forests, wetlands and peatland, causing additional greenhouse gas emissions*." The current wording limits the application of the ILUC criteria to cultivation of crops, omitting the case in which forests expansion displaces areas with high-carbon stock and high biodiversity. This provision would not affect the active management of forests for the purpose of producing biomass but would restrict manmade expansion of forests into areas with high biodiversity and high carbon stock, such as wetlands, peatlands and primary forests. This new option will maintain the exemptions for low indirect land-use change-risk biofuels, bioliquids and biomass fuels.

At the moment, forests biomass cannot be extracted from protected areas, but if a MS has failed to sanction some areas as such, old-growth forests can be still harvested for biomass. This option will also set an additional no-go area defined as old-growth forests. The EEA defines old growth forests as: *primeval, ancient, wilderness, virgin, pristine while in forester's terminology they are called as over-matured, decadent, and senescent, old growth. The old growth forests may be defined as a climax forest that has never been disturbed by man. The old growth forests can be classified as per the age and disturbance criteria.* Forbidding the inclusion of old-growth forests will ensure that biomass is obtained from younger forests, where man's intervention has already affected the ecosystem, and will ensure that forests with high-carbon stock are not replaced by younger forests with much lower carbon content.

The extension of the no-go areas for forest biomass will overcome the poor granularity of LULUCF accounting and it will support the objectives of the Biodiversity Directive by protecting naturally richer ecosystems.

Application of the GHG saving criteria (Article 29.10) also to existing heat and power installations

The GHG saving criteria requires that transport fuels of biological origin and bioliquids that contribute to the RES target have to be generated through processes that ensure at least a minimum amount of

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[827] European Commission. (2019). Guidance on cascading use of biomass with selected good practice examples on woody biomass. Available at: https://op.europa.eu/en/publication-detail/-/publication/9b823034-ebad-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-80148793

GHG savings compared to traditional fuels. A requirement of at least 70% savings will also *apply to electricity, heating and cooling production from biomass fuels used in installations starting operation from 1 January 2021 until 31 December 2025, and 80 % for installations starting operation from 1 January 2026*. The European Commission provides guidelines on how these savings should be calculated.[828]

Option 2 concerns extending the application of the GHG saving criteria to existing heat and power installations, rather than only transport fuels and new heat and power installations. In order to implement this, RED will have to specify the thresholds for installations of different type and age, and clarify the implementation period (i.e., the time available for these installations to reach the standards before the energy they produce will be excluded from accounting for the purpose of the RED target).

This provision will tackle two problems:

- Inconsistency in how fuels with the same characteristics and sustainability credentials are treated across sectors;
- Avoiding that biomass and biofuels used in H&P comes from inefficient pathways.

Stricter energy efficiency criteria for large-scale electricity installations (Article 29.11);

Articles 29.10 and 29.11 set a number of requirements for electricity production from biomass. Article 29.10 concerns the GHG saving criteria and applies to installation starting operations from 1 January 2021. Article 29.11 specifies different energy efficiency requirements according to the thermal inputs of electricity plants, unless the plant is equipped with CO_2 capture. Article 29.11 specifies three sizes with the following minimum efficiency requirements:

- Below 50 MW: no requirement;
- Between 50 MW and 100 MW;
    - high-efficiency cogeneration technology; or
    - best available techniques (BAT-AEELs) as defined in Commission Implementing Decision (EU) 2017/1442 (26), (if electricity-only installations);
- Above 100 MW:
    - high-efficiency cogeneration technology; or
    - net-electrical efficiency of at least 36% (if electricity-only installations)

The criteria for plants below 100MW apply to installations starting operation or converted to the use of biomass fuels after 25 December 2021.

This option concerns electricity-only plants above 100 MW, as those between 50 MW and 100 MW are dealt with by 2017/1442 (26). The option considers an increase of the 36% net-electric efficiency required for these plants.

Option 3

Option 3 includes the provisions of option 2, also adding sustainability and GHG saving criteria to small installations.

[828] JRC, ICF, and Fraunhofer ISI. (2020). Draft Methodology for Calculation of GHG emission avoidance. Available at: https://ec.europa.eu/clima/sites/clima/files/innovation-fund/20200205_ghg_en.pdf

Article 29.10 states that: "Biomass fuels shall fulfil the sustainability and greenhouse gas emissions saving criteria laid down in paragraphs 2 to 7 and 10 if used in installations producing electricity, heating and cooling or fuels with a total rated thermal input equal to or exceeding 20 MW in the case of solid biomass fuels, and with a total rated thermal input equal to or exceeding 2 MW in the case of gaseous biomass fuels. Member States may apply the sustainability and greenhouse gas emissions saving criteria to installations with lower total rated thermal input."

Essentially, in order to minimise the administrative burden on smaller electricity, heating, and cooling installations, these are exempt from complying with sustainability criteria. This creates a risk that a large share of biomass is sourced outside the sustainability framework.

Option 3 foresees the changes as indicated for option 2 plus the extension of the sustainability and GHG saving criteria to small installations, essentially concerning Articles 29.2 to 29.7. The limit could be set to include installations above 5 or 10 MW in the case of solid biomass fuels, and with a total rated thermal input equal to or exceeding 1 MW in the case of gaseous biomass fuels. This option would apply to existing and new plants.

Option 4

Option 4 is also additive to the previous ones (it includes all elements considered up to option 3) but also includes the introduction of national caps on the energy use from stemwood (above a certain diameter size). An alternative to the cap is a complete exclusion of stemwood (sub-option 4.1).

Both options aim to limit forest bioenergy use only to tops and branches of trees felled for industrial roundwood, and by-products of timber processing such as sawdust and black liquor.

Implementing either option 4 or 4.1 would require specifying the boundaries and rules of application of the cap/ban. For example:

- Maximum thresholds may still be set in the directive, although the maximum diameter may be set at the MS level which would vary with the species;
- A cap/ban would likely apply to imports, but modalities for application may vary;
- Salvage logging (i.e. wood from storms, pests, and diseases) would be excluded from the cap/ban;
- Flexibility systems may be allowed within the cap, for example to smooth out annual variations;
- Allowance of some species and/cultivation methods, e.g. stemwood from coppice could be exempt from the ban.

The analysis presented here does not consider these implementation details, focussing on the higher level impacts of such options.

Option 5

Option 5 is additive to option 3 and alternative to option 4. This option would impose national caps on the energy use from forest biomass, indicatively, based for example on 2019-2020 values. This option means that additional forest bioenergy would not be eligible for subsidies or accountable for the European/national renewable targets/mandates.

Similar to option 4, the rationale behind option 5 is to protect EU forest from excessive exploitation driven by bioenergy. In this case the limit would apply to all quantities to forest bioenergy, also ensuring a close monitoring and discouraging any substantial or unchecked expansion of fuelwood production.

Other options considered

Full harmonization

This option **considers a full harmonization of sustainability criteria for biomass fuels in heat and power.** Unlike biofuels and biogas consumed in the transport sector, additional sustainability requirements (land and end-use criteria) for biomass fuels are still possible at MS level as well as various options for compliance verification. For biomass fuels, therefore, a full EU harmonisation is not yet achieved under RED II. For example, MSs may apply higher energy efficiency requirements for biopower[829], apply energy efficiency requirements to installations with lower rated thermal input or extend the application of end-use criteria to existing installations.[830]

This option would prevent MSs from imposing additional sustainability criteria, or from imposing criteria on installations with lower capacities than those specified in RED. Further, MSs will not be able to impose restrictions to the type of feedstock (such as requiring certification) beyond what is required under RED II.

The aim of this option is to improve the workings of the internal market by avoiding divergent implementation, while the other elements of option 2 will ensure a heightened coverage is achieved.

Certification

This option considers replacing the RED II risk-based criteria for forest biomass with an obligation to demonstrate compliance with sustainability and LULUCF criteria at the biomass sourcing area level or the forest unit level. It is assumed that this option will be implemented together with the changes considered under option 2, and the analysis will focus on the additional impacts to those estimated for option 2.

Articles 29.6 and 29.7 define a process for ensuring that biomass complies with the risk-based criteria. There is first a check of whether evidence is available for compliance at a national/sub-national level (Evidence A). If evidence is not available for any of the criteria mentioned in Article 26.6 (a), then evidence at forest sourcing area level should be provided (Evidence B).[831]

The risk-based name is used because, while it cannot be ensured that the biomass sold from a certain forest is sustainable, the fact that the country has a national/subnational legislation and monitoring/enforcement system provides sufficient guarantees that the biomass used will be sustainable.

[829] Article 29.11 states that “Member States may apply higher energy efficiency requirements than those referred in the first subparagraph to installations with lower rated thermal input”.
[830] CA-RES. (2020). Core theme 4 – Biomass mobilisation and Sustainability. Available at: https://www.ca-res.eu/fileadmin/cares/PublicArea/CA-RES3FinalPublication/CARES3_Final_CT4_Summary.pdf
[831]REDIIBIO. (2019). Technical Assistance Project on the implementation of the new bioenergy sustainability criteria set out in the revised Renewable Energy Directive, Workshop report. Available at: https://efi.int/sites/default/files/files/bioeconomy/project-bank/REDIIBIO_Workshop%20report.pdf

The Commission has launched the REDIIBIO project, to contribute to the harmonized and cost-effective implementation by the EU MSs of the new RED II sustainability criteria. This work will also provide input for economic operators who are active in the sourcing of sustainable biomass for energy generation, and auditors and verifiers in their assessment on whether economic operators have effectively complied with the new bioenergy sustainability criteria.

A JRC analysis of the most common pathways for forest biomass production concludes that several negative impacts associated with the pathways could be effectively minimised through swift and robust implementation of the RED II sustainability criteria related to forest biomass. A successful implementation relies on the strength of the upcoming EU operational guidance on the evidence for demonstrating compliance with the forest biomass criteria. JRC also observes that compliance with the RED II criteria for sustainable forest management relies, in the first instance, on the existence of national forest legislation or on management systems at the level of the sourcing area. Therefore, the realisation of the guarantees provided by the sustainability criteria will depend on the fitness of national legislation and guidelines, as well as on their effective implementation.[832]

This option would entail removing case *a* in Article 29.6[833]. To ensure forest biomass is sustainably produced it would not be sufficient to rely on national laws and monitoring processes being in place, but monitoring and certification will have to be carried out at the biomass sourcing area level or the forest unit level. This option will address differences and shortcomings in legislation and its implementation at MS level. However, given that certification does not cover emission removals from agriculture, forestry, and land use, the country of origin must still comply with Article 29.7. This means being a signatory to the Paris agreement, having submitted estimates of nationally determined contribution (NDC) and having national or sub-national laws in place to comply with LULUCF and conserve and enhance carbon stocks and sinks, including providing evidence that reported LULUCF-sector emissions do not exceed removals.

Forest certification schemes are market-based instruments which seek to improve consumer awareness of the environmental qualities of sustainable forest management and to promote the use of wood and forest products as environmentally friendly and renewable raw materials[834]. Using existing certification schemes for the purpose of monitoring the implementation of RED sustainability criteria will require an assessment of whether these ensure coverage of the areas listed in Article 29.6(b):
management systems are in place at forest sourcing area level ensuring:

1. the legality of harvesting operations;
2. forest regeneration of harvested areas;

[832] Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S. (2021). The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

[833] Case a in Article 29.6 requires that "The country in which forest biomass was harvested has national or sub-national laws applicable in the area of harvest as well as monitoring and enforcement systems in place ensuring: (i) the legality of harvesting operations; (ii) forest regeneration of harvested areas; (iii) that areas designated by international or national law or by the relevant competent authority for nature protection purposes, including in wetlands and peatlands, are protected; (iv) that harvesting is carried out considering maintenance of soil quality and biodiversity with the aim of minimising negative impacts; and (v) that harvesting maintains or improves the long-term production capacity of the forest."

[834] European Commission. (n.d.). Forest Certification. Available at: https://ec.europa.eu/environment/forests/fcertification.htm

3. that areas designated by international or national law or by the relevant competent authority for nature protection purposes, including in wetlands and peatlands, are protected unless evidence is provided that the harvesting of that raw material does not interfere with those nature protection purposes;
4. that harvesting is carried out considering the maintenance of soil quality and biodiversity with the aim of minimising negative impacts; and
5. that harvesting maintains or improves the long-term production capacity of the forest.

Limiting the use of certain feedstock

This is a further extension to the provisions included in option 2, which aims at replacing the RED II risk-based approach for forest biomass with a limit on the use of certain feed-stock. The limit could be imposed so that:

- only feedstock listed in Part A of Annex IX of RED II is eligible;
- only small roundwood below a certain dimeter (e.g. 20 cm) is eligible.

Currently, Annex IX allows:

(o) Biomass fraction of wastes and residues from forestry and forest-based industries, namely, bark, branches, pre-commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin and tall oil;

(p) Other non-food cellulosic material;

(q) Other ligno-cellulosic material except saw logs and veneer logs.

By restricting forest removals to feedstock other than saw logs and veneer logs, it would essentially forbid the use of wider roundwood/stemwood.

Mapping impacts

The following table provides an overview of the mapping of impacts per option, providing:

- Direction: Positive or negative;
- Magnitude: limited or significant;
- Horizon: Short to long term;
- Affected parties: following categorization indicated below.

Table 0-7 Mapping of impacts per option

Option	Description	Expected effects	Economic	Environmental	Social
Option 1	- New guidance on harmonised implementation of the new sustainability criteria (e.g. Article 29.2 on soil management for agriculture biomass); - new guidance on implementation of Article 3.3 on support schemes for bioenergy; - developing an European tool for harmonised calculations of GHG emissions of biomass in heat and power (e.g. updating Biograce 2); - updated guidance on cascading use of forest biomass.	Improved application of RED II provisions; improved harmonisation; reduced implementation and monitoring costs	D: positive M: limited H: short A: MSs', bioenergy installations, forest owners	D: positive M: limited H: short A: MSs, bioenergy installations, forest owners	D: neutral M: limited H: short A: bioenergy installations, forest owners
Option 2	Option 0 + - application of the existing land criteria (no-go areas) for agriculture biomass to forest biomass (Article 29.3 -5) + new no-go area for 'old-growth forests'; - application of the GHG saving criteria (Article 29.10) also to existing heat and power installations; - stricter energy efficiency criteria for large scale electricity installations (Article 29 para 10)	Reduction of forests available for compliance with the target; increase in costs/closure of existing H&P installations and large-scale electricity installations; improved power-only efficiency;	D: positive M: limited H: short A: MSs, bioenergy installations, forest owners	D: positive M: limited H: short A: MSs, bioenergy installations, forest owners	D: positive M: limited H: short A: MSs, bioenergy installations, forest owners
Option 3	Option 2 + - Application of the sustainability and GHG saving criteria to small installations (e.g. equal or above [5] or [10] MW).	Share of biomass from smaller heat and power installations (currently equal to 25%) is sustainably sourced	D: Negative (increased compliance & fuel costs) M: limited H: short A: small bioenergy installations, local biomass suppliers, MS	D: Positive M: limited H: short A: small bioenergy installations, local biomass suppliers	D: Neutral M: limited H: short A: small bioenergy installations, local biomass suppliers
Option 4	Option 3 + - Extend the RED II risk-based approach for forest biomass with a cap or complete ban on stemwood above a certain size.	Address negative impacts on biodiversity, soil, water deriving from excessive harvesting of stemwood	D: Negative (Increase in certification, compliance cost and in biomass fuel cost, monitoring costs) M: Significant H: Medium A: Forest owners, intermediaries, biomass installations, MS	D: positive (Improved environmental management and increased sustainability of forest biomass) M: Significant H: Medium A: Forest owners	D: Positive M: Limited H: Medium A: Certification industry
Option 5	Option 3 + - Extend the RED II risk-based approach for forest biomass with a cap or complete ban on stemwood above a certain size.	Address negative impacts on biodiversity, soil, water deriving from additional harvesting of forest fuelwood	D: Negative (Limited supply, possible increase in biomass fuel cost, monitoring costs) M: Significant H: Medium A: Forest owners, biomass installations, MS	D: positive (Improved environmental management and increased sustainability of forest biomass) M: Significant H: Medium A: Forest owners, biomass installations	D: Neutral M: Limited H: Medium A: Small forest owners

Analysis

This section presents the result of the qualitative analysis, drawing from a number of sources. A key reference document is the 2016 Impact Assessment *Sustainability of Bioenergy* (accompanying the *Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources)* and the various studies and analysis produced in its support. This was complemented by a number of additional sources that provide more updated information. Based on these findings and on additional sources, the next chapter draws conclusions in terms of economic, social and environmental impacts.

Option 1

Biomass sustainability is a complex issue, and this complexity is often reflected in national and local policy frameworks, leading to potential compliance risks with RED. For example, the Nordic countries have highlighted risks with regards to differences in definitions between the directive and local legislation, in particular regarding harvesting permits and forest regeneration.[835] There is no information regarding the implementation gap at this stage given that the transposition deadline is set for mid-2021; however, it can be expected that these issues would lead to under performance as well as increased administrative burden for national authorities. Additional guidance to address the gap in understanding would improve compliance with RED and reduce differences across MSs.

This option consists in providing additional support to MSs with regards to:

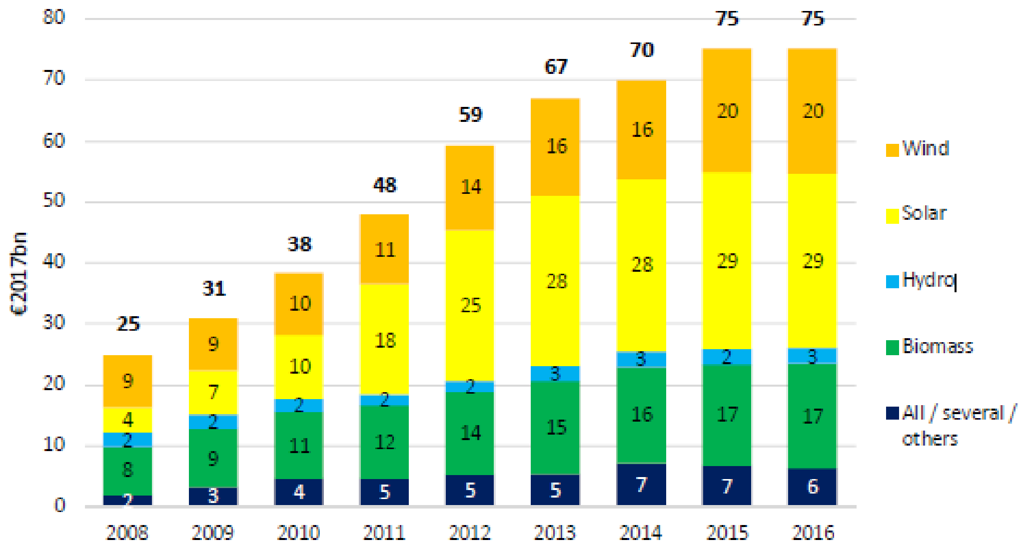
- Guidance for harmonised implementation of the new sustainability criteria;
- Guidance for implementation of Article 3.3 on support schemes for bioenergy;
- European tool for harmonised calculations of GHG emissions of biomass in heat and power;
- Updated guidance on cascading use of forest biomass.

Option 1 would provide technical and institutional support, and would therefore ease and accelerate the process of implementation, reducing the costs for national authorities responsible. Providing guidance at EU level (option 1) will have direct benefit to **national authorities by reducing their administrative costs**. The RED II IA (2016) estimated the cost of public administration of the 5 bioenergy options assessed using the standard cost model. Costs include one-off costs in the range of €60,000 to €200,000 as well as recurring yearly costs between €400,000 and €1 M. Part of these costs go to setup national guidance and national monitoring tools. By providing guidance, developing methodologies and tools, and defining default values at EU level, this option would reduce the costs of implementing RED II at national level and it will improve monitoring practices – for example reducing the sector operator’s challenges to national ruling. However, it is important to take into account that, depending on the time of implementation, these one-off costs (or a large part thereof) may already have been incurred as the RED II implementation should take place by mid-2021. Therefore, the largest share of the impact will be on recurring administrative costs. The main cost associated with Option 1 is the development of guidance at EU level, with negligible costs compared to the implementation cost of the directive.

[835] NER and Pöyry. (2018). A Nordic analysis of the proposed EU policy for bioenergy sustainability. Available at: https://www.nordicenergy.org/wordpress/wp-content/uploads/2018/01/A-Nordic-analysis-of-the-proposed-EU-policy-for-bioenergy-sustainability_Final.pdf

Financial support for biomass has been steadily increasing over the past years and reached over €17 billion in 2016 in EU28.[836] Additional guidance for the implementation of Article 3.3. on support schemes for bioenergy may also lead to a larger indirect impact by affecting how MSs set financial support measures for biomass.

Figure 0-4 Financial support to RES by energy source for EU28 (2008-2016, €2017bn).[837]



A study reviewing biomass subsidies in 15 EU countries found that over 2015-2016 the subsidies provided to the use of solid biomass for energy purposes increased.[838] The study also found a clear correlation between countries with high share of the renewables support going to biomass and the share of biomass in gross electricity generation.[839] Especially for those countries, more strict guidance on the implementation of Article 3.3. may have an impact on the amount of subsidies available and therefore on the biomass used.

[836] Trinomics. (2018). Study on Energy Prices, Costs and Subsidies and their Impact on Industry and Households. Available at: https://op.europa.eu/en/publication-detail/-/publication/d7c9d93b-1879-11e9-8d04-01aa75ed71a1/language-en
[837] Ibid.
[838] Trinomics. (2019). Financial support for electricity generation & CHP from solid Biomass. Available at: http://trinomics.eu/wp-content/uploads/2019/11/Trinomics-EU-biomass-subsidies-final-report-28nov2019.pdf
[839] Ibid.

Table 0-8 Overview of share of biomass in total renewable energy subsidies for selected countries in 2015 and 2016.[840]

Country	Bioenergy subsidies (EUR million)		RES subsidies (EUR million)		Bioenergy as % of total	Bioenergy as % of total
	2015	2016	2015	2016	2015	2016
Finland	79	47	229	194	35%	24%
Austria	283	275	1,096	1,179	26%	23%
Belgium	279	309	1,395	1,378	20%	22%
United Kingdom	1,384	1,399	9,391	8,658	15%	16%
Sweden	60	53	381	368	16%	14%
Slovakia	52	67	474	464	11%	14%
Spain	781	948	9,261	8,179	8%	12%
Portugal	86	80	963	1,137	9%	7%
Germany	1,724	1,746	25,544	26,199	7%	7%
Italy	242	740	12,169	11,877	2%	6%
Poland	79	39	1,019	636	8%	6%
Ireland	4	9	97	160	4%	6%
Denmark	60	59	1,117	1,107	5%	5%
The Netherlands	29	57	863	1,159	3%	5%
France	256	319	5,544	6,497	5%	5%
Total	**5,399**	**6,147**	**69,541**	**69,192**	**8%**	**9%**

The cost and the benefits of Option 1 are relatively limited in the context of RED. It is expected these will be net positive as the option will improve the implementation of the Directive, therefore ensure a higher degree of compliance with sustainability criteria and, ultimately, lead to a reduction in GHG emissions.

Option 2

This section estimates the effects of the three proposed changes separately. In particular, the analysis focusses on determining the affected quantities of biomass and extent of forest areas; number of bioenergy installations affected; and effects on internal trade.

No-go areas

Extending the protection of ecosystems currently granted to agriculture biomass to forest biomass, means that forest owners will not be able to extend their productive area into areas of high biodiversity or high carbon stock (converted after 2008). The benefits of extending protection to primary forests[841] has been raised in the past and has recently been confirmed by the JRC[842]: "*biomass produced from plantations established on recently cleared natural forest cannot be eligible for bioenergy use. This would also remove pressure for future conversions by lowering the demand of wood from these plantations, at least for energy use*". The same report also states that: "*Expanding such land criteria to forest biomass would introduce additional safeguards to ensure that forest biomass for energy is not associated with the afforestation pathways that have the most negative impacts, i.e., those on*

[840] Ibid.
[841] The JRC conclusion does not refer to highly biodiverse forests, peatland and wetlands – all no-go areas for agricultural biomass under REDII.
[842] Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S. (2021). The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

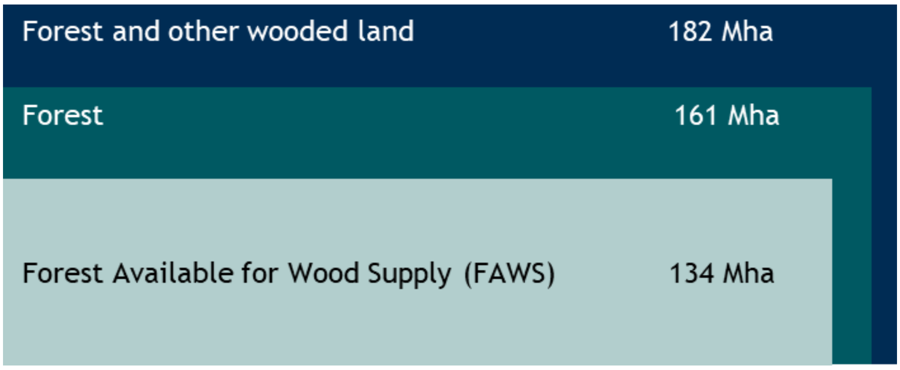
high-nature value grasslands or anthropogenic heathlands, and it would also forbid the sourcing of wood from plantations established on converted old-growth, primary forest for energy feedstock." The main effect of such a provision will be a reduction in forest areas available to be harvested for the purpose of bioenergy. This may include some forest plantations created after 2008 and currently exploited, but to a large extent it would affect any potential development into these sensitive areas in the future.

Currently, the application of Article 29 to forest biomass relies on MSs having in place adequate protection for forest areas and accurately identifying those to be protected. In practice, this means that if a forest area is not formally protected it can be exploited for biomass production, even though it may have all the characteristics to be protected or meet the exclusion criteria in Article 29.3-5. To understand the magnitude of this effect, it is necessary to estimate the amount of forest area that may be affected and compare this with the total area currently exploited for bioenergy purpose. If the provision affects significant areas, it is reasonable to expect an impact on availability and price of forest biomass. If the areas affected is small, it is reasonable to expect the effect of this extended protection on quantities and prices to be minimal, as it may simply shift harvesting from no-go areas to allowed areas.

It is also important to recognise that such a provision will not completely stop commercial exploitation of these areas, if MSs allow it. However, it will reduce the economic incentives of doing so, as fuelwood removed would not be claimed towards the target or receive incentives.

Forest is defined as land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10%, or an area where trees are able to reach these thresholds in situ. The vast majority of woody biomass comes from forests, but it is additionally found in trees outside of *forest areas* (defined as *other wooded land*). Across the EU, 38% of the land is occupied by forests being made up of two or more tree species. Around 60% of this area is under private ownership, and it is estimated that in Europe there are over 16 million forest owners, the majority of which possess small holdings. In total, woody biomass grows in 182 Mha of land, although not all of this is available for wood supply.[843]

Figure 0-5 Availability of woody biomass (EU28) [844]



[843] JRC. (2018). Biomass production, supply, uses and flows in the European Union. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC109869/jrc109869_biomass_report_final2pdf2.pdf
[844] Idem.

Old-growth forests includes primary and secondary forest, according to the definitions of the European Commission and Convention on Biological Diversity. Primary forests are defined as "*naturally regenerated forests of native species where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed*.[845] DG ENV, with the support of JRC, is currently working to identify primary and old-growth forest in the EU, and the result of a recent JRC publication are presented below.

The rest of this section examines three sources that evaluate the overall status of forests in Europe from Forest Europe), Sabatini et al. (2020) and FAO's Global Forest Resources Assessment, as reviewed by the JRC[846]. Data from Sabatini et al (2018) is also used to estimate extension of protected areas. Finally, the results of the 2016 Impact assessment for bioenergy sustainability, which attempts to model the consequences of an extension to forest bioenergy of the limitation applied to energy crops, are discussed.

The three studies confirm that primary forests occupy a limited extent of forests area in EU, between 2% and 3%, with differences due to methodology, definition and data collection methods. The vast majority (90%) of primary and old-growth forests in the EU is located in Sweden, Bulgaria, Finland and Romania, and about 93% of the mapped primary and old-growth forests are part of the Natura 2000 Network. Overall, 87% of primary and old-growth forests in the EU are strictly protected (IUCN categories Ia, Ib and II).

Estimates of primary and old growth forests

According to Forest Europe[847], most of the forests undisturbed by man[848] are located in North, South-East and Central-East Europe. Overall, these undisturbed forests represent 2.35% of the forest in EU. The EU countries that have the highest proportion of undisturbed forest were Bulgaria (18.1%), Sweden (8%), Denmark (3.4%), Slovenia (2.7%) and Romania (2.4%). In terms of total area, Sweden (3,324,000 ha) and Finland (214,000 ha) have the most extensive primary forests.

Sabatini et al. (2018)[849] explored the extent and characteristics of EU primary forests. The research identifies scarcity or complete lack of data, but manages nonetheless to provide important information concerning their distribution and their status.[850]

Primary forests mapped by the study covered approximately 1.4 Mha in 32 European countries, which represent 0.25% of terrestrial Europe and 0.7% of Europe's forest area excluding Russia. Most of the

[845] Food and Agricultural Organization (FAO). (2020). Global Forest Resources Assessment: Main report. Rome. Page 34. https://doi.org/10.4060/ca9825en.
[846] Barredo, J.I., Brailescu, C., Teller, A., Sabatini, F.M., Mauri, A. Janouskova, K. (2021). Mapping and assessment of primary and old-growth forests in Europe, EUR 30661 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-34230-4, doi:10.2760/797591, JRC124671
[847] Forest Europe. (2020). State of Europe's Forests 2020. Available at: https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf. The study includes non-EU countries.
[848] Forest Europe (2020) defines forests undisturbed by man as those in which "the natural forest development cycle persists or was restored and show characteristics of natural tree species composition, natural age structure, deadwood component and natural regeneration and no visible signs of human activity. Forests undisturbed by man have high conservation value, especially when they form large continuous forest areas allowing also natural ecosystem dynamics to occur."
[849] Sabatini, FM, Burrascano, S, Keeton, WS, et al. (2018). Where are Europe's last primary forests? *Divers Distrib*. 24: 1426– 1439. https://doi.org/10.1111/ddi.12778
[850] The study also includes European countries not part of the EU (Albania, Ukraine, Switzerland, Belarus, Moldova, Bosnia and Herzegovina, Montenegro and Serbia) and does exclude some EU countries (Ireland, Cyprus, Latvia, Luxembourg and Malta) which means that totals and broader conclusions have to be considered with this caveat.

primary forests are located in northern Europe (Finland is the European country with the largest primary forest area, 0.9 Mha), followed by countries in eastern Europe (a total of 0.2 Mha, especially located in Bulgaria and Romania). The countries having the highest proportion of primary forest were Finland (2.9% of national territory), Lithuania, Slovenia, and Bulgaria (each about 0.5%). The mapped primary forest patches were, on average, very small: The median size was only 24 ha, and only 4.3% of the patches were larger than 1,000 ha. These estimates have since been reviewed and updated in the European Primary Forest Database.

The JRC (2021) compared the different estimates of primary forests from three sources:

1. Joint Forest Europe / UNECE / FAO Questionnaire on Pan-European Indicators for Sustainable Forest Management7. Results of the questionnaire are published in the State of Europe's Forests report (FOREST EUROPE 2020);
2. FAO's Global Forest Resources Assessment;
3. The European Primary Forest Database (EPFD v2.0) (Sabatini et al., 2020a).

While the overall estimates do not differ substantially, there is some notable discrepancy at country level (Table 0-9). The main discrepancy between Forest Europe and FAO is the treatment of primary forest in other wooded land, but it is of limited extent. On the other hand, Sabatini et al.'s estimates differ more substantially at country level because of different methods and adjustments used to overcome methodological limitations.

Table 0-9 Area of primary forests in EU countries [1,000 ha], according to FOREST EUROPE (2020). Source: JRC, 2021[851]

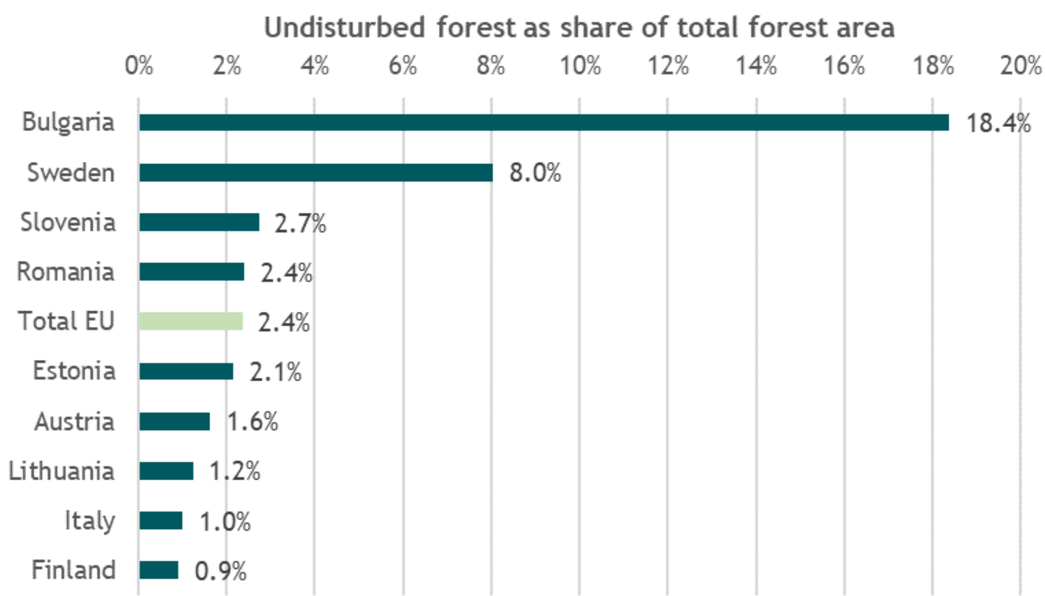
Country	Forest area 2020	Forest undisturbed by man			Primary forests (FAO, 2020)	Primary forests (Sabatini et al. 2020a)
		In forest	In other wooded land	In forest and other wooded land		
Austria	3.881	63	55	118	63	15.2
Belgium	689	0	0	0	0	0.3
Bulgaria	3.833	704	0	704	704	56.9
Croatia	1.922	7	0	7	7	9.6
Cyprus	173	13[(a)]	ND	13	ND	0.0
Czech Republic	2.668	10	ND	10	10	12.8
Denmark	625	21	3	24	21	1.7
Estonia	2.421	52	2	55	52	0
Finland	22.409	203	11	214	203	2,814.6[(c)]
France	16.836	30[(a)]	0	30	ND	12.3
Germany	11.419	0	0	0	0	14.3
Greece	3.903	ND	ND	ND	ND	1.9
Hungary	2.061	0	ND	0	0	0.3
Ireland	755	ND	ND	ND	0	0.0
Italy	9.297	93	0	93	93	8.7

851 Barredo Cano, J.I., Brailescu, C., Teller, A., Sabatini, F.M., Mauri, A. and Janouskova, K. (2021). Mapping and assessment of primary and old-growth forests in Europe, EUR 30661 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-34229-8, doi:10.2760/13239, JRC124671

Country	Forest area 2020	Forest undisturbed by man			Primary forests (FAO, 2020)	Primary forests (Sabatini et al. 2020a)
		In forest	In other wooded land	In forest and other wooded land		
Latvia	3.391	17	0	17	17	4.8
Lithuania	2.187	27	0	27	27	32.0
Luxembourg	89	0	ND	ND	0	0.0
Malta	0	0	0	0	0	0.0
Netherlands	365	0	0	0	0	0.1
Poland	9.42	0	ND	0	0	22.4
Portugal	3.312	24[(a)]	ND	24	24[(a)]	16.4
Romania	6.901	165	0	165	165	70.0
Slovakia	1.922	11	0	11	11	13.1
Slovenia	1.248	34	17	50	34	9.5
Spain	18.551	ND	ND	ND	ND	10.3
Sweden	27.98	2,249	1,075	3,324	2,249	37.8[(e)]
Total EU	**158.258**	**3,723**	**1,163**	**4,886**	**3,679**	**3,165[(d)]**
% of forest	**100**	**2.35**	**-**	**2.71[(b)]**	**2.32**	**2.0**

(a) 2015.
(b) As percentage of the area of forest and other wooded land.
(c) Note that this area is most likely overestimated. A more accurate extent would be ~1 Mha.
(d) As consequence of the issue in note c, this area is most likely overestimated. A more accurate extent would be ~1.35 Mha (~0.9% of forest in the EU).
(e) Note that Sabatini et al. (2020a) indicate the existence of 2.4 Mha of potential (unconfirmed) primary forests in Sweden. Therefore, the number in the table is likely underestimated.
ND: No data.

Figure 0-6 Share of forest undisturbed by man in the total forest area, by country, 2020.[852]



852 Forest Europe. (2020). State of Europe's Forests 2020. Available at: https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

According to the Global Forest Resources Assessment 2020[853], primary forest occupies 1.11 billion ha across of the world, or about one-third of forest areas in the countries surveyed by the study. Together, Russia, Canada and Brazil account for 61% of the world's primary forest.

Table 0-10 Area and global share of primary forest across world subregion. Source: Global Forest Resources Assessment, 2020[854]

Subregion	Area of primary forest (1 000 ha)	Share of global area of primary forest (%)
Europe	4,180	0.4
Africa	149,586	13.5
Asia[855]	341,604	30.8
North and central America	313,313	28.2
South America	298,698	26.9
Oceania	2,617	0.2
World	**1,109,997**	**100**

Forest protection

Barredo et al. (2020) [856] provide an overview of protection levels of primary forests in EU and European countries. At EU level, 93% of the documented primary and old-growth forests (3.2 Mha) are located in Natura 2000 sites and 87% lies in strictly protected areas (IUCN Ia, Ib and II) (Table 0-12). Across the EU, only 35% of forests have a strict protection level (IUCN Ia, Ib and II), but overall these countries own a limited amount of primary forest (620 000 ha, compared to the 3.165 Mha in EU).[857] Natura 2000 areas have generally a good coverage of primary forests across MSs, with the majority having above 90% coverage of national primary forests. However, there are substantial discrepancies when it comes to IUCN protection: only eight countries have over 80% of primary forests strictly protected, while many fall under 50% coverage.

Natura 2000 and IUCN Ia, Ib and II are considered strict protection areas, generally corresponding to national parks. Data on current protection level can help estimating the extent of primary forest area that may be affected by an exclusion of bioenergy from primary forests, assuming that areas outside this strict level of protection are currently viable for bioenergy.

Based on the data in Table 0-12, the provision may affect 404 000 ha of primary forests not currently protected, which means an increase of 15% in areas compared to current protection level. At MS level, the increase will be significant in few cases (Sweden, Portugal) but it is important to note the various limitations to the level of precision of data used. Outside the EU, the impact could be more substantial, as countries that export to the EU such as Russia, Us and Canada have a sizeable extent of primary

[853] FAO. (2020). Global Forest Resources Assessment 2020: Main report. Rome. https://doi.org/10.4060/ca9825en
[854] Food and Agricultural Organization (FAO). (2020). Global Forest Resources Assessment: Main report. Rome. Page 34. https://doi.org/10.4060/ca9825en.
[855] Including Russian Federation
[856] Barredo, J.I., Brailescu, C., Teller, A., Sabatini, F.M., Mauri, A. Janouskova, K. (2021).Mapping and assessment of primary and old-growth forests in Europe, EUR 30661 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-34230-4, doi:10.2760/797591, JRC124671
[857] As reported in Barredo et al. (2021), there are several limitations and caveats to the data presented

forest area (Table 0-11). Data for protection of primary forest outside Europe is not available, but it is likely to be substantially below the level of protection below the level granted in the EU.

Table 0-11 Top five countries for primary forest area, 2020[858]

Country	Area of primary forest (1 000 ha)	Share of global primary forest (%)
Russian Federation	255,212	22.99
Brazil	216,187	19.48
Canada	205,131	18.48
Democratic Republic of the Congo	82,752	7.46
United States of America	75,300	6.78

It is also important to note that timber harvesting and salvage logging is allowed in many national parks in Europe (outside core areas), which means fuelwood removals may also be happening in strict protection areas. However, the data presented suggests that most MSs protect primary forests, but gaps exist. A ban on fuelwood from primary forests will have limited impact on European production but would ensure that primary forests in countries with lower coverage are protected.

[858] Elaborated from FAO. (2020). Global Forest Resources Assessment 2020: Main report. Rome. https://doi.org/10.4060/ca9825en

Table 0-12 Area of primary and old-growth forests in EU countries according to the European Primary Forest Database (EPFD v2.0) of Sabatini et al. (2020a) and percentage falling in Natura 2000 sites (EEA 2020) and in IUCN protected areas (UNEP-WCMC 2019)[859]

Country	Primary forests (Sabatini et al., 2020) (1,000 ha)	Natura 2000 (%)	IUCN category (%)						
			Ia	Ib	II	III	IV	V	VI
Austria	15.2	78	0	13	38	0	27	14	0
Belgium	0.3	100	0	0	0	0	69	0	8
Bulgaria	56.9	99	75	0	3	1	1	4	2
Croatia	9.6	99	0	0	0	0	0	0	0
Cyprus	0	-	-	-	-	-	-	-	-
Czech Republic	12.8	82	10	6	10	3	24	46	0
Denmark	1.7	75	6	0	26	0	30	1	0
Estonia	0	-	-	-	-	-	-	-	-
Finland	2,814.6	94	6	69	16	0	2	0	0
France	12.3	85	16	0	4	0	45	8	0
Germany	14.3	82	0	0	43	0	24	10	0
Greece	1.9	99	39	0	44	12	5	0	0
Hungary	0.3	100	0	0	49	0	18	22	0
Ireland	0	-	-	-	-	-	-	-	-
Italy	8.7	93	22	0	71	0	2	1	0
Latvia	4.8	100	0	2	98	0	0	0	0
Lithuania	32.0	99	77	0	12	0	0	11	0
Luxembourg	0	-	-	-	-	-	-	-	-
Malta	0	-	-	-	-	-	-	-	-
Netherlands	0.1	97	0	0	0	0	100	0	0
Poland	22.4	100	1	0	85	0	11	2	0
Portugal	16.4	77	13	13	1	1	0	7	53
Romania	70.0	92	2	0	48	0	7	5	0
Slovakia	13.1	97	45	8	3	0	1	36	0
Slovenia	9.5	96	0	29	8	2	0	7	0
Spain	10.3	90	35	2	48	1	1	1	0
Sweden	37.8	37	2	31	3	0	2	0	0
Total	3,165	93	8	62	17	0	2	1	0

Table 0-13 Area of primary and old-growth forests in a group of 14 non-EU countries according to the European Primary Forest Database (EPFD v2.0) of Sabatini et al. (2020a) and percentage falling in IUCN protected areas (UNEP-WCMC 2019).

Country	Primary forests (Sabatini et al., 2020) (1,000 ha)	IUCN category (%)						
		Ia	Ib	II	III	IV	V	VI
Albania	14.0	37	0	23	0	0	4	0
Belarus	189.0	31	0	18	0	0	0	0
Bosnia Herzegovina	3.4	3	0	45	3	0	0	0
Iceland	ND	-	-	-	-	-	-	-
Liechtenstein	ND	-	-	-	-	-	-	-
Moldova	0	0	0	0	0	0	0	0
Montenegro	3.6	0	0	74	0	0	0	0
North Macedonia	0.8	0	0	99	0	0	0	0
Norway	277.5	16	0	6	0	1	0	0
Serbia	1.0	3	4	11	0	31	22	0
Switzerland	23.1	74	0	0	0	3	0	0
Turkey	ND	-	-	-	-	-	-	-
Ukraine	107.9	22	0	7	0	8	1	0
United Kingdom	0.1	0	0	0	0	66	0	0
Total	**620**	**24**	**0**	**11**	**0**	**2**	**0**	**0**

[859] Barredo Cano, J.I., Brailescu, C., Teller, A., Sabatini, F.M., Mauri, A. and Janouskova, K. (2021). Mapping and assessment of primary and old-growth forests in Europe, EUR 30661 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-34229-8, doi:10.2760/13239, JRC124671

2016 Impact Assessment

An option with a similar scope was considered in the 2016 impact assessment prepared for RED II[860] (Option 2: *Extend existing sustainability criteria for biofuels to solid and gaseous biomass for heat and electricity*) and the modelling exercise, conducted using PRIMES and GLOBIOM/G4M, concluded that such an option would:

- have minimal effect on demand of biomass for energy (0.4% reduction by 2030). This will be compensated by other renewable energy sources in order to meet the renewable energy targets, with effects on gross added value, investment costs and employment;
- generate a small decrease in the use of biogas (-5%) and an increase in domestic roundwood use (+6% in 2030 and +23% in 2050);
- reduce imports by 7% in 2030 and 22% in 2050, because the criteria would exclude a considerable amount of non-EU supply. A second-degree effect of this reduction in import is a small increase in the conversion of unused forests into used forests in the EU;
- reduce cumulative total emissions from the LULUCF sector worldwide by 469 $MtCO_2$ eq. This is due to the protection of high carbon stock areas assumed by option 2. The report warns that this is likely to be an overestimate, as this option only excludes the use of high-carbon stock areas for bioenergy use, but their use for wood material may continue;
- have a positive impact on biodiversity in EU and non-EU countries.

At macro-economic level, extending existing sustainability criteria to forest biomass would generate a positive change in gross value added of €330 million (+0.3%)[861], have negligible effect on capital expenditure and have minimal price effect on use of wood materials.

The analysis identified administrative costs amounting to €47 million per year plus a one-off cost of €109 million, due mostly to certification costs. This includes forest owners, the wood value chain, and bioenergy plants. Operators would have to demonstrate their compliance with the sustainability criteria for all consignments of biomass used for energy, thus requiring information along the supply chain. This may be particularly burdensome for SMEs such as small forest owners, although group certification would reduce the burden. However, it is unclear whether such an obligation would require imposing certification at forest area level or could more efficiently be introduced as a limitation at national level and be then captures under the country criteria.

Other conclusions concerning the option of extending existing sustainability criteria to forest biomass were the following:

- it is unlikely to have significant impacts on rural development;
- it would have certain benefit for the internal market trades, as it would lead to more harmonised national rules;
- it would reduce the level of imports from non-EU countries;
- it is unlikely to have significant impacts on energy security or on innovation and research.

Implications of extending criteria to forest biomass and including the no-go areas

According to the result of the 2016 analysis and of the additional surveys of primary forest area carried out more recently, it can be concluded that:

[860] European Commission. (2016). Impact Assessment, Sustainability of Bioenergy. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF
[861] Excluding administrative costs

- extending sustainability criteria to forest biomass would have very limited effect on biomass availability and prices in EU, although administrative costs may be important and may discourage some SMEs from the market if this criterion adds additional certification burden to forest owners;
- extending the no-go area to primary forest would affect at most between 0.7% and 2.2% of forest area in Europe, but it may fill in the gaps current left by policies in different countries;
- larger area in key exporting countries will be affected.

The assessment focussed on the risk of exploitation of primary forests for bioenergy, and did not attempt to estimate the extent of other no go areas such as highly biodiverse forests, peatland and wetlands that would be affected by an extension of the sustainability criteria. This is because of limitation in the data available. However, further benefits to biodiversity are expected to be achieved in these areas, but also some negative effects on biomass availability and prices.

Protecting forests with a high biodiversity value may affect more significantly biomass imports from 3rd countries, where most of the world's primary and highly biodiverse forests are located. According to the Global Forest Watch initiative[862], primary forest occupies one-third of forest areas (1.10 Gha) in the countries analysed.

While in the EU there is a significant level of protection and the impact on total available forest area will be minimal, the effect on imports could be more substantial. According to modelling carried out in 2016[863], this option may lead to a reduction of imports by 7% by 2030 as criteria would exclude a large part of the supply originating outside the EU (which may lead, at a global level, to reduced LULUCF emissions and positive effect on biodiversity). Increased protection requirement could have a rebound effect on EU production: as third-country producers may be unable to comply with more stringent compliance and certification requirements, EU producers may benefit. Lower imports may increase prices sufficiently to compensate EU forest owners for increased administrative costs, and it may be possible to observe an expansion in the area of EU forests exploited in order to compensate for the lower imports. As a consequence of the extension in EU forest area exploited, there may be negative effects on forest biodiversity.

- ***Application of the GHG saving criteria to existing heat and power installations***

Article 29.10 requires that greenhouse gas emission savings from the use of biofuels, bioliquids, and biomass fuels taken into account for the purposes referred to in paragraph 1 shall be: […] "*at least 70% for electricity, heating and cooling production from biomass fuels used in installations starting operation from 1 January 2021 until 31 December 2025, and 80% for installations starting operation from 1 January 2026*". GHG emissions are to be calculated based on the methodology described in previous Commission documents and on the values calculated by the Commission's Joint Research Centre and described in Annex 6 of RED II.

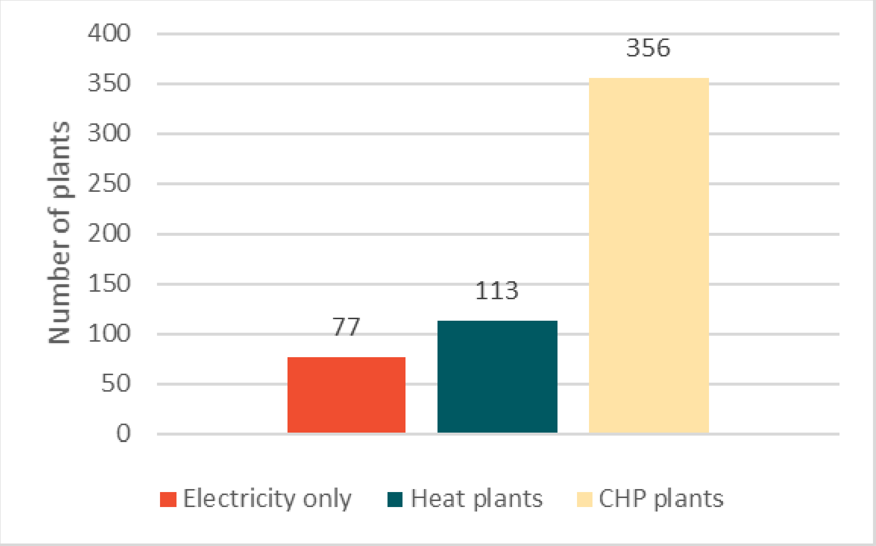
This element of option 2 concerns expanding this requirement to existing heat and power installations (including combined H&P). In order to evaluate the impacts of this option, it is necessary to understand how many additional installations may be covered, whether the criteria would make any substantial

[862] Global Forest Watch. (n.d.). Available at: https://www.globalforestwatch.org/
[863] European Commission. (2016). Impact Assessment, Sustainability of Bioenergy. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF

difference to their operations, and the economic, social, and environmental effects that would result from this extension. As this option concerns installations existing before January 2021, the maximum number of plants concerned is the number of plants in operation at this date. Looking at the impacts over the next ten years, it is to be expected that this number may decrease during this time period, as some of these plants reach the end of their life.

The BASIS bioenergy project mapped over 540 installations over 20 MW in 2016, covering 75% of use of biomass in commercial installations (where the 88 largest plants account for over 30 Mt of biomass per year).[864] However, since the project was completed, it is likely that the total number of biomass plants has increased to some extent.

Figure 0-7 Number of existing wood chip plants >20 MW in Europe. Source: Bioenergy Europe, 2016



Extending the GHG criteria to these plants will affect the feed type they will be able to use, which means they may have to switch to a different fuel supply. In turn, this will affect woodchip and pellets producers (forest owners and agricultural feedstocks producers) that current provide the feedstock via the more CO_2-intensive paths. Largely, the issue will be addressed by traders stocking different supplies, and according to previous analysis this I not expected to pose significant issues.

This question was already explored in the Sustainability of Bioenergy Impact assessment (2016)[865] for different thresholds, by comparing feedstock used in various installations. The analysis concludes that "*in the case of forest-based bioenergy, almost all of the biomass used would comply with a minimum threshold of 70%, and only a few pathways would be excluded if that threshold was raised to 75%.*"[866] These are pathways where wood drying is made with natural gas and feedstocks is transported over 10,000 km. Essentially, this option may affect third countries and the quantity of forest-based imports from outside the EU. Because this option concerns extending the GHG criteria to currently existing plants (at a minimum level of 70% saving), this is unlikely to have any direct significant impact on the

[864] Data provided by Bioenergy Europe BASIS bioenergy project. (2016).
[865] European Commission. (2016). Impact Assessment: Sustainability of Bioenergy. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF
[866] Ibid.

amount of forest-based bioenergy. If anything, this criterion may increase EU production of forest biomass by excluding some long-distance forest feedstock.[867]
Impacts may be more substantial for agricultural feedstocks, in particular those transported over long-distance, intensely cultivated, and short rotation coppice feedstocks. Other pathways excluded would be the ones based on agricultural residues transported over long distances (which is very unlikely to happen), as well as certain biogas pathways (in particular those using exclusively of maize crops).

Concerning environmental impacts, the 2016 impact assessment concludes that “there seems to be almost no environmental benefit of a minimum greenhouse gas performance criterion for supply chain emissions of biomass as long as it is set at the level of 75% or lower”.[868] Extending the criterion to existing plants is therefore also expected not to have any significant impact on total amount of bioenergy but may have the effect to alter the balance between forest-based and agriculture-based feedstock in favour of the former.

In terms of macroeconomic effects, the Biosustain report[869] analysed the effect on introducing biomass criteria to existing heat and power installations. The main conclusions is that it “*would have only limited impacts on bioenergy demand (-0.4%, ~0.5 Mtoe) compared to the baseline, because solid and gaseous biomass used for heat and electricity generation can generally meet the threshold of 70% direct savings in GHG emissions. As for biomass supply, the model indicates a negligible decline in forest biomass demand, a very small increase in agricultural biomass and a small decline in waste biomass demand. This last is attributable to the impact of the GHG requirement on biogas plants using maize as co-feed in the anaerobic digestion process*”.

Concerning the administrative burden, the parties affected by this provision are existing heat and power plants, that will have an additional criterion to adhere to. To a lesser extent, supply chain and biomass producers would also be affected. In order to estimate the effect on administrative costs, it is necessary to bear in mind that solid biomass installations over 20 MW and biogas installations over 2 MW already have to comply with sustainability criteria concerning the provenance of their feedstock. The addition of the GHG saving criteria is unlikely to constitute a significant additional burden to them, as at most it will require them to switch to fuels with lower supply chain emissions.

Energy efficiency criteria for large scale electricity installations

The 2016 impact assessment[870] analysed an option to introduce a minimum level of conversion efficiency in heat and power installations (option 4). The option considered a minimum efficiency level of 60% to be applied to CHP plants, but did not separately consider a criterion for electricity-only plants. Article 29 indeed distinguishes between CHP and electricity-only installation and requires large plants (100 MW and above thermal input) to achieve a net energy efficiency of 36%, applied to new and existing plants. This element of option 2 concerns an increase of the 36% minimum threshold, which could be applied either to only new plants or to new and existing plants. However, the latter may face substantial resistance from MSs and investors, given the implications for large investments made in recent years in the biomass plants affected.

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[867] Ibid.
[868] Ibid.
[869] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf
[870] European Commission. (2016). Impact Assessment: Sustainability of Bioenergy. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF

Therefore, for the purpose of analysing this option, the focus will be on the future potential for electricity-only large plants, while estimating the current spread of the technology to gauge possible evolutions and to understand the quantities of bioenergy affected by this provision. It is also necessary to understand the potential energy efficiency increase that can be imposed on these plants above the 36%.

Number of planned large electricity-only plants

Modelling carried out for the purpose of the 2016 impact assessment[871] suggests that very little new electricity-only capacity is projected for after 2020 (this would represent around 1% of total solid biomass consumption between 2020 and 2030) but it is as yet unclear whether this assumption holds true for the updated projections associated with the new target[872], in particular after the coal ban planned by many MSs since the 2016 analysis. Recent research from EMBER[873] on currently planned conversions in EU, shows a total of 64 TWh of electricity per year may come from new biomass plants (either as co-firing, conversion or replacement). The research also identified at least 7 large electricity-only conversions, and estimates the amount of biomass these would require, assuming a 70% load factor. Assuming a conversion of 5 MWh for each tonne of biomass (input) this gives a total of 10.4 GW of additional capacity (Table 0-14).

Table 0-14 Future biomass conversions (in orange own calculations)[874]

Name	Owner	Country	Potential Biomass Burn [Mt/year][875]	Potential Biomass Burn (ton/hour)	Assumed input capacity (MW)
Eemshaven (full conversion)	RWE	Netherlands	3.8	616.9	3,084.4
Moneypoint	ESB Group	Ireland	3.0	489.2	2,445.9
Pego	Engie, Marubeni, Endesa	Portugal	2.1	345.6	1,728.0
Abono GRII	EDP España	Spain	1.7	280.8	1,404.0
Fiume Santo	EPH	Italy	1.1	176.8	884.1
Soto de Ribera III	EDP España	Spain	1.1	175.8	878.8
Total			**12.8**	**2,085.1**	**10,425.2**

To put the 12.8 MT/year in context, at 17 GJ per tonne this is equivalent to 218 PJ (Peta Joule), roughly equivalent to 70% of biomass consumed as energy input in large plants in EU in 2017.[876]

[871] European Commission. (2016). Impact Assessment: Sustainability of Bioenergy. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF
[872] This element will be clarified by new modelling analysis, but these results are not yet available at the moment of writing.
[873] EMBER. (2019). Playing with Fire. Available at: https://ember-climate.org/wp-content/uploads/2020/10/Ember-Playing-With-Fire-2019.pdf
[874]Data from ShareAction includes the Habour-Moorburg plant, a coal fired power plant. However, in December 2020, the German Federal Network Agency (Bundesnetzagentur) decided to award compensation for a complete phase-out of the plant. As a result, it is not available anymore for biomass conversion.
[875] Assuming 17 GJ/tonne (NCV/LHV).
[876] EMBER estimates a total biomass consumption in current and former coal power plant in EU of 322 PJ in 2017. (EMBER, 2019)

Number of existing large electricity-only plants

There is no single source that identifies with reliability the number of large electricity-only biomass power plants in the EU. A number of sources were analysed for this purpose:

The Industrial Reporting (Large Combustion Plants) database[877] shows a total of 212 installations fuelled by biomass, categorised as "*Combustion of fuels in installations with a total rated thermal input of 50 MW or more*" and reporting a thermal input capacity of 100 MW or more. However, it is not possible to discern between output (heat-only, power-only, or CHP). Half of these plants are located in just four countries (Germany, Italy, Poland, Spain).

Table 0-15 Number of installations classified as *Combustion of fuels in installations with a total rated thermal input of 50 MW or more* and fuelled by biomass

Size (MW input)	Number of installations
50 to 100	96
100 to 500	146
Larger than 500	66
Total	**295**

JRC Open Power Plants Database (JRC-PPDB-OPEN)[878] is a new resource that is attempting to map all power plants in Europe, but it is still incomplete. The database includes also some data concerning efficiency level of each plants. However, this dataset too does not allow to discriminate between output (heat-only, power-only, or CHP) and plant capacity is provided as electrical output rather than input. The dataset lists 26 plants with capacity over 30 MW (which, at a 30% net efficiency, is equivalent to 100 MW input). The reported electrical efficiency level for large biomass plants is reported only for 14 out of 26 large plants and varies between 27% and 38%.

Table 0-16 Number of biomass installations by size and reported efficiency level

Size MW output	Installation efficiency						Total
	No efficiency reported	0.27	0.32	0.35	0.38	0.47	
>100	2	1	7	2	1		13
>30	10		3				13
less than 30	109					1	110
Total	121	1	10	2	1	1	136

European Biomass plants database[879]. ShareAction is a not-for profit organisation that lobbies for sustainable investments. As part of their activities, they maintain the European Biomass plants database, which contains details of 76 major plants consuming around six million tonnes of biomass every year. This dataset captures both thermal and electrical production from power plants, therefore allowing to identify electricity only large plants. The dataset includes 12 plants as electric only and with an electric output of at least 20 MW.

[877] European Environment Agency. (2020). Industrial Reporting under the Industrial Emissions Directive 2010/75/EU and European Pollutant Release and Transfer Register Regulation (EC) No 166/2006. Available at: https://www.eea.europa.eu/data-and-maps/data/industrial-reporting-under-the-industrial-2
[878] JRC Open Power Plants Database (JRC-PPDB-OPEN). Available at: https://data.europa.eu/euodp/en/data/dataset/9810feeb-f062-49cd-8e76-8d8cfd488a05
[879] ShareAction: European biomass plant database. Available at: https://shareaction.org/research-resources/european-biomass-plant-database/. The UK is included in this database.

Table 0-17 Extract from European Biomass Plants database - power-only installations[880]

Plant Name	Country	Total Electricity output [MWe]	Electricity output from biomass [MWe]	Biomass % of Fuel	Tonnes biomass/yr	Biomass type	Additional Comments: Fuel
Polaniec, 1 & 2	Poland	225	225	100	1,346,000	wood chips, agricultural waste	80% wood chips, 20% agricultural waste (890 000 tonnes wood chips, 222 000 tonnes agricultural waste)
Rodenhuize (Max Green)	Belgium	205	205	100	800,000	wood pellets	100% wood pellets: 700 000 to 800 000 tonnes pellets per year. 225 000 tonnes/year imported from Canada as part of long-term contract
Provence, 4	France	150	150	100	850,000	wood chips, forest residues	100% wood: 2/3 from regional timber industry, 1/3 imported biomass (objective to achieve 100% local supply by 2025)
Strongoli	Italy	46	46	100	400,000	wood chips, agricultural waste	biomass made of wood chips derived from forest maintenance and agri-food residuals coming from local and foreign markets, olive cake, PKS (palm kernel shells)
Russi	Italy	30	30	100	270,000		clean wood, agro waste
Biomasse Crotone	Italy	27	27	100	300,000	wood chips, process waste, agricultural waste	wood chips from forest maintenance and agro-food residuals from local and international sources. These include: wood chips, exhausted olive residues, palm kernel shells, other virgin biomass of agro-forestry industry
Oostrozebeke	Belgium	25	25	100	170,000		non-recyclable wood residues
Bando d'Argenta	Italy	21	21				
Delitzsch	Germany	20	20	100	160,000		waste wood
Edenderry	Ireland	128	54	42	430,000	wood chips	42% biomass & 58% peat. 350000 tonnes (of 429445 energy tonnes total) sourced domestically. The Irish government set a target for cofiring, transitioning from 100% peat to 70% peat/30% biomass by 2015. The longerterm aim is to transition to 100% biomass by 2030, to 1500000 energy tonnes per annum. PKS(mainly from Indonesia), wood, including some eucalyptus woodchips from South Africa.
Mátra (Mátrai)	Hungary	966	?	?		wood chips, agricultural waste	86% brown coal lignite (7.9 million t/a), 14% biomass
Figueira da Foz	Portugal	28	?	?		process waste	process waste from paper mill

[880] Data as of January 2020

The World Electric Power Plants Database, March 2018[881] reports 216 plants burning either biomass or wood of which 48 above 30 MW electrical output. Assuming a minimum efficiency of 30%, plants with output above 30 MW may be assumed to fall into the 100 MW input category. More plants may have an input above 100 MW, but because of low efficiency they will be already excluded from the purpose of the directive. This dataset too does not allow to distinguish electricity-only plants.

Table 0-18 Biomass plants in Platts dataset

Size	Biomass	Wood	Total
>100&<300	1	5	6
>300	1	9	10
>30&<100	10	22	32
<30	57	111	168
Grand Total	69	147	216

The Basis project[882] (2015) aimed at assessing biomass supply and its use across Europe. In its country analysis the project identified 77 electricity-only plants (1% of the total number of plants mapped), which were found in few countries:

- **Italy**: there were 25 electricity-only woodchips plants, with an average input of 48 MW thermal. Most of the woodchip consumed in the country (1.7 million ODT, 71%) is used to fuel electric plants;
- **Spain**: there were 21 electricity-only woodchips plants, with an average input of 18 MW thermal. Most of the woodchip consumed in country (1.5 million ODT, 59%) is used to fuel electric plants;
- **Remaining major EU countries** assessed (Austria, Denmark, France, Sweden, Germany) had none or minimal electricity-only capacity. GB had 16 electricity-only plants.

Given the mix of sources described above, it is possible to assume that at least 13 plants may be captured in the category "*electricity-only with a thermal input of at least 100 MW*", but it is unclear how many are currently fully captured by the efficiency requirement (above 36%); only the JRC reports of one single plant that fulfil both criteria. According to PRIMES modelling carried out in 2016, it is unlikely that in the next 10 years new electricity-only biomass plants will be built or converted. It is possible to assume that the current requirements are already sufficient to exclude all but a few of electricity-only plants.

Net-electrical efficiency

Conversion efficiency (or net electrical is efficiency) is the ratio between energy provided as input (fuel) and energy delivered in output (electricity, heat, or both). Biomass power plants can deliver either only one of the two or both at the same time, with different efficiency levels achievable:

- CHP is the most efficient technology, allowing to achieve an overall efficiency level for the combined generation of about 70 to 90%, depending on the fuel and plant type as well as on

[881] World Electric Power Plants Database, March 2018. Available at: https://www.spglobal.com/platts/pt/products-services/electric-power/world-electric-power-plants-database
[882] BioenergyEU - Basis project. (2015). European Wood chips plants - Country analysis. Available at: http://www.basisbioenergy.eu/fileadmin/BASIS/D3.6_Global_Country__analysis_version2.pdf

the characteristics of the heat demand. These are generally smaller plants, and the priority electricity/heat varies according to design. On average, electrical output is about 30%, the rest is heat;

- electricity-only plants are rare, but are more common in case of large conversion, where there is no use in nearby buildings or processes for the heat. These plants burn biomass directly or may introduce a gasification step to achieve higher efficiency (very few examples of the latter are available in combination with biomass, due to higher costs). Ballpark figures for efficiency levels achieved are:
  - Common burner: 30-38%
  - With gasification (IGCC): ~40-45%
  - biomass gasification with high-temperature fuel cells: >45%.

The JRC maintains the Best Available Techniques (BAT) Reference Document for Large Combustion Plants; the values included in the document are used to set allowed operating ranges of EU's large emitters in terms of pollution levels and combustion efficiency. The BAT for solid biomass and peat boiler (Table 0-19) shows electrical efficiency ranges of between 33.5% and 38% for new units and between 28% and 38% for existing units. As per current RED directive, only installations with efficiency above 36% can be taken into account for the purpose of renewable generation. Therefore, an increase to the thresholds will limit the inclusion in the renewable share of electricity produced only by the most efficient power-only plants.

Table 0-19 BAT-associated energy efficiency levels (BAT-AEELs) for the combustion of solid biomass and/or peat[883]

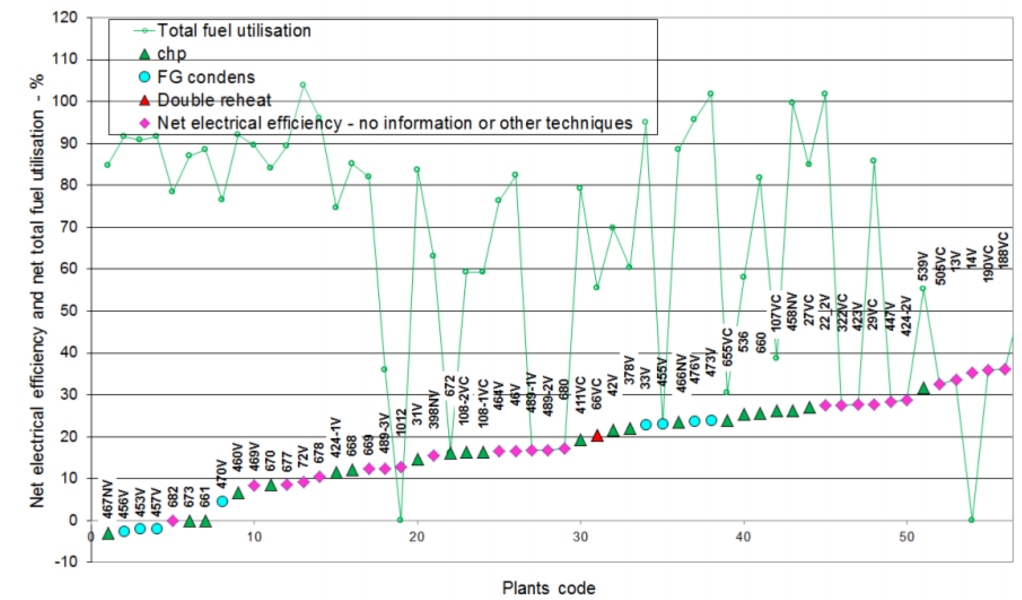
Type of combustion unit	BAT-AEELs (1) (2)			
	Net electrical efficiency (%) (3)		Net total fuel utilisation (%) (4) (5)	
	New unit (6)	Existing unit	New unit	Existing unit
Solid biomass and/or peat boiler	33.5–to > 38	28–38	73–99	73–99

(1) These BAT-AEELs do not apply in the case of units operated < 1 500 h/yr.
(2) In the case of CHP units, only one of the two BAT-AEELs 'Net electrical efficiency' or 'Net total fuel utilisation' applies, depending on the CHP unit design (i.e. either more oriented towards electricity generation or towards heat generation).
(3) The lower end of the range may correspond to cases where the achieved energy efficiency is negatively affected (up to four percentage points) by the type of cooling system used or the geographical location of the unit.
(4) These levels may not be achievable if the potential heat demand is too low.
(5) These BAT-AEELs do not apply to plants generating only electricity.
(6) The lower end of the range may be down to 32 % in the case of units of < 150 MW_{th} burning high-moisture biomass fuels.

An analysis of the operating efficiency of plants that participated to the 2012 data collection, used as a key source in the production of the BREF BAT[884], shows that only few plants were above the 30% threshold. However, the analysis includes plants of different types and does not distinguish between output type (heat, power, or heat and power).

[883] JRC. (2017). Best Available Techniques (BAT) Reference Document for Large Combustion Plants. Available at: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/JRC_107769_LCPBref_2017.pdf
[884] Ibid.

Figure 0-8 Operating efficiencies of biomass- and/or peat-fired combustion plants (2012) [885]



Source: [3, LCP TWG 2012]

The BASIS project[886] reported ranges between 27% and 37% for electricity-only large power plants. Table 0-19 presents the results by MS.

Table 0-20 BASIS - reported efficiency electricity only plants >25 MW

Country	Identifier (year commissioning)	Efficiency level
Germany	DE-21-31 (1999)	32%
	DE-22- (2004)	31%
	DE-F0 (2004)	31%
Italy	IT-H3-1	27%
	IT-H5-1	27%
	IT-I1-1	30%
Poland	PL- (2013)	37%
	PL-22-163 (2006)	35%
	PL- (2004)	37%
Spain	ES-41-2	30%

The JRC-PPDB-OPEN dataset[887], reports the following efficiency values for biomass plants. As discussed above, the dataset does not allow to distinguish between electricity-only and CHP plants, but it offers a snapshot of generating efficiency for some plants (Table 0-21).

[885] JRC. (2017). Best Available Techniques (BAT) Reference Document for Large Combustion Plants. Page 763. Available at: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/JRC_107769_LCPBref_2017.pdf
[886] Basis BioenergyEU. (2015). Report on conversion efficiency of biomass. Available at: http://www.basisbioenergy.eu/fileadmin/BASIS/D3.5_Report_on_conversion_efficiency_of_biomass.pdf
[887] JRC Open Power Plants Database (JRC-PPDB-OPEN). (n.d.). Available at: https://data.europa.eu/euodp/en/data/dataset/9810feeb-f062-49cd-8e76-8d8cfd488a05

Table 0-21 Producing and generating efficiency of biomass plants in JRC-PPDB-OPEN

Plant id	Capacity producing unit (MW)	Capacity generation unit (MW)	Country	Generating Efficiency
22WRODENH000213L	268	268	Belgium	0.35
44W-T-YT-000017B	260	260	Finland	0.32
19W000000000165Z	225	225	Poland	0.32
17W100P100P03647	150	150	France	0.32
15WPANNON----PPS	44	44	Hungary	0.32
14W-PROD-SIM---P	1,272	24	Austria	0.23
26WIMPI-0543164A	16	16	Italy	0.47

In general, increasing efficiency requirements is expected to have positive environmental impacts as it may "*result in lowering to some extent the risk of adverse climate effects, as well as the risks on biodiversity, soil and water quality. It would also lower air pollution through more efficient combustion*"[888] because higher energy efficiency would require lower volumes of biomass required to produce a given amount of energy.

However, given the limited number of installations able to comply with the current efficiency requirement, and the uncertainty associated with further coal plants conversions, it is unclear whether an increase to the 36% threshold will have a material effect on amount of biomass used. In terms of impacts of this provision, it is possible to envisage two extreme scenarios:

- In case no new or converted power-only plants would be built in the baseline, the effect of a higher threshold would not have any effect;
- In case additional new/converted biomass plants were to be built in the baseline, the effect of the new efficiency requirement will be of reducing drastically this number, and allowing only the most efficient ones to be built. On an extreme case, assuming all major plants identified by the research conducted by EMBER and Sandbag[889] go ahead (see also Table 0-14), this may affect 12.8 GWh input capacity – ensuring that either it is built at the highest standard or energy produced will not be considered for the RES target.

In practical terms, as few conversions will be able to achieve the required 38%, the provision may end up excluding biomass plants without CHP or a gasification step.

Option 3

Option 3 foresees the changes as indicated for option 2 plus the extension of the sustainability and GHG saving criteria (Article 29.2 to 29.7) to small installations. The limit could be set to include installations above 5 or 10 MW in the case of solid biomass fuels, and with a total rated thermal input equal to or exceeding 1 MW in the case of gaseous biomass fuels. To evaluate this option is necessary to understand the number of installations potentially affected, the quantities of biomass affected, and the costs imposed on stakeholders.

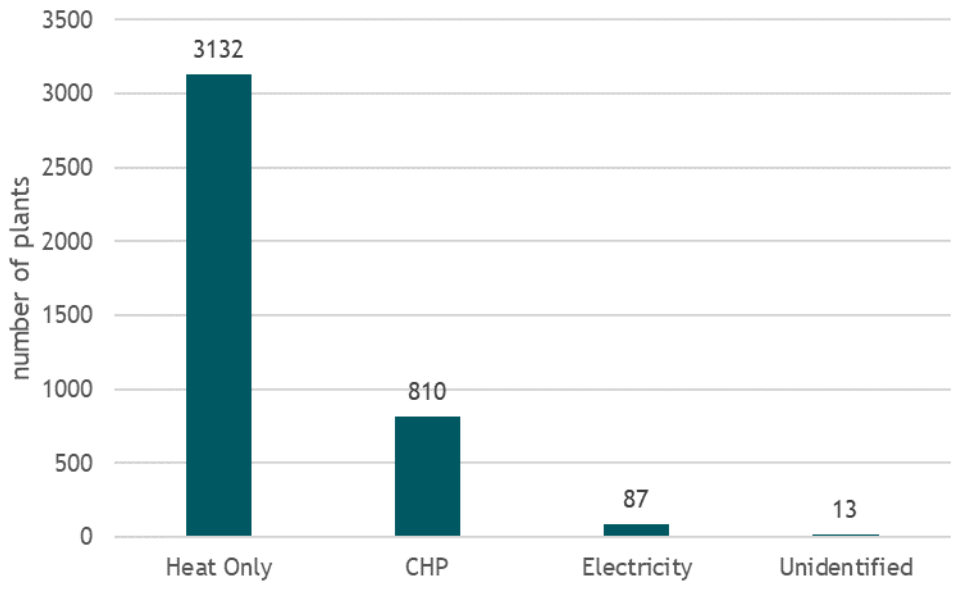
[888] European Commission. (2016). Impact Assessment: Sustainability of Bioenergy. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF
[889] EMBER. (2019). Playing with Fire. Available at: https://ember-climate.org/wp-content/uploads/2020/10/Ember-Playing-With-Fire-2019.pdf

The consumption of solid biomass in EU for heating and for electricity generation is fragmented across a high number of commercial installations and smaller residential heating systems. The most common type of feedstock for commercial scale plants is woodchips, while pellets are more common for residential installations. Pellets are also used in some large-scale plants.

The most common types of installations are:

- **Residential**: biomass-fed home heating systems are becoming more and more popular in some MSs, in the form of pellet stoves. These are replacing traditional firewood stoves and in some MSs even gas boilers;
- **Small commercial CHP plants**: combined heat and power plants, generally under 20 MW (thermal input) and using wood chips, are scattered across MSs, usually run by SMEs or part of large building complexes. The Basis bioenergy project890 has mapped over 2,944 plants in the categories comprised between 1 MW and 20 MW in 2016**Error! Reference source not found.**.

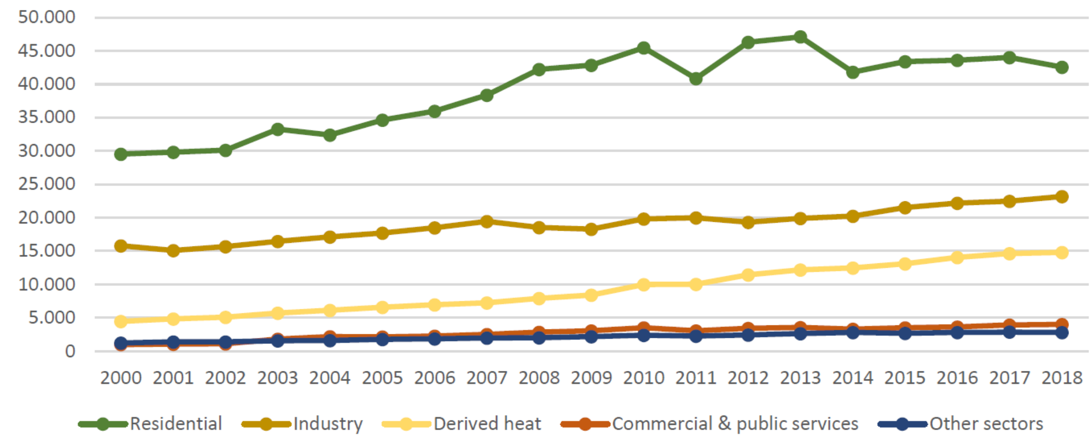
Figure 0-9 Number of solid biomass plants by output[891]



Trends concerning the evolution of consumption by sector shows that residential and derived heat[892] have been delivering increasing share of heat, and these are the sectors where micro and small scale installations are more likely to be contributing. Since 2000, bioheat consumption has increased by 68%, with the largest increases seen in the industrial and residential sector. However, even after a fall in use recorded since 2014 because of mild winters, the residential sector still accounts for half of the renewable heat produced.

[890] BasisBioenergy EU. (2016). Project results. Available at: http://www.basisbioenergy.eu/uploads/media/Project_results_presentation.pdf
[891] Ibid.
[892] Derived heat is heat directly distributed to the final consumer (district heating).

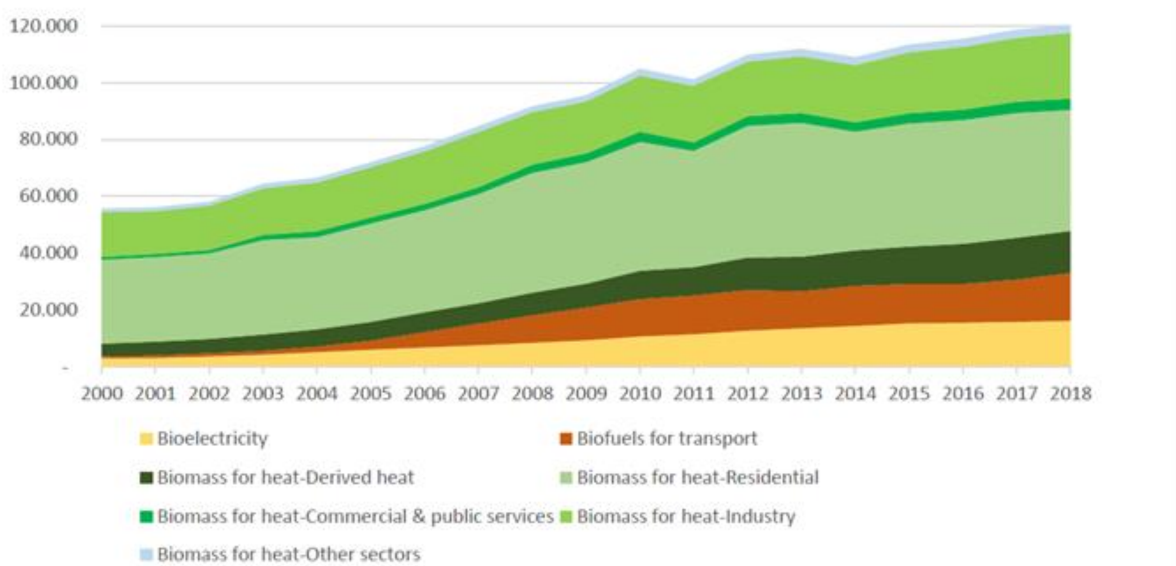
Figure 0-10 Evolution of the final consumption of bioheat by sector in EU28 (ktoe). Source: Bioenergy Europe, 2020[893]



Note: Other sectors includes agriculture, fishing and not elsewhere specified
Source: Eurostat

Considering overall bioenergy use (not limited to heat), it is also clear how residential use is by far the largest sector, and that growth in use was spread across all sectors during the period observed. Bioelectricity, generally produced in larger plants (above 20MW), appears to be relatively stable.

Figure 0-11 Evolution of bioenergy in gross final energy consumption by end-use in EU28 (ktoe). Source: Bioenergy Europe, 2020[894]



Stakeholders affected

Large plants above 20 MW, currently obligated to comply with sustainability criteria, consume the vast majority of woody biomass used in commercial installations (plants above 1 MW). Extending sustainability criteria to smaller installations would affect a different number of installations depending

[893]Calderón C., Avagianos I., Jossart J.M. (2020). Statistical Report 2020, Bioenergy Europe.
[894]Ibid.

on the level of the new threshold (Figure 0-12**Error! Not a valid bookmark self-reference.** and Table 0-22). Based on data from the BasisBioenergy EU project, excluding UK plants, and assuming the number of plants has remained stable since 2016:

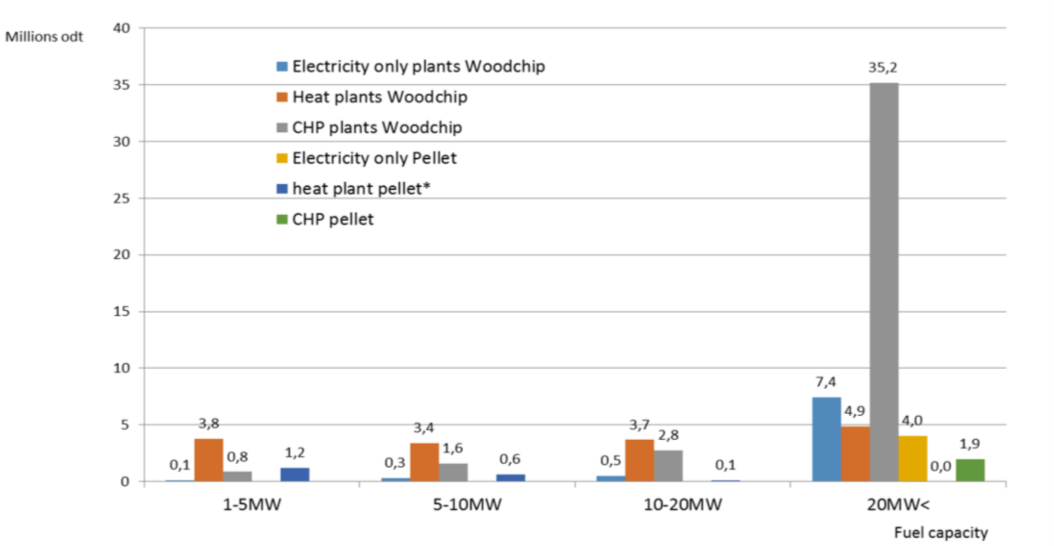
- The current 20 MW limit affects ~600 installations, which consume 74% of biomass used in commercial plants (above 1 MW). Assuming a total consumption of 53.7 Mt895 (oven dry tonnes), this is equivalent to 39.7 Mt;
- a 10 MW threshold would capture an additional 10% of total feedstock used in plants above 1MW (5.6 Mt), and require compliance from ~420 additional plants;
- a 5 MW threshold would capture an additional 8% of feedstock use (+18% from current level, an additional 4.5 Mt) and require compliance from ~700 additional installations (+1,100 from current level);
- if the applicability of criteria is lowered to a 1 MW threshold, they would capture an additional 7% of feedstock use (+25% from baseline) and require compliance from ~2,300 additional installations (+3,450 from current level).

Table 0-22 Share of consumption of woody biomass for energy by plant size class (EU 27)[896]

Plant size	1-5 MW	5-10 MW	10-20 MW	20+ MW	Total
Number of installations in 2016 (wood chip and pellets)	**2,325**	**691**	**424**	**603**	**4,042**
Wood Chip biomass consumption (Mt)[897]	3.9	4.5	5.6	39.7	53.7
Wood Chip biomass consumption (%)	7%	8%	10%	74%	100%
Pellet biomass consumption (Mt)	0.2	0.1	0.0	0.8	1.1
Pellet biomass consumption (%)	15%	8%	2%	76%	100%
Total consumption (Mt)	4.1	4.6	5.6	40.5	54.8
Total consumption %	7%	8%	10%	74%	100%

[895] Calderón C., Avagianos I., Jossart J.M. (2020). Statistical Report 2020, Bioenergy Europe.
[896] Own calculation based on BasisBioenergy EU (2016) Project results and JRC data
[897] Oven dry tonnes

Figure 0-12 Consumption of wood bioenergy plants in Europe by size categories and type of plant (EU28). Source: Bioenergy Europe, 2016 [898]



The MSs most affected by an extension of the minimum threshold from 20 MW to 10 MW are Sweden, France, and Austria. They remain the most affected countries even when the threshold is lowered to 5 MW.

Table 0-23 Number of biomass plants by size and MS. Source: Bioenergy Europe (2016) [899]

	Larger than 10 MW and up to 20 MW	Larger than 5 MW and up to 10 MW
Sweden	81	81
France	69	142
Austria	46	69
Germany	40	41
Finland	35	59
Lithuania	24	15
Latvia	17	45
Spain	16	27
Slovakia	16	24
Denmark	13	28
Italy	8	24
Other EU	42	103
Total	**407**	**658**

Compliance and administrative costs

The cost of complying with option 3 will be essentially administrative in nature, although in some cases there may be increases in fuel costs due to the different supplies allowed.

A recent analysis carried out by Pöyry[900] analysed the administrative burden of complying with sustainability criteria for plants of different size in four Nordic countries (Sweden, Finland, Denmark, Norway). The analysis considered one-time costs (setting up contracts, build-up the management system, approval of the system) and annual costs (covering operation of the system and auditing). For a 10 MW plant, these are expected to range between €0.7 and €1.3 per MWh (5% to 7% of fuel costs). For

[898] Bioenergy Europe. (2016). BASIS database
[899] Data for Austria is incomplete
[900] NER and Pöyry. (2018). A Nordic analysis of the proposed EU policy for bioenergy sustainability. Available at: https://www.nordicenergy.org/wordpress/wp-content/uploads/2018/01/A-Nordic-analysis-of-the-proposed-EU-policy-for-bioenergy-sustainability_Final.pdf

comparison, the lower end is an increase of €0.1 per MWh of fuel compared to a 20 MWh plant. This is estimated by assuming the following costs:

- Annual audit: 4-5 days (50% by auditor, 50% by energy plant);
- Annual operation: 25 to 45 days;
- One-off Contracts and IT: 30 to 60 days;
- One-off system approval (audit + authority): €7,350 – €9,450.

The high end of the range is estimated for plants that import from high-risk countries feedstock that is recorded according to own GHG calculation. The lower end, which would be the case for the majority of small plants, is for an installation that buys from an EU country and that uses default GHG values.

The costs on the supply chain are more difficult to analyse given the different configuration this could take. However, a number of considerations can be made:

- Administrative burden in the supply chain is expected to be limited (Pöyry estimates the admin burden on average falls for 85% on energy plants and the remaining on suppliers);
- installations between 10 MW and 20 MW would typically have a mix of suppliers, including medium-large traders and local producers (e.g., landscape management, management of local forests). Suppliers that serve many plants are expected to already comply with sustainability criteria, which means they will not incur additional administrative costs. Compliance and certification for small biomass producers could instead be more onerous, especially as income from bioenergy is often a secondary source of income.

The Biosustain report[901] analysed administrative costs of imposing sustainability criteria to biomass installations using the standard cost model. For costs affecting operators, the report identifies two types of costs:

- one-off, costs related with activities to get the certification (incurred the first year); and
- recurring costs related with activities to maintain the certification (yearly cost in the subsequent years after obtaining the certification).

The analysis does not expect a material increase in cost for public administrations (plant size will not require setting up and running new process, at most it will require monitoring few additional plants). Main affected stakeholders would be:

- solid biomass producers from agriculture;
- forest owners;
- owners of heat and power bioenergy plants.

The analysis looked at different thresholds of application (4 MW and 20 MW) and used the following assumptions concerning the number of operators in 2030:

- the total number of all electricity, CHP and heat power plants above 4 MW is estimated at 11,750 plants (while in 2013 there were 6,000). Of these, 1,400 are estimated to be above 20 MW;
- the number of forests entities is estimated at 1,452, equivalent to around 1.2 million forest owners;
- approximately 9,133 farm groups producers of solid biomass from agriculture;

[901] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf

- in the option where the applicability threshold is set at 20 MW, the analysis assumes that all forest entities and group producers would still choose to be certified, in order not to have their market restricted to <20 MW.

The administrative cost of extending the sustainability criteria to biomass plants from the current >20 MW to a lower threshold of >4 MW can be calculated based on the difference between the results from the two cases (Table 0-24).

Table 0-24 Administrative costs deriving from the introduction of sustainability criteria. Source: PWC, 2017[902]

Threshold	>20 MW			>4 MW			extending from 20 to 4		
Market participant	Number affected	One-off costs €M	Recurring costs €M	Number affected	One-off costs €M	Recurring costs €M	Number affected	One-off costs €M	Recurring costs €M
Producers of agriculture biomass for biofuel	9,979	24 - 45	12 - 22	9,979	24 - 45	12 - 22	0	0	0
Producers of solid biomass from agriculture	9,133	40 - 75	19 - 36	9,133	40 - 75	19 - 36	0	0	0
Forest owners	1,452	158 - 294	38 - 70	1,452	158 - 294	38 - 70	0	0	0
Bioenergy plants	1,399	3 - 5	2 - 3	11,782	25 - 46	15 - 28	10,383	22-41	13-25
Total - Market participants	19,963	323 (avg)	101 (avg)	30,346	354 (avg)	120 (avg)	10,383	19	12
Total - Public administration	NA	0.06 - 0.11	0.36 - 0.67	NA	0.06 - 0.11	0.06 - 0.83	NA	0	0

According to the model, extending the minimum threshold from 20 MW to above 4 MW is likely to only add costs to the 10,383 bioenergy plants affected. These costs are estimated to be a one-off of between 41 and 22 €M and a recurring one of 13 to 22 €M per year for plant operators. In terms of increase from baseline, these are equivalent to an increase in 52% in the number of plants affected, but a much smaller increase in costs (respectively, 6% increase in one-off costs and 12% increase in recurring costs). This is because admin costs are likely to affect bioenergy plants only.

However, the analysis assumes that producers of biomass from agriculture and forest owners already comply with these criteria in order to sell to larger installations. This is unlikely to always be the case, as there is evidence that often smaller installations rely on local suppliers for their biomass. For a substantial share of these local suppliers, biomass is a by-product of their main agricultural activity, so it is unlikely all of them would choose to certify their production. Therefore, the estimated cost of lowering the threshold from 20 MW to 4 MW should also include a share of recurring and one-off costs calculated for other categories of stakeholder. On the other hand, the number of plants between 4 MW and 20 MW (estimated at 10,383 units), seems high compared to the last figures available (a total of 4,000 plants above 1 MW).

[902] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf

Text box 2 Administrative costs - the case of a 15 MW biomass CHP plant

A 15 MW (input) CHP biomass plant is able to produce 4 MW of electricity and 9 MW of heat. Assuming a load of 50% (i.e. the plant runs at full power for 50% of the time) and a conversion efficiency of 3.5 tonnes of oven-dry biomass per MWh, the plant would need 19,000 tonnes of fuel per year[903]. At an indicative price for woodchips at €120 per tonne, the plant would have annual fuel cost of €2.3 million per year.

In order to demonstrate compliance, an installation has to keep records of purchases of certified woodchips sufficient to cover the fuel needed to produce the MWh output generated over a certain period. The installation has then to be audited and certified, which means an independent third party has to verify that this information is available and satisfies the criteria.
Audit cost may vary between €5,000 and €10,000[904] per year, while working hours spent on administrative tasks depend on a number of factors. For example, how many fuel shipments the plant requires per year, the extent to which software allows the system to be automated etc. However, these are expected to be limited: in 2017[905] these were estimated to be 64 one-off and 36 hours per year.

Besides direct costs, the plant may have to face increased fuel costs, as it has to ensure the purchase of certified fuelwood. Some cost of certification would accrue for each step in the supply chain, but they may vary according to the trader (for example, a trader that already supplies certified wood or currently supplies plants above 20 MW is likely to have in place the appropriate process so that its cost increase will be limited to the associated quantities).

Option 4 and 4.1

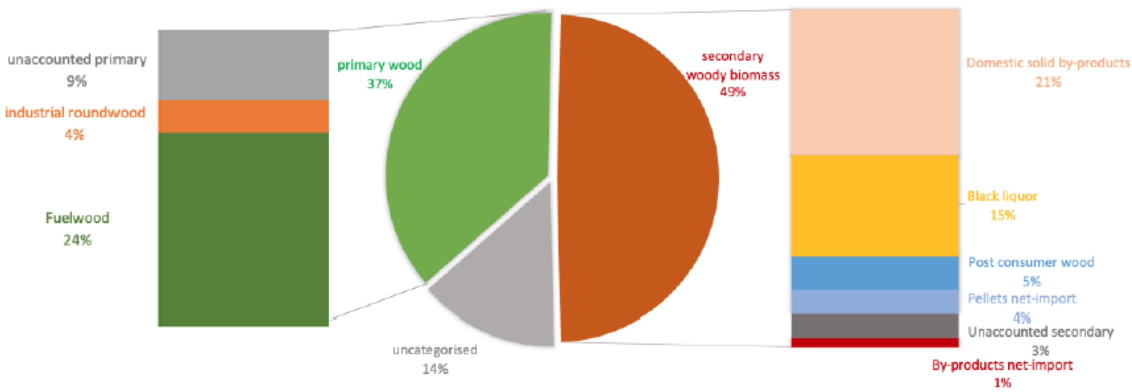
Option 4 involves setting a cap at national level on the use of stemwood for bioenergy, which could be set at a level similar to volumes recorded in the period 2015-2020. Option 4.1 considers a ban on the use of stemwood for bioenergy. Both options would affect the entire market, not only installations covered by the sustainability criteria, but given the remit of the directive both a cap or a ban will not completely stop or limit the use of stemwood for bioenergy. However, they would avoid these quantities are counted towards the RED target and receive financial support from MSs.

A cap on stemwood recognises the fact that, while using stemwood is desirable and an effective way of producing bioenergy, RED may create perverse incentives to destine too large amounts of stemwood to this use. A cap on stemwood would also ensure that quantities are closely monitored and that they are kept at a level considered sustainable, for example the current level. While forecasts of the European Commission do not predict a substantial increase in biomass demand, at least in the next ten years, there is a risk of demand surges, driven for example by new large scale installations. It is also important to consider the delay in forestry data availability and the long reaction time between identifying the problem at EU level and implementing any change in MSs.

[903] This is equivalent to 380 truck-trailers (largest available) per year. Based on Laitila, J., Asikainen, A., and Ranta, T. (2017). Cost analysis of transporting forest chips and forest industry by-products with large truck-trailers in Finland. Available at: https://metsateho.fi/wp-content/uploads/L2.2.-Laitila.pdf
[904] Based on various estimates. For example, in *A Study on Energy Efficiency in Enterprises: Energy Audits and Energy Management Systems (EC, 2016)*, energy audit costs in manufacturing range between €9,000 and €30,000, but these will involve far more complex assessments than those envisaged for compliance with RED criteria.
[905] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/default/files/documents/biosustain_report_final.pdf

According to analysis from the JRC[906], wood-based bioenergy production is, to a large extent, based on secondary woody biomass (forest-based industry by-products and recovered post-consumer wood), which makes up almost half of the reported wood use (49%). Primary woody biomass (stemwood, treetops, branches, etc. harvested from forests) makes up at least 37% of the EU input mix of wood for energy production. The remaining 14% is uncategorised in the reported statistics, meaning it is not classified as either a primary or secondary source. Based on JRC analysis of the biomass flows, the source of the unaccounted biomass is more likely to be primary wood.

Figure 0-13 Origin of wood fibres used for bioenergy in the EU (2015). Source: JRC, 2021[907]



Fuelwood is wood that is harvested to be used directly as fuel or to produce processed wood fuels such as wood pellets and briquettes. It is composed of stems that are normally of low quality, and of branches, tops and other parts of tree. Removals for fuelwood (estimated to be 166 Mm^3 in total) account for 34% of total removals from forest.[908]

Overall, JRC estimates that roughly 47% (88 Mm^3) of primary wood destined to bioenergy is made of stemwood while the remaining 53% (78 Mm^3) of other wood components (treetops, branches, etc.). At least half of the stemwood removed for bioenergy in the EU can be assumed to derive directly from coppice forests.

According to these estimates:

- Option 4 would require any further increase in forest biomass to derive from other wood component, with stemwood allowed limited to around 88 Mm^3 (or 45 Mm^3 if coppice is excluded from the cap);
- Option 4.1 means that there will be a shortfall in the market equivalent to 88 Mm^3 (or 45 Mm^3 if coppice is excluded from the cap).

These figures are likely to be an underestimate of the quantities affected, as they are based on production up to 2013, and there is evidence that primary wood harvesting has gone up since.

[906] Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S. (2021). The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

[907] Ibid.

[908] Based on a 10 year average during the period 2004 to 2013

These figures are likely to be an underestimate of the quantities affected, as they are based on production up to 2013, and there is evidence that primary wood harvesting has gone up since.

The scale of the impacts of the two options on stakeholders and on the market depends primarily on the demand for fuelwood during the implementation period. If demand for bioenergy (and consequently for woody biomass) is going to remain flat, the impact of option 4 will be limited, while the impacts of option 4.1 would affect only the quantities indicated above. If it is assumed that demand is going to increase, option 4 will also affect the current market and stakeholders. The current best estimates of bioenergy generation from the European Commission suggest a relatively stable demand in the next 10 years, followed by an increase of over 80% post 2030, which means the effect of these options may became more pronounced in the medium term.

Effects on the wood market

A ban or limit on the quantities of fuelwood would affect different actors in different ways:

- Forest owners may have difficulties placing all (in case of a ban) or part (in case of a cap) of their stemwood harvested for fuelwood. In the long term, this is likely to decrease the price of low quality stems destined to fuelwood. On the other hand, the demand of non-stem fuelwood will increase in order to compensate for missing quantities, which is likely to lead to higher prices for this product;
- The reduction in demand for stemwood is likely to drive down the price of lower quality stems, which would indirectly benefit the industrial roundwood industry and the pulp and paper industries. The demand for secondary wood (wood residues and by-products) to be sold as fuelwood from these industries may also increase, allowing them to obtain better prices;
- Final consumers (energy installations) may also be affected, as the reduced availability of fuelwood affects the market and put pressure on fuelwood prices. Therefore, it could be expected that option 4 (cap) would limit the number of new installations coming to the market (as each new installation would drive prices up), while option 4.1 (ban) may even reduce the amount of bioenergy compared to current level in the short to medium term if prices increase substantially. However, it is expected that other forms of solid biomass (e.g. from energy crops or from secondary wood) would be able to fill in the majority of the shortfall;
- The entire supply chain will have to comply with more precise and burdensome administrative practices, although there could be implementation option that see no reporting obligation imposed on forest owners (see next section).

A ban or a cap on stemwood may also have unintended secondary effects on forest practices and on the market, which would reduce the benefits of the options:

- The amount of fuelwood demand that remains unsatisfied after the cap or ban could drive an expansion of forests exploited for fuelwood, to compensate for the missing quantities (see Text box 3);
- The reduction in income from fuelwood may render uneconomical some harvests of small forest units which often serve the local demand, especially if the ban or cap requires changes in forest practices. The difference is likely to be filled by large industrial growers, and to a lesser extent secondary market;
- Currently, forest owners harvest their product in order to maximise their income from different buyers. These, in order of profitability per tonne, could be broadly grouped in three categories: industrial roundwood, which pays the highest; pulp and industry; and bioenergy

(see Text box 4). Any wood that is not fit for the other categories would generally end in the bioenergy category. Limiting the type or quantities that the bioenergy sector is able to buy may affect forestry practices in a number of ways. For example:

- Often, a stem is labelled of poor quality and destined to fuelwood after it has been cut, once the pulp is exposed. A ban or a cap would not discourage the practice and may result in stems being left on the ground. While this is not a negative effect per se (rotting stems also play an important role in supporting biodiversity), in larger quantities it could affect the health of the forest;
- Setting up a ban based on stem diameter may bring some forest owners to anticipate harvest and cut the tree before it reaches the limit size; or, the height of the stomp could be increased, so to leave out the wider end of the stem. Both practices are not desirable from a sustainability point of view.

Text box 3 Modelled effect of a cap on roundwood

A 2016 study by the European Commission (*Follow-up study on impacts on resource efficiency of future EU demand for bioenergy (ReceBio follow-up)*)[909] investigated the effect of a cap on the EU28 use of roundwood for bioenergy (either directly in the form of roundwood or indirectly in the form of imported wood pellets made of roundwood). Modelling assumptions (PRIMES was used for the assessment) included restrictions for harvestable areas to protect biodiversity and roundwood used directly for energy production was restricted at quantities used in 2020.

According to the modelling results, restricting the use of roundwood leads to a situation where roundwood is no longer combusted directly for bioenergy production and import of wood pellets to the EU from the rest of the world is reduced (this is because 75% of the pellet feedstock is assumed to be roundwood). The resulting gap in the feedstocks for bioenergy in the EU is, in this scenario, fulfilled by industrial by-products, mostly through a change in the feedstock composition within the pulp and board industries towards use of roundwood instead of by-products, and an increase in sawn-wood production (11% increase compared to REDU2 in 2050), since sawmills become more profitable as the by-products are in high demand for bioenergy and achieve high market prices. A consequence of the reduced availability concerns total used forest area. In fact, the changes in demand for wood are expected to result in an intensification of forest management and lead to an increase in the area of used forest within the EU by 8.5% in 2050 compared to the baseline scenario. The used forest area increases at the expense of unused forest area and only a small area of additional new forest is established on other natural land. Focussing on pellets, the analysis found that: "*A decrease of the share of roundwood used for pellets from 75% to 50% leaves almost 2 Mha of forest unused in EU in 2050. An increase from 75% to 100%, instead, increases the area of used forest in the EU by 1 Mha in 2050. Similar effects can be reported for RoW.*"

In terms of climate impacts, this scenario is expected to lead to net emission saving in the range of 15 Mt CO_2 in 2050. At the same time, net GHG emissions from LULUCF increases (about 9 Mt CO_2 higher as of 2050). This net balance is dominated by a reduction of the forest management carbon sink (about 30 Mt CO_2 compared to baseline) and an increased storage of carbon in wood products (about 22 Mt CO_2 compared to baseline).[910]

[909] Forsell, N. et al. (2016). Study on impacts on resource efficiency of future EU demand for bioenergy (ReceBio). Final report. Project: ENV.F.1/ETU/2013/0033. Available at: https://ec.europa.eu/environment/enveco/resource_efficiency/pdf/studies/KH-02-16-505-EN-N%20-%20final%20report.pdf

[910] The net emissions reductions of the scenario only refer to the savings related to the LULUCF sector as the energy demand is fixed and the estimates should be reviewed in consideration to the underlying assumptions of the study. In particular, it should be kept in mind that potential additional GHG emissions reduction related to material substitution effects are not considered within this study.

Text box 4 Small forest management

There are over 16 million forest owners in the EU, and the vast majority of them are smallholders with a few acres of forest areas. For them, forestry is generally not the main source of income, but it is a secondary activity that provides additional income and services. Logging is not always the main service provided by these forests (these are used for recreation, hunting, etc), but it is still an important source of income as removing whole or part of trees is already part of standard forest management practices.

Forest owners maximise the income from the removals of trees and branches by selling different products to different industries, where:

- logs are the most profitable source, fetching the highest prices per m^3 when sold as industrial roundwood. While price ranges vary substantially among MSs and type of wood, an indicative value for large pinewood is a sale price of €50 to €60 per m^3. In some cases, buyers may ensure group certification and provide a price premium of around 1 €/$m^{3;}$
- the second most profitable product is pulpwood, sold for the production of paper and similar. In terms of quantity, forests would produce a comparable amount of pulpwood and logs, but the price of pulpwood is much lower (around €32 - €35 per m^3);
- the last category, generally sold as fuelwood or biomass, contains both small diameter trimmings (branches, treetops, stems removed to thin out forests and allows best trees to grow bigger, stumps) and poor quality roundwood and pulpwood (€11-€27 per m^3).

Trimmings and removals sold as fuelwood are a by-product of forest management, and in the absence of a market for fuelwood they would be left in the forest to decompose.

The prices of different wood removals to forest owners indicated above are those reported by Luke, which track prices in Finland (one of the major forest products producer in the EU). Table 0-25 shows the latest prices available from the Luke database.

Table 0-25 Roadside price by wood type[911]

Category	Type	Price €/m^3 (roadside collection)
Fuelwood (2020 prices)	Stumps	10.74
	Logging residues	17.72
	Unpruned stems	23.01
	Pruned stems	26.60
	Fuelwood average	23.94
Roundwood (2019 prices)	Pulpwood	32.35 - 34.52
	Small-size logs	39.14 - 39.75
	Logs	50.39 - 62.88

In Finland, forest owners are able to extract 200 m^3 of wood per ha, of which half may be sold either as logs or pulpwood. Based on the prices above, and assuming an average price of €19/m^3 for fuelwood and €41/m^3 for any other removal, a forest may be able to generate around €6,000 per hectare, after the trees have been felled and the logs arranged for easy roadside pickup. Of this, €1,900 may derive from fuelwood sales. The share of revenue from fuelwood includes logs not suitable to be sold as other (more valuable) forest products; fuelwood logs are currently able to fetch a much better price than other fuelwood (pruned stems price is currently 50%

[911] Natural Resources Institute Finland. Luke statistics database. Available at: https://statdb.luke.fi/PXWeb/pxweb/en/LUKE/

higher than other removals). If these are not allowed to be sold as fuelwood, and assuming forest owners are not able to find other markets for it, up to one third of the income may be affected. Assuming stems represent 30% of fuelwood removals[912] this would halve fuelwood revenue and reduce total revenue per ha by around 30%. This is only and indicative estimate, which would vary substantially by country, forest type and density of the area harvested.

The majority of forest owners across Europe manage a very small area[913], often 1 ha or less but there is no data that estimates the average holding size from which fuelwood is harvested.

Administrative burden

One of the biggest challenges of these options is the monitoring and certification of the fuelwood. Either a ban or a cap based on diameter would require some form of measurement of the stems and would require this to be included in a certification process of sustainable biomass.

Current sustainability criteria already require installations above 20 MW (2 MW for biogas) to demonstrate compliance of their feedstock via a certification process, for example to demonstrate the country of origin and (for new installations) the quantification of GHG savings. However, option 4 and option 4.1 will affect the entire supply of forest bioenergy, not only the share covered by the current sustainability criteria as is currently the case. This means that the entire market from forest to users will have to be monitored, resulting in higher costs for operators that currently do not need to certify the biomass they use.

Two factors will be determinants to estimate the extent of the administrative burden:

- whether implementing option 4 or 4.1 requires certification of forest holdings, or if it just relies on certification of the supply chain. EU forest biomass is sourced from few large forest holdings and a large number of small forest units (hundreds of thousands); if the sourcing area has to be monitored, in order to certify that stemwood does not end up as sustainable biomass feedstock, the overall administrative burden may increase substantially compared to the current burden. However, it is possible to envisage an implementation and enforcement system where the certification process has to start only at the point where the wood has left the forest. If this is the case, the actor in charge of ensuring the absence of stems in the quantity of sustainable biomass would be either:
    - traders/wholesalers;
    - sawmills/fuelwood processing plants;
    - energy plants, in the case of direct sale from forest to energy generator.
- The exception is the case where forest owners process wood into woodchip at the forest site. In this case, they will be the first link in the supply chain that will have to be certified.
- **How the measurement and certification process will take place.** Operators that deal with whole logs will have to setup processes and record how they manage stems of different sizes. They will also have to set up the system in such a way that can be audited and certified by

[912] Based on Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S. (2021, page 47). The use of woody biomass for energy purposes in the EU. EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

[913] UNECE/FAO research shows that: 61% of all private forest holdings have an area of less than 1 hectare and 86% of all holdings belong to the size classes of up to 5 hectares. 13% of the private forest holdings are in the size classes from 6 to 50 hectares and around 1% of the owners have forest units over 50 hectares. Based on “Geneva timber and forest study paper 26, private forest ownership in Europe” (UNECE and FAO, 2010). Available at: https://unece.org/DAM/timber/publications/SP-26.pdf

external auditors. Once the logs have been transformed into standard products (e.g. woodchips, pellets) it will be necessary to ensure the Chain of Custody, via processes already fairly established in the industry (these would be similar to those currently used to certify sustainable forest practices). However, the high cost required to set up and certify such a system is likely to affect particularly small suppliers (either at forest level or in the supply chain) and small installations. Because of these costs, the latter may decide not to source directly from local forests and opt for large-scale traders. Further, there will be particular challenges in auditing self-consumption, for example for sawmills and pulp and paper industries.

- **At what level the certification obligation stops.** It will not be possible to monitor and verify all biomass installations, including domestic ones. However, it should be possible to track these quantities up to a wholesale/resellers. The majority of small consumers will purchase feedstock from retailers that could be considered as the last certification point in the chain of custody.

Based on the considerations above, if is not possible to estimate with any degree of precision the additional administrative cost required to discriminate stem size. Certification based on quantities and provenance are common the industry and costs are better known. However, stem size is not a standard measure currently collected and tracked by the supply chain, and it is likely to pose significant challenges in terms of logistic of operations and third party certification. Further, the administrative burden may discourage short, local flows (i.e. from forest directly to power plants) as either one of them will have to setup the verification and monitoring system for stem-size, and be audited to ensure its compliance. This would negatively affect locally-sourced biomass from small scale business, usually considered highly sustainable.

Finally, setting up appropriate caps and monitoring them adequately at national level could require substantial administrative costs for national governments, and there will be complex estimates to be made to calculate the correct quantities to be used as the baseline for the target.

Environmental impacts

Option 4 and 4.1 would have positive effects on biodiversity and climate, unless they lead to a complete removal of other residues to compensate missing quantities[914]. Prioritising residues and the circular use of wood is key for maximising the positive climate impact of wood-based bioenergy, the benefits of the bioeconomy[915], and to ensure RED supports the objectives of the Biodiversity Strategy.

Modelling conducted in 2016[916] (see also Text box 3) suggests that limiting the use of stemwood for energy may result in an increase in stemwood used in products and increases the traded quantities of by-products of these processes, essentially limiting the positive effect on forest harvests. On the other hand, limiting stemwood will have positive effect on GHG emissions, as wood products are likely to store carbon for longer periods (years or decades).

[914] Sustainable forest Management guidelines also recommends a certain amount of residues is also left on the ground.
[915] See European Commission. (2019). Commission guidance on cascading use of biomass with selected good practice examples on woody biomass. Available at: https://op.europa.eu/en/publication-detail/-/publication/9b823034-ebad-11e8-b690-01aa75ed71a1
[916] Forsell, N. et al. (2016). Study on impacts on resource efficiency of future EU demand for bioenergy (ReceBio). Final report. Project: ENV.F.1/ETU/2013/0033. Available at: https://ec.europa.eu/environment/enveco/resource_efficiency/pdf/studies/KH-02-16-505-EN-N%20-%20final%20report.pdf

Option 5

Option 5 involves setting fixed caps at national level on the quantity of energy from forest biomass (primary wood used in bioenergy), without discriminating between stemwood and other residues. The main aim of the option is to limit any further expansion of forest-based bioenergy production. Having the required monitoring system in place will also allow MSs to evaluate the quantities of forest biomass destined to bioenergy with more granularity and frequency compared to current practices. As for option 4 and 4.1, the cap will not be limited to installations above a certain threshold, but the entire quantities counted towards the target.

A cap-type solution is supported in particular by environmental NGOs, pointing to the fact that sustainability issues for bioenergy are sensitive to scale rather than the wooded areas' management processes used by forest owners, or the provenance of wood. The concept of a cap is already present in RED (limiting the amount of biofuels), and it was introduced with a similar aim: limiting the use of bioenergy from particular sources beyond levels considered sustainable.

Based on the JRC estimates[917], the cap would affect roughly 50% of wood bioenergy used (which was equivalent to 166 Mm^3 per year, on average, between 2004 and 2013) and 34% of all removals from forest (the remaining being used in other industries such as construction and pulp and paper). As is the case of option 4, non-forest biomass would continue to be allowed without limitations, which means increase in bioenergy production are still possible, even after a cap.

Several considerations raised for a cap on stemwood (option 4) apply to a cap on quantities, albeit with some differences.

- The scale of the impacts on stakeholders and on the market depends primarily on the demand for fuelwood during the implementation period. If demand for bioenergy will remain relatively flat, as the Commission expects will happen up to 2030, a cap would have limited or no effect, because total demand will be equivalent to, or below, the cap. If instead new installations come to the market, therefore increasing demand, forest owners will not be able to expand their production to satisfy the new demand. This is likely to have two effects: an increase in the price of forestry products, which will discourage new installations to enter the market; and an increase in the production of non-woody solid biomass, and possibly of by-products;
- Forest owners will not be able to increase the quantities currently produced, although it is likely that redistributions across MSs and forest areas will still happen. The overall economic impact on forest owners is unclear. On one side, limits to forest bioenergy may increase their price, for example for the production of high quality chips or pellets; on the other side, an oversupply in the market may push prices down and force the more inefficient producers out of the market;
- Final consumers may be affected by an increase in prices, as the supply of woody biomass from forest is limited.

Given the prominence of bioenergy among energy sources in many MSs and given the expected long-term growth of bioenergy use project by the modelling carried out by the Commission, this option could

[917] Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S., The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719 https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

have the substantial impacts on the quantity of bioenergy and on the cost of meeting the RES target. Excluding the possibly of a further expansion in bioenergy would require extensive deployment of energy crops and alternative technologies, the uptake of which for heat generation is still limited. The overall costs of reaching the target in the short term may increase, both because of an increase in fuelwood prices and because of the additional investment in alternative heating technologies.

In contrast, having strengthened sustainability rules in place that are consistent with the higher renewable energy ambition and accepted by public opinion would create longer-term investor certainty and avoid giving wrong market signals. Further, the option will give clearer signals against further investments in bioenergy that could be redirected towards electrification powered by other renewable sources.

Administrative burden

The administrative cost of tracking the provenance of all bioenergy from forest will be substantial, but less so than having a diameter-based system. This is because quantities (either tonnes or m^3) are a standard element utilised in a market transaction.

Similar to a cap or a ban based on stemwood diameter, administrative costs depend on:

- whether implementing option 4 or 4.1 requires certification of forest holdings, or if it just relies on certification of the supply chain;
- the last market participant that has to demonstrate compliance with the system (if energy user or resellers for plants below a certain size).

As for caps based on quantities, there will also be a complex work to be done by National Governments to define the appropriate cap level and to monitor the implementation across a much wider range of market participants (to cover the entire market).

Environmental impacts

Option 5 offers more certainty than option 4 and 4.1 that energy generated from forest biomass would not increase, or that it would do so within controlled limits. As discussed above, the net impact of the option depends on the baseline trend in bioenergy generation: an expected flat trend means that the cap will have limited effect, but in practice this option will protect against the risk of unrestricted growth. Limiting the amount of bioenergy will have a number of positive environmental impacts on biodiversity, biogenic emissions, and ecosystem protection.

However, a ban may also create counterproductive effects. For example, a limit on biomass production may lead to abandoning some forests currently managed or to shelve plans for expanding forested area under management. Active forest management can have a positive effect for biodiversity and avoid a net forest sink saturation in the medium-long term, as managed forests are able to grow more trees than mature forests.[918] Further, limits to bioenergy use may also discourage investment in new forest plantations, which would be beneficial to wider EU objectives (such as those of the biodiversity directive) and increase forest sink in the long term.

[918] It is important to note this depends on which use the wood is destined. Industrial wood used in construction will ensure a sink of decades, while pulp and paper's use has a much shorted sink effect.

Other options considered

This section presents findings associated with options the have been discarded or adapted during the process. The majority of the analysis developed as part of the evaluation of these options has been adapted and integrated into the analysis of the main five options presented above. Here is presented only remaining evidence and the high level economic, environmental and social impacts expected for these options.

Harmonising criteria

Articles 29 and 30 set a number of criteria that affect the entire supply chain of bioenergy production, from producers to end users. These criteria are in place to ensure bioenergy does not cause negative effects on biodiversity, ecosystem, and GHG emissions, while at the same time trying to avoid imposing excessive burden on key stakeholders, as this would reduce the contribution of bioenergy to renewable generation.

The criteria set in RED and further clarified in its implementing acts (some of which are currently being developed) set a minimum standard that all bioenergy must meet in order to be accounted for the purpose of the targets imposed on MSs by the directive. However, the directive also allows MSs to go beyond these minimum requirements (for example, article 29.10 explicitly states that "*Member States may apply higher energy efficiency requirements than those referred in the first subparagraph to installations with lower rated thermal input.*").

This option would remove the possibility for MSs to impose stricter requirements for national installations. This would have the broader effect of aligning all MSs to the minimum standard, albeit including a stricter standard than the current one in light of the other changes to sustainability criteria as part of option 2. There are two main benefits associated with full harmonisation:

- level playing field across commercial installations located in different MSs;
- trade in the internal market would benefit by the removal of barriers created by different criteria: as feedstocks producers and forest owners would be able to access every EU market, rather than being restricted by some increased requirements in some MSs.

Associated with lowered barriers to trade, a further benefit would be the reduced administrative cost for the supply chain, as they do not have to keep up with different rules in different MSs. This option does not have direct economic costs for stakeholders, but it has negative impact associated with reduced sustainability credentials compared to a counterfactual scenario where some MSs are allowed tighter rules.

In occasion of the first iteration of RED, the Commission left MSs freedom to implement sustainability criteria for solid and gaseous biomass, while retaining a more harmonised approach for liquid fuels. Several MSs, mostly those with larger biomass imports such as United Kingdom, the Netherlands, Belgium, and Denmark chose to put in place mandatory requirements or rely on a voluntary sustainability scheme. One such example is the Sustainable Biomass Partnership.

Intra-EU biomass trade market

When looking at intra-EU trade data for fuel wood or wood in chips /wood waste, there is no apparent effect from the introduction of these mandatory requirements. Eurostat data[919] shows both intra-EU28 imports and exports of fuel wood exist for all countries except for Cyprus and Malta.

NECPs which report on their biomass origins (14 out of 24 NECPs) mention not only their domestic potential but also expected imports from third countries. Ireland, Lithuania, Denmark, Finland, Italy and Slovenia all indicate they produce solid biomass domestically in volumes large enough to meet part, or all of their demand. Whilst the Czech Republic and Estonia have large biomass sectors which export biomass to other MSs. Contrarily, Sweden, Belgium, Hungary and Bulgaria plan to meet their future demand for biomass through imports. Sweden is the only MS with significant biomass potential which expects to continue significant biomass imports due to the relatively low costs compared to domestic production[920].

Literature

A recent paper titled *The European wood pellets for heating market - Price developments, trade and market efficiency (2020)*[921] analysed recent data on trade flows and price developments between Italy, Austria, Germany and France to understand the developments of wood pellet market efficiency and to draw conclusions about its efficiency. The study concludes that, based on the observed price differential, the markets of the countries considered appear still to be inefficiently integrated and with arbitrage activities ongoing. No link, however, is made to the RED II requirements and further analysis of these price differentials (e.g., using data with more resolution) as well as a better understanding of the pellet market is needed. Large price differences are seen for Slovakia, the Netherlands and Italy (exports) and Ireland, Romania, Bulgaria (imports). These do not seem to be linked to additional biomass sustainability criteria.

Conclusion

This option considers harmonising sustainability criteria of Article 29 and 30 for biomass fuels in heat and power. Harmonisation will ensure MSs cannot introduce additional criteria than those specified in RED II, although local legislation would still apply, for example concerning forest practices. In the past, some MSs have introduced stricter and diverging criteria, but it is as yet unclear if and to what extent this will be repeated with the new criteria (which have to be implemented by June 2021).

The element of further harmonisation of sustainability criteria will reduce barriers and costs, while reducing differences in MSs' rules and facilitating internal trade by providing an improved level playing field. The removal of barriers created by different criteria would improve trade in the internal market and lead to reduced administrative costs for the supply chain.

This option may lead to negative environmental impacts, compared to a counterfactual where MSs are able to introduce stricter sustainability criteria. However, if this option is combined with Option 2 (or with other options), the level of protection ensured across the EU will be higher than the current one.

[919] Eurostat: EU trade since 1988 by SITC [DS-018995] for SITC codes 245 (Fuel wood (excluding wood waste) and wood charcoal) and 246 (Wood in chips or particles and wood waste)
[920] Svebio (2014). IEA Bioenergy, Task 40- Country report Sweden, https://www.bioenergytrade.org/wp-content/uploads/sites/17/2013/09/iea-task-40-country-report-2014-sweden.pdf
[921] Schipfer et al. (2020) The European wood pellets for heating market - Price developments, trade and market efficiency, Energy, https://www.sciencedirect.com/science/article/pii/S0360544220317448

Forest certification

This option considers replacing the RED II risk-based criteria for forest biomass with an obligation to demonstrate compliance with sustainability and LULUCF criteria at the biomass sourcing area level or the forest unit level. Countries that have not signed the Paris agreement and that do not report LULUCF emissions have already to comply with this requirement, but this currently affects only a marginal share of imports from outside the EU. In fact, all MSs will have in place national and local policies to comply with requirements as per Article 29.6(a).

In order to assess the impacts of this option is necessary to estimate:

- Forests areas affected, including how many forests or sourcing areas are currently certified in EU;
- the administrative costs per ton of wood of forest management certification (including the costs of certification and cost of compliance with the required measures);
- how would mandatory certification affect the availability of fuelwood in Europe.

Sustainable forest management practices (e.g. implemented through national legislation or in the context of certification schemes) play a role in mitigating the risk of overharvesting of forests. As such, they cannot guarantee that an increase in forest biomass for energy will deliver greenhouse gas savings, but they can avoid excessive wood removals which would result in a decrease in carbon sinks.

During the analysis in support of RED recast[922], the option to mandate certificate at forest level was considered too intrusive and too costly, as it would make not profitable operating forests for many smallholders:

Textbox 0-2 Options discarded in 2016[923]

> Applying requirements on sustainable forest management to all forest biomass, regardless of its origin
> For forest biomass, the land criteria would be replaced by a criterion on Sustainable Forest management in order to demonstrate that forest biomass is sourced through sustainable forest management practices and this should be demonstrated by means of certification.
>
> The option was discarded due to its proportionality (high increase of costs for forest owners) and subsidiarity concerns. The requirement to certify all the forest will be a heavy burden for the number of private forest owners, in particular for small forest owners. The strict requirements of the sustainable forest management criteria <u>are less consistent with the subsidiarity principle</u> and <u>do not respect the competence of EU MSs on forests</u>. In addition, transposition of such requirements will also be burdensome for public administration.

The conclusion was based on the result of the Biosustain report[924], which in assessing option 3a (SFM certification) concludes that it would severely affect bioenergy demand and supply capacities due to an assumed shift from the “reference” to the “restricted” scenario concerning the potential of bioenergy supply. The modelling results suggest biomass demand would decline by 16% in 2030 (compared to the baseline), affecting mostly the heat sector (30% decline in direct use of biomass for heating & cooling in

[922] European Commission. (2016). Impact Assessment: Sustainability of Bioenergy. Available at: https://eur-lex.europa.eu/resource.html?uri=cellar:1bdc63bd-b7e9-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF
[923] Ibid.
[924] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf

households, tertiary and industry). The decline of forestry biomass (by ca. 36% in relative terms, or 26 Mtoe concerning domestic supply and by 7 Mtoe in the case of Extra-EU imports) is only partly offset by an increased use of agricultural biomass. Due to renewable generation being shifted to other RES, about 69 Mt CO_2 would be avoided by 2030, an increase in emission avoidance by 4.4%. Decreased supply of forest biomass is associated with a higher demand for secondary or tertiary wood (competing with other uses) and an increase cultivation of lignocellulosic, perennial crops compared to the baseline, which can have positive impacts if cultivated on surplus cropland. The shift to other RES will determine an increase in CAPEX of 24% by 2030 compared to the baseline (net increase of about €7.3bn).

An obligation to certify forest area is likely to introduce a set of criteria additional to those currently used by mainstream certifying organisations such as FSC and PEFC. However, it is possible to assume an implementation mechanism similar to the one implemented for biofuels, in which the European Commission approves a certification scheme if it complies with a set of criteria[925] such as:

- feedstock producers comply with the sustainability criteria;
- information on the sustainability characteristics can be traced to the origin of the feedstock;
- all information is well documented;
- companies are audited before they start to participate in the scheme and retroactive audits take place regularly;
- the auditors have both the generic and specific auditing skills needed with regards to the scheme's criteria.

Concerning the implementation of sustainability criteria for forest biomass, the criteria set by RED II align to some extent with current certification schemes. Therefore, examining the current extent of currently certified forests can give an indication of the change that would be driven by such a provision.

In Europe, the total certified area of forests already amounts to around 13% of total forest area, combining FSC and PEFC. This is equivalent to 155 million ha. Forest operators would certify their forest to be able to sell to buyers of timber demanding proof of sustainable practice. This means that the vast majority of certified areas is already exploited for timber and (likely) for bioenergy purposes. Currently, forest owners choose to certify because of the additional benefits, which reduce or fully compensate the additional costs of certification. Generally, forest owners will be able to recover part of the certification costs thanks to the increased sale price of certified wood.

It is also important to take into account that certification is not without issues, as compliance can vary and the definition of sustainable management and how it is translated in the certification criteria is questioned by many. For example, certification does not guarantee GHG savings, nor does it avoid clear cuts of large areas. This is for example the case for FSC that allows clear-cutting of up to 90% in northern forests dominated by coniferous trees, as this is similar to how nature manages them as they are frequently destroyed by forest fires or severe storms.

[925] European Commission. (2020). Voluntary schemes. Available at: https://ec.europa.eu/energy/topics/renewable-energy/biofuels/voluntary-schemes_en

Recent research[926] on the effects of certification of nonindustrial private forest owners on forest degradation in Sweden concludes that "*certification has not halted forest degradation in that it has not improved any of the environmental outcomes. Moreover, for forest certification to have an effect, the standards should be tightened, and the monitoring and enforcement of forest certification schemes strengthened*."

Forests currently certified

A recent study[927] attempted to map certified forests in Europe. The study mapped forest certification across 43 European states, according to 499 FSC and 284 PEFC reports and assessed the proportion of certified forest area on public and private land and the rate of increase. In Europe, 107 million hectares, or 52% of all forest land, are in hands of private owners (Forest Europe 2015). The majority, close to 16 million of individuals are so called non-industrial private owners. The conclusion is that, at European level, about six percent of the forest is certified under FSC scheme (70 Mha), and about seven percent under PEFC scheme (86 Mha), for a total of 13% of forest area. Certification is increasing in both public and private land.

Table 0-26 Proportion of certified forest land in some ECE countries. Source: Joint COST Action FACESMAP/UNECE/FAO Enquiry on Forest Ownership in the ECE Region.[928]

Country	Public Forest			Private Forest			Total	
	Prop. Certified 2010 (%)	Prop. Certified 2015 (%)	Change 2010-2015	Prop. Certified 2010 (%)	Prop. Certified 2015 (%)	Change 2010-2015	Forest area 1000 ha	Prop. Certified 2015 (%)
Austria	67	67	0	47	75	+31	3,869.0	74
Belgium	85	87	+2	7	11	+4	683.0	47
Bulgaria	9	24	+15	0	1	+1	3,812.0	21
Croatia	94	95	+1	0	0	0	1,922.0	67
Cyprus	0	0	0	0	0	0	172.7	0
Finland	-	72	-	-	90	-	22,218.0	85
France	74	82	+8	17	18	+1	16,988.0	33
Iceland	0	0	0	0	0	0	49.1	0
Ireland	100	-	-	2	-	-	726.0	-
Luxembourg	0	87	+87	0	6	+6	88.7	44
Netherlands	-	62	-	-	28	-	376.5	45
Russia	3	5	+2	0	0	0	814,930.5	5
Serbia	27	88	+61	-	-	-	2,720.0	37
Slovakia	0	96	+96	0	37	+37	1,942.0	60
Slovenia	79	82	+3	0	6	+6	1,248.0	24
Switzerland	85	86	+1	48	44	-4	1,254.0	55
Turkey	0	19	+19	0	0	0	12,666.2	19
United Kingdom	100	100	0	22	22	0	3,154.0	44

According to Bioenergy Europe, 52% of EU28 forest areas available for wood supply are certified PEFC and 26% are certified FSC (some forests may be certified both PEFC and FSC, so these cannot be aggregated). This represents a substantial proportion of forest owners who, by certifying their forests,

[926] Villalobos, Laura, et al. (2018). "Has Forest Certification Reduced Forest Degradation in Sweden?" *Land Economics*, vol. 94 no. 2, p. 220-238. Available at: muse.jhu.edu/article/690445.
[927] Maesano M, Ottaviano M, Lidestav G, Lasserre B, Matteucci G, Scarascia Mugnozza G, Marchetti M. (2018). Forest certification map of Europe. iForest 11: 526-533. – doi:10.3832/ifor2668-011
[928] Ibid.

demonstrate commitment to sustainable forest management. However, currently, bioenergy is not strong enough a driver to certify a forest as it represents a small portion of wood utilisation. The incentive seems to only be effective when it is required by buyer of high quality wood.

Certification costs

The main assumption used in previous analysis (Biosustain report[929]) is that external costs for the certification of solid biomass from agriculture and forest are of around €0.11 - 0.20/tonne (these are assessed in Technical Annex F of the same document). Estimating the average price per tonne of wood is complex, as it depends on pricing structure and by a number of factors. Below, we present the certification costs for FSC, PFSC, and SBP. These are the external costs – to be paid to the certification company – and do not include any compliance costs that certification would involve, such as change of practices.

FSC

FSC sets out global requirements (Principles & Criteria) for achieving FSC forest management certification. Thereafter, the National Standards Development Groups adapt the FM standard at the regional and/or national level, in order to reflect the diverse legal, social and geographical conditions of forests in different parts of the world, creating a local standard based on global principles. Nineteen National FSC Standards are present in Europe, and Certification Body interim standards are operational in countries where these have yet to be developed. The costs of forest certification provided by FSC[930] are calculated according to a number of factors and cover the forest holding, primary and secondary processing facilities group forest management certifications and chain of custody. The latter verifies that FSC-certified material has been identified and separated from non-certified and non-controlled material as it makes its way along the supply chain, from the forest to the market.

For basic certification, FSC it charges a fixed rate of USD 10 for each certificate and an additional per hectare fee on top of this rate. The rate per hectare varies between zero for community forestry to $0.02 for plantations.

PEFC

The PEFC is an umbrella organization that endorses national forest certification systems. Twenty-four Council Members have been endorsed by the PEFC in Europe PEFC relies on national certification systems, which are then the ones charging fees to local owners. No data is available on the range of fees. PEFC too offers group certification for small forest owners, which now counts over 1 million forest owners.

SBP

The Sustainable Biomass Program (SBP) is a certification system designed for woody biomass, mostly in the form of wood pellets and woodchips, used in industrial, large-scale energy production. SBP has developed a certification system to provide assurance that woody biomass is sourced from legal and sustainable sources.

SBP applies two different tariffs to producers and to traders and end users:

[929] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf
[930] FSC. (2013). Annual Administration Fee (AAF). Available at: https://cn.fsc.org/preview.fsc-pol-20-005-v2-1-en.a-84.pdf

- Producers;
- Biomass Producers producing wood pellets: €0.15 per tonne of all wood pellets sold with an SBP claim;
- Biomass Producers producing woodchips: €0.08 per tonne of all woodchips sold with an SBP claim;
- SBP-certified Traders and End-users pay an annual fixed fee according to their size.

Table 0-21 SBP fees in Euros

	Annual volume (tonnes)	Annual fixed fee
Large entities	**250,000+**	**€25,000**
Standard fee	**100,000 - 249,999**	**€10,000**
Small entities	**99,999 or less**	**Nil**

Literature

A number of studies have explored the cost and benefits of forest certification:

European Family Forest Owners' views on Forest Certification (Confederation of European Forest Owners [CEPF] 2019)[931]**.** The paper looks at forest owners' expectations concerning a number of aspects of forest certification schemes (in particular PEFC and FSC), such as governance (including owner's participation), organisation, sustainability and business growth. The paper fund that in PEFC is better adapted to the needs and expectations of family forest owners. PEFC bases its development on international forest policy processes, balances the three dimensions of sustainability in a bottom-up system and ensures more predictability and transparency in its development. Furthermore, PEFC recognises the role of forest owners as resource holders and acknowledges their knowledge and long-term perspective.

On the other hand, in FSC there is no requirement to involve forest owners, and standards can be approved without their consent. Forest owners reported that the process puts less confidence in their ability and interest to manage the forests sustainably. Further, the scheme appears to favour larger actors who are able to cope with the complexity of the system and pay the associated costs. In relation to costs, the study found that a large part of the costs associated with FSC are due to the cost of experts hired to carry out the environmental and social compliance checks. On the other hand, PEFC minimises these costs by allowing self-certification to a larger extent. Other sources quoted in the paper reach similar conclusions on the costs for smaller forest owners being lower with PEFC than FSC. A further findings shared among many papers reviewed as part of the study is that the price premium for FSC wood was not sufficient to offset the additional costs (including indirect costs to abide by rules related to work safety, identifying HCVF (High Conservation Value Forests) and develop and maintain information systems). In this respect, forest owners also expressed reserves concerning the market benefit of PEFC certification compared to its costs.

[931] Confederation of European Forest Owners. (2019). European Family Forest Owners'views on Forest Certification. Available at: https://cdn.pefc.org/pefc.org/media/2019-09/0f8157a7-a520-4395-86ce-279987c7b201/8ffa28bd-f7b5-5e95-bae9-bbcf0cf626de.pdf

Forest certification map of Europe (Maesano et al., 2018)[932]. The study mapped certified forest areas in Europe, but also explored evidence collecting the perceived costs and benefits of certification. It reports that, in relation to the perceived benefits, the certification process is often expensive in terms of cost and organizational effort for small forest owners (Zhao et al. 2011). Quoting Di Lallo et al. (2016), certification costs are the most critical limiting factor for smallholders. In Europe, the exact forest area managed by small forest owners is unknown, but it is estimated to represent about 60 % of the total forest area (UNFF-11, 2015; Di Lallo et al., 2016). Currently, for both schemes, facilitations exist for smallholders, such as the Small or Low Intensity Managed Forests program from FSC or the "group certification" that, under both schemes, allows a group of forest owners to join together to get the certification.

The use of woody biomass for energy production in the EU (JRC, 2021)[933] draws attention to the necessity of certification for any use of wood, as only requiring it for bioenergy would not be sufficient: "*additional demand for wood for bioenergy will simply add to the overall demand for wood for other uses, meaning that even if wood for energy is subject to strict sustainability criteria, wood for other purposes might still be produced through detrimental practices and pathways. Therefore, further developing, operationalising and expanding the requirements of sustainable forest management to all forest products consumed in Europe, irrespective of final use and geographical origin, would be an effective measure to promote a sustainable forest-based sector as a whole.*

Economic impacts of FSC certification on forest operators (WWF, 2015)[934]. The study reports on primary research carried out on 11 forestry entities operating across four continents. It assesses assess upfront investments, annual costs, annual benefits, and the overall net present value (NPV) of the decision to pursue FSC certification. It concludes that "on *average, the companies monitored earned an extra US$1.80 for every cubic metre of FSC certified roundwood or equivalent, over and above any new costs, due to price premiums, increased efficiency, and other financial incentives.*" Contrary to expected effect on smallholders, it also finds that "*The business case was strongest for [..] small/medium producers (regardless of geography) who experienced significant financial gains, while temperate and large producers experienced small losses. It took the companies, on average, six years to break even on their FSC investment.*" The average total cost of attaining FSC certification was US$3.74 per m^3 of certified roundwood production, with the majority of cost being indirect, embedded in business operations but the average is also skewed by tropical forests, where costs were substantially higher. Ongoing costs amounted on average to US$3.71 per m^3.

[932] Maesano, M., Ottaviano, M., Lidestav, G., Lasserre, B., Matteucci, G., Scarascia Mugnozza, G., & Marchetti, M. (2018). Forest certification map of Europe. iForest-Biogeosciences and Forestry, 11(4), 526. Available at: https://iforest.sisef.org/pdf/?id=ifor2668-011

[933]Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S. (2021). The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

[934]WWF. (2015). Profitability and Sustainability in Responsible Forestry -Economic impacts of FSC certification on forest operators. Available at: https://wwfint.awsassets.panda.org/downloads/profitability_and_sustainability_in_responsible_forestry_executive_summary_final_1.pdf

A number of studies carried out in Vietnam[935,936,937]**.** At least 3 studies have looked at the business case for certified wood in Vietnam, and they all reach similar conclusions that certification costs are too high for most smallholder producers, and the 10-18 percent premium on certified wood is not sufficient to cover the certification and compliance costs.

Forest certification: past trends and future options (Simula, M., 2020)[938]**.** The paper looks possible actions to reduce competition between certification schemes and enhance their role in eliminating unsustainable forest management. The paper also notes that it is surprising "*how strong a role the EU instruments have given to a voluntary, non-government based instrument like forest certification in view of its weaknesses and uncertainties on how the systems will evolve over time instead of relying more on regulatory instruments.*"

15 years of forest certifications in EU (Gómez-Zamalloa et al., 2011)[939]**.** The analysis suggests that the impact of certification in the EU forest-base sector is positive-neutral with respect to ecological aspects, positive-negative on the economic and positive-neutral on the social ones. However, its positive effect is limited, due to the fact that the changes needed for the certification are minor. An improvement in the information to both society and local people by the actors involved in forest certification could increase the positive impact on the sector.

Conclusion

Replacing the current risk-based approach for forest biomass with an obligation to demonstrate compliance with sustainability and LULUCF criteria at the source area or forest unit level would mainly affect those areas which are not certified and would imply an additional administrative cost per ton of wood for certification and compliance. In Europe, total certified area of forests amounts to around 13% of total forest area, combining FSC and PEFC. According to Bioenergy EU, 52% of EU28 forest areas available for wood supply are certified PEFC and 26% are certified FSC (some forests have both certifications). Mandating certification at forest level was assessed previously and considered too intrusive and too costly while being less consistent with the subsidiarity principle and not respecting the competence of EU MSs on forests. External costs for the certification of solid biomass from agriculture and forest can vary widely depending on the scheme, but range from around €0.11 - 0.20/tonne. It is important to note that certification does not guarantee GHG savings or completely avoid unsustainable practices, as these depend on the certification scheme's definition of sustainable management and the related criteria as well as on monitoring and enforcement.

[935]Quang et al. (2018). Linking Smallholder Plantations to Global Markets: Lessons from the IKEA model in Vietnam, Forest Trends Report Series, Forest Trends and Viforest. Available at: https://www.forest-trends.org/wp-content/uploads/2018/06/IKEA-case-study-15-June_Final.pdf

[936] Hoang, H. T. N., Hoshino, S., Onitsuka, K., & Maraseni, T. (2019). Cost analysis of FSC forest certification and opportunities to cover the costs a case study of Quang Tri FSC group in Central Vietnam. Journal of Forest Research, 24(3), 137-142.. Available at: https://www.researchgate.net/publication/332903829_Cost_analysis_of_FSC_forest_certification_and_opportunities_to_cover_the_costs_a_case_study_of_Quang_Tri_FSC_group_in_Central_Vietnam

[937] Hoang, H. T. N., Hoshino, S., & Hashimoto, S. (2015). Costs comparison between FSC and non FSC acacia plantations in Quang Tri province, Vietnam. International Journal of Environmental Science and Development, 6(12), 947. Available at: https://www.researchgate.net/publication/277354200_Costs_Comparison_between_FSC_and_Non_FSC_Acacia_Plantations_in_Quang_Tri_Province_Vietnam

[938] Simula, M. (2020). Forest certification: Past trends and future options. Available at: http://www.ardot.fi/Documents_2/Trends.pdf

[939] Gómez-Zamalloa, M. G., & Caparrós, A. (2011). 15 years of Forest Certification in the European Union. Are we doing things right?. Forest Systems, 20(1), 81-94. Available at: http://www2.montes.upm.es/Dptos/Dsrn/SanMiguel/PUBLICACIONES/2011-2015/Gafo_etal_2011_9369_Forest%20Certification%2015%20years.pdf

This option is likely to increase the cost of bioenergy, especially forest products. Costs will increase either because of additional production costs (certification, compliance) or because of reduced supply and will affect principally forest owners and biomass plants owners, but also the supply chain. This cost increase is expected to lower the amount of renewable energy derived from forest biomass leading to the deployment of other bioenergy stocks (e.g., crops) and other RES in order to meet the RES target. As bioenergy via forest biomass is one of the most popular renewable energy sources, the cost of meeting the new 55% target may increase in the short term, with the costs borne by final consumers.

According to how this option is implemented, it is likely to impose substantial costs, felt in particular by (small) forest owners, as they will be obligated to hold a mandatory sustainable forest certification. Large forest holdings are more likely to have in place a certification system, for at least part of their managed areas, which means extending the certificate to cover the entire production will be incremental. The costs associated will be to a large extent administrative, as only few changes of practice may be required[940]. This may result in an increase in cost or reduction in output for some forest owners, in particular for those that currently operate at the limit of forest certifications criteria. Additional costs may also be imposed on intermediaries because of the Chain of Custody (CoC) requirement, which means they too will have to demonstrate compliance with certification. While there will be a cost increase, in few cases certified biomass would lead to a price premium (an example was given for 1 €/m^3 of roundwood for which the average market price is €50-60).

The way in which this option is implemented will be the main determinant of its costs and effectiveness. On one side, RED may require forest owners a specific certificate of compliance with the provisions in Article 29, and third-party audits. This will require extensive efforts and high costs both by MSs or the European Commission (to set up the certification scheme) and by forest owners to comply. On the other side, RED may rely to a larger extent on existing schemes (FSC, PEFC), and work with them to align requirements when necessary. As a substantial share of forest areas available for wood supply in EU are already certified, costs are likely to be much lower. National authorities are likely to face increased monitoring costs associated sustainable forest management certification. This option, while imposing a cost to comply with RED II, will have positive effects in other sectors. For example, if the majority of forest biomass comes from certified forests, the industrial wood coming from these forests will also be certified, increasing its market value.

Concerning impacts from third countries, Bioenergy used in the EU is, for the largest part, produced in the EU. Non-EU forests already certified (in order to comply with Article 29.6) would suddenly have better sale prospects in the EU. For remaining cases, stronger criteria may have an impact (reducing import from outside the EU of biomass fuels), as third countries choose not to comply with them and redirect their export away from the EU. This would have a positive effect on the internal supply, allowing EU producers (farmers and forest owners) to obtain higher prices.

This option would have a wide positive effect on biodiversity because of the more sustainable forest management practices ensured. Further, climate impacts of bioenergy may also be reduced because of the limit on stemwood, which has a higher sink capacity than removals of lower size. However, this option may have a counterproductive effect: by limiting the use of certain areas for bioenergy (for lack of certification), biomass fuels will be sourced from other areas. While this is likely to increase the

[940] For example, national legislation in some Member States may be substantially more lenient than sustainable certification requirements, which will force these forest owners to change their practices.

share of bioenergy coming from energy crops, it may also lead to an increase in total forest area exploited for biomass. On the other hand, residuals from small forest owners that have chosen not to certify will not have a market and will be left on the ground. If this option determines a decrease in total amount of bioenergy and biomass used for energy, it will also generate a positive effect in the form of lower pollutant emissions.

Concerning impacts on employment, these would mostly depend on additional job opportunities in the certification industry and new jobs created by operators in order to cope with the additional requirements. Employment impacts will also arise as a result of the small shift from bioenergy to other renewable energy, due to a higher labour-intensity of other RES. Further, this option may negatively affect jobs in third countries where current regulation and compliance with LULUCF is lax. Certification requirements may also lead to additional jobs in these countries.

Feedstock limitation

This option is a further extension to option 2, and aims at replacing RED II risk-based approach for forest biomass (Article 29(6)) with a limit on the use of certain forestry residue as feed-stock. The limit could be imposed so that:

- only feedstock listed in Part A of Annex IX of RED II is eligible;
- only small roundwood below a certain dimeter (e.g. 20 cm) is eligible.

The rationale behind this option is to exclude certain types of forest materials in order to limit unsustainable forestry practices that are proven to have negative effect on biodiversity and on GHG emissions, in particular the use of stemwood, and comply with the principle of cascading use of wood products. Understanding the impacts of either restriction would require a complex analysis of current practices, whether they are having material negative effects, and what would happen to forest biomass in case the risk-based criteria is replaced with a ban on certain types of residue. This option has been replaced by option 4, 4.1 and 5.

In order to estimate the impacts of this option, it would be necessary to analyse data on forest removals, and estimate the share of forest biomass affected by the new limitation. Further, it would be necessary to understand what is more likely to happen to the roundwood (would it be felled anyway and left to the ground? Would it find alternative use?). While data on forest extractions is limited and not sufficiently detailed to estimate these with precision, a number of recent analysis have tried to estimate biomass flows and extraction rates. These are reviewed below. The main source is: ***The use of woody biomass for energy production in the EU***[941], a report published by the JRC in January 2021 analyses the whole value chain of woody biomass: primary wood production; the processing and uses of wood; its re-use and end of life. The analysis considers sustainable forest management in light of current trends concerning the status of European forests, and in the context of growing demand of wood for products manufacturing and bioenergy production. Forests are considered for the multiple services that they provide, and sustainable practices are aimed at ensuring continued provision in the future.

[941] Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., Mubareka, S. (2021). The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-27867-2, doi:10.2760/831621, JRC122719. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122719/jrc-forest-bioenergy-study-2021-final_online.pdf

Share of forest removals for energy use

JRC data show a steady increase in the extent of forest area in the since 1990, with forests now covering 39.8% of total land area in Europe (of which more than 95% are managed[942]). At the same time, data concerning wood removals show an increase in the intensity of harvesting from 2009 to 2015 in Europe. A research paper shows an increase in the harvested forest area (49%), particularly marked in countries that have relevant forestry-related economic activities; and an increase in biomass loss (69%) over Europe for the period of 2016–2018 relative to 2011–2015.[943] Ceccherini et al. attribute this increase in the rate of forest harvest for the most part to the recent expansion of wood markets, wood-based bioenergy and international trade. The ageing of European forests would only explain 10% of the observed increase in harvest areas.[944] The existing policy framework, promoting the use of wood in the context of the bioeconomy, in particular for renewable energy generation, is mentioned as a potential driver, while acknowledging that causal connections are difficult to prove and quantify.

Alternative uses for woody biomass

The JRC[945] also analyses a number of pathways for the provision of woody biomass that may support future increases in demand for wood while limiting impacts detrimental to climate and to biodiversity. These pathways are created by analysing three types of interventions:

- removal of logging residues;
- afforestation; and
- conversion of natural forests to plantations.

The analysis identifies five win-win management practices that benefit climate change mitigation and have either a neutral or positive effect on biodiversity. Forest removals in these pathways include slash (fine, woody debris) below thresholds defined according to local conditions. Other positive pathways included afforestation of former arable land with mixed forest or naturally regenerating forests. Although pathways do not specifically address the extent of removal of stemwood, lose-lose pathways include removal of coarse woody debris, removal of low stumps, and conversion of primary or natural forests into plantations.

The authors also point out that several negative impacts could be effectively minimised by a robust implementation of the RED II sustainability criteria related to forest biomass, supported by the guidance to be provided in upcoming implementing acts to RED II (on the evidence for demonstrating compliance with the forest biomass criteria). However, the protection guaranteed by the RED II criteria for sustainable forest management relies, in the first instance, on the existence of national forest legislation or on management systems at the level of the sourcing area. Essentially, while the criteria per se are sufficient to ensure sustainable management and reduce impacts on biodiversity and climate, the effectiveness of the criteria will depend on the fitness of national legislation and guidelines, as well as their effective implementation.

[942] Ceccherini, G. et al. (2020). Abrupt increase in harvested forest area over Europe after 2015. Nature 583, 72-77. Available at: https://www.nature.com/articles/s41586-020-2438-y
[943] Ibid.
[944] Ibid.
[945] Ibid.

Conclusion

Replacing the current risk-based approach for forest biomass with a limit on the use of certain forestry residue as feed-stock aims to limit unsustainable forestry practices and to comply with the principle of cascading use of wood products.

Data show a steady increase in the extent of forest area in the since 1990, as well as an increase in the intensity of wood removals from 2009 to 2015 in Europe. Fuelwood removal is now 40% higher than it was in 2000, though this also includes an increase in salvage loggings (bringing damaged wood to the market). Woody biomass used for energy increased about 87% from 2000-2013, after which the growth slowed. 49% of the reported wood used for energy in the EU is secondary woody biomass (forest-based industry by-products and recovered post-consumer wood), while primary woody biomass (stemwood, treetops, branches, etc. harvested from forests) makes up 37% and the remaining 14% is uncategorised, though most likely primary wood. It is estimated that around 40% of stem removals are low quality and used directly as wood fuel or to produce processed wood fuels such as wood pellets and briquettes.

This option would lead to a limit in stemwood and roundwood used for energy production, requiring substantial changes to forest management practices and monitoring costs.

- This option is likely to increase the cost of bioenergy, especially forest products. Costs will increase either because of additional production costs (compliance cost; monitoring costs) or because of reduced supply of biomass available for bioenergy. This increase will primarily affect forest owners, and higher costs would be passed up the supply chain up to biomass plants owners. This cost increase is expected to lower the amount of renewable energy derived from forest biomass, leading to the deployment of other bioenergy stocks (e.g., crops) and other technologies in order to meet the RES target. As bioenergy via forest biomass is one of the cheapest form of renewable energy, the cost of meeting the new 55% target may increase in the short term, with the costs borne by final consumers;
- Stronger sustainability criteria may have an impact (reducing import from outside the EU of biomass fuels), as third countries choose not to comply with them and redirect their export away from the EU. This would have a positive effect on the internal supply, allowing EU producers (farmers and forest owners) to obtain higher prices;
- Forest owners will be severely affected by a restriction of the biomass allowed to be used for bioenergy. This option will require substantial changes in forest management practices and impose higher costs related to compliance and monitoring. The monitoring costs may vary substantially according to whether third-party verification is required. These costs may be more important for some type of forests where roundwood makes up a substantial share of fuelwood removals. Costs may be too high for many SMEs, which may shift some of the market towards large-scale industrial farming and forest management;
- National authorities are likely to face increased monitoring costs associated with fuelwood limitations;
- It may require a substantial amount of administrative costs (depending on how it is implemented and enforced) but non-administrative costs (related to changes of practice) are more relevant;
- This option would have the widest positive effect on biodiversity because of the more sustainable forest management practices ensured;
- Climate impacts of bioenergy may also be reduced because of the limit on roundwood, which has a higher sink capacity than removals of lower size. A decrease in total amount of bioenergy

and biomass used for energy will also generate a positive effect in the form of lower pollutant emissions;

- However, this option may also have a counterproductive effect: by limiting the extent to which a certain area can be exploited for bioenergy, biomass fuels will be sourced from other areas. While this is likely to increase biomass coming from energy crops, it may also lead to an increase in total forest area harvested for biomass. For example, some forest management practices involve thinning the forests so that better trees have more room to grow. This provision would not stop these tree being felled, but it would only allow forest owners to sell thinner residuals for bioenergy;
- Small negative employment effects could arise for forest owners or farmers linked to additional compliance costs and reduced production (additional criteria would reduce the output per m^2 of forest owned) which may be balanced out by small positive impact on new jobs created by operators in order to cope with the additional requirements;
- This option may negatively affect jobs in third countries where current regulation and compliance with LULUCF is lax.
- Also, employment impacts will arise as a result of the small shift from bioenergy to other renewable energy, due to a higher labour-intensity of other RES.

Synthesis

Summary of impacts

In this section, the headline findings from the analysis of each option are brought together under the three headlines of economic, social and environmental impacts.

Table 0-27 Impacts considered

Economic	Social	Environmental
• Costs to economic operators, including effects on industry • Administrative costs • Impacts on SME • Impacts on rural development • Impact on internal and external trade • Energy security and innovation	• Employment • Impacts on third countries	• GHG emissions • Air quality • biogenic emissions • land use and biodiversity

The current draft reflects only the findings from the qualitative analysis, with the remaining impacts being estimated by the modelling exercise. Table 0-28 summarises the key impacts per option.

Table 0-28 Summary of impacts

Option	Economic	Social	Environmental
Option 0	--	--	--
Option 1	• Net reduction in administrative and implementation costs	• Negligible	• Limited positive impacts due to better and faster implementation of criteria
Option 2	• Limited increase in compliance and administration costs • Possible small negative effect on local supply chain	• Negligible	• Increased forest protection; reduction in biogenic emissions • Reduced use of biomass • Possible rebound effects
Option 3	• negative impacts on small installations and local supply chain (SMEs) • increased monitoring costs for MSs	• Possible job losses in the bioenergy sector (likely compensated by other RES sectors)	• Increased forest protection • Possible rebound effects if local supply chain is excluded
Option 4	• Likely reduction in biomass supply from forests, leading to an increase in cost of bioenergy • Increase in complexity (and associated costs) for primary suppliers • Increase in administrative costs for supply chain	• Possible job losses in the bioenergy sector (likely compensated by other RES sectors) •	• Increased forest protection • Possible reduction in forest biomass supply • Possible rebound effect: growth in forest area for biomass production

Option	Economic	Social	Environmental
	• Loss of income for forest owners • SMEs negatively affected if compliance and admin costs are too high		
Option 5	• increase in cost for forest owners (compliance and administrative) • SMEs negatively affected if compliance and admin costs are too high	• Possible job losses in the forestry sector (likely compensated by other RES sectors)	• Increased forest protection • Limit to forest biomass supply • Decreased risk of increases in forest exploitation

Economic impacts

Costs to economic operators, including effects on industry

The options considered, in order to ensure better coverage of sustainability criteria, are expected to affect costs and reduce the overall amount of bioenergy in the mix compare with the status quo (option 0) with varying strength according to the option.

Option 1 (non regulatory) is the only option that may reduce the overall costs to economic operators, including supply chain. This is because option 1 may provide tools and guidance to speed up the application and implementation of sustainability criteria, while also reducing differences between MSs' rules, thus facilitating internal trade. The remaining options are likely to increase the cost of bioenergy, especially forest products, and consequently reduce the amount of renewable energy derived from forest biomass. Costs will increase because of additional production costs and because of reduced supply: option 4 (cap on stemwood), option 4.1 (ban on stemwood) and option 5 (cap on forest fuelwood) will reduce or limit forest biomass available for bioenergy.

Assuming the overall RES target is met, the increase in prices and reduction in forest biomass availability have two effects:

- the deployment of other bioenergy stocks (e.g., crops) and other renewable sources (solar, wind) will increase in order for the target to be met;
- as bioenergy via forest biomass is one the most popular form of renewable energy, the cost of meeting the new 55% target may increase, with the costs borne by final consumers. Consumers in different MSs will be affected to a different extent, depending on their current and projected use of biomass.

The extent of the reduction in biomass supply and use depends on a range of factors, including the cost of other technologies.

As energy generation shifts towards other forms of renewables to meet the RES targets, the size of the bioenergy sector decreases. However, stronger criteria may have an impact (thus reducing import from outside the EU of biomass fuels), as third countries choose not to comply with them and redirect their export away from the EU. This would have a positive effect on the internal supply, allowing EU producers (farmers and forest owners) to obtain higher prices.

The effect on bioenergy production of the increased energy efficiency requirement for large power-only plants (option 2) cannot be defined with certainty. The higher threshold would increase the amount of power generated per unit of biomass (higher output per unit of input), but, in practice, the criteria may halt any new coal conversions or new power-only plants, and therefore reduce total energy generation from biomass. Considering that few plants met the current level of 36%, an increase of the threshold may definitely stop future power-only projects, possibly diverting investments towards more efficient CHPs. Option 2 will affect marginally existing heat and power biomass installations, as they may have to switch fuels to comply with GHG criteria, while option 3 will affect only small heat and power installations under 20 MW, estimated to be around 1,000 additional plants if the threshold is lowered to 10 MW as of today (a limited increase in this number if expected up to 2030). Indirectly, this may impact local biomass producers, as they often provide biomass to these smaller plants (see below on SMEs). The majority of costs in both cases are expected to be associated with certification costs, rather than compliance and change of practices.

Options 4, 4.1, and 5 would not directly increase the cost to operators besides administration costs (which could be important, see section below). However, they would limit an expansion of the forest bioenergy sector and affect particularly the demand for quantities of affected products (either stems only or entire range of primary fuelwood). Further, according to how the cap is set and by market conditions, forest owners may either see the price of their product increase or decrease.

Impacts on SME

Among the five main options considered, options 3, 4, 4.1, and 5 are those with the more prominent impacts on SMEs:

- Option 3 will impose costs on small heat and power installations, requiring their compliance with sustainability and GHG criteria; indirectly, SMEs that supply small will also be affected, as they are unlikely to currently have in place the processes to certify their biomass. In both cases, it is likely that the bulk of costs will be associated with the administrative burden, rather than changes in operational processes;
- Options 4 and 4.1 will affect primarily the actors in the supply chain that deal and process stemwood, either as trader or processing plant (e.g. pelletisers). Costs will be both of operational nature (associated with determining the size of the log) and administrative nature (certifying the process). Depending how implementing requirements are set (i.e. who has to demonstrate compliance with the option, the administrative burden could increase substantially (for example, if forest owners or micro-sized installations also have to demonstrate compliance);
- Option 5 will also affect the entire supply chain, but to a lesser extent because tracking quantities will be less cumbersome than diameter. The same challenges with certifications across the supply chain however still exists.

Impact on internal and external trade

Bioenergy used in the EU is, for the largest part, produced in the EU. Some of the options considered (2, 4, 4.1, 5) are likely to have a minor negative effect on imports, as foreign suppliers may look at other markets to avoid the further restriction imposed on old-growth forests, stemwood and/or quantities. Although the import of pellets (with high content of stemwood) has decreased substantially after Brexit, a ban on stemwood may reduce this even further.

Impacts on rural development

All options considered will have limited impacts on rural development. Options 2, 3, 4, 4.1, and 5 may reduce income of small forest owners, especially for cases where they decide not to sell fuelwood because of certification requirements. Although for them income from the same of biomass for energy use is often only a small share of their income, cumulatively the change may add up to substantial loss of income for some areas.

Administrative burden

The administrative burden is caused by the costs of complying with information obligations stemming from the policy option considered, either external costs or costs associated with changes to business processes; EU directives put obligations on MSs, thus actions that national and/or local governments have to take to comply are included in the definition.

Besides MSs, the main economic operators that may be affected by the options considered are: owners of heat and power bioenergy plants (commercial and residential), traders and processing units (intermediate supply chain), and producers (forest owners, farmers).

Textbox 0-3 Nordic countries analysis of RED II administrative burden

A recent analysis from Pöyry[946] estimates the administrative cost of implementing the current sustainability criteria to vary between 0.1 and 0.7 EUR/MWh per energy plant, equivalent to 1% to 4% of fuel cost. The higher end of the range is reached for small power plants that choose to import biomass from countries that do not meet country criteria (sustainability of harvesting Article 26, paragraph 5), and the LULUCF criteria (Article 26, paragraph 6). The choice to certificate different GHG savings compared to default value has a limited impact on costs. Pöyry also looked at the case of a 10 MW plant, showing as expected higher compliance cost per unit of fuel (Table 0-29).

Table 0- 29 Share Administrative costs per energy plant (EUR/MWh)

Fuel capacity	Country level criteria met		Country level criteria not met	
MW	Default GHG	Own GHG	Default GHG	Own GHG
20	0.4	0.4	0.7	0.7
40	0.2	0.2	0.4	0.4
60	0.2	0.2	0.3	0.3
100	0.1	0.1	0.2	0.2
*10**	*0.7*	*0.7*	*1.3*	*1.3*

(not currently under obligation of compliance)

The analysis assumes that the requirements will not place any administrative burden on forest owners, and that suppliers and installations will face one time and annual costs (

Table 0-30).

[946] NER and Pöyry. (2018). A Nordic analysis of the proposed EU policy for bioenergy sustainability. Available at: https://www.nordicenergy.org/wordpress/wp-content/uploads/2018/01/A-Nordic-analysis-of-the-proposed-EU-policy-for-bioenergy-sustainability_Final.pdf

Table 0-30 Assumed administrative costs for suppliers and installations

	Suppliers	Installations (10MW to >20MW)
One time		
Contracts	10-16 days	10-25 days
System build-up	20-50 days	20-50 days
System approval	--	€7,350 - €10,500
Annual		
System operation	7-14 days	25-60 days
Auditing	7-10	4-6

Pöyry concludes that, in order to comply with current criteria, administrative costs will affect mostly installations rather than the supply chain (about 85% of the system level administrative cost would fall on energy plants). Small installations (10 MW) [947] would face an administrative costs 40% higher per MWh compared to a 20 MW plant (€0.7/MWh compared to €0.4/MWh), while the GHG criteria may increase the admin burden by 15% for plants that choose to calculate their own GHG savings.

Option 1 is the only option that may reduce overall administrative burden and compliance costs with the RED II sustainability criteria for economic operators. Providing guidance at EU level could also generate (modest) compliance cost savings for national authorities in charge of implementing bioenergy sustainability criteria. Guidance and tools may also limit administrative costs of future heat and power installations by simplifying the calculation of GHG savings.

The remaining options will increase the administrative burden by requiring obligated entities to collect additional information about the fuel they use and by obtaining certification that this complies with the sustainability criteria. Given that some operators have already to comply with criteria as they currently are, the administrative costs will only be those associated with:

- Extending the coverage of current criteria (e.g. to exclude biomass from old-growth forest, to include all forest biomass);
- Obligating new operators (e.g. heat and power plants below 20 MW);
- Requiring additional criteria to be monitored (e.g. stem diameter).

Operators will have to demonstrate compliance with the provisions set by each option via an audit and certification process, with certifications and audit costs charged to all the market actors participating in the transaction. In theory, each intermediary step of the value chain needs to be certified and bear the costs of auditing and certifications, having the potential to impact biomass fuels costs and the bioheat/bioelectricity costs. However, it will not be feasible in practice to monitor and certify every single biomass installation in every MS, as it could be the case under option 4, 4.1, and 5. For these options, compliance would have to be ensured up to the point of sale to the final user, and it may be possible to enforce these options without requiring certification of forest areas.

[947] Note that RED only requires compliance with criteria for installations above 20 MW for solid biomass and 2 MW for biogas.

Option 2 is likely to result in minimal increases to the administrative burden for economic operators currently already required to comply with sustainability criteria:

- The exclusion of additional forest areas is unlikely to increase current certification and audit costs;
- Applying the RED II GHG saving criteria to existing installations would lead to limited increases in administrative costs for economic operators, relating the collection of evidence of GHG savings of the biomass pathways used. Pöyry948 estimates a significant cost increase (15% and higher of administrative burden) only in the case of installations importing biomass that do not meet the country criteria and that opt for using own GHG savings values, rather than default values;
- Increasing the energy efficiency threshold for electricity only plants would not add administrative costs compared to the baseline.

National authorities are likely to face moderately increased administrative burden associated with the monitoring of the new no-go areas.

Option 3 (extending sustainability criteria to smaller installations) will increase the administrative costs for small heat and power installations between 10 MW and 20 MW (around 400 operators in 2016, a number which may increase slightly in the coming years), which would have to demonstrate compliance with sustainability and GHG criteria. The majority of administrative costs in both cases are expected to be associated with certification costs of the interested energy plant, rather than compliance and change of operational practices. However, fuel costs may also be affected because in complex supply chains audits and certification costs will be charged to all operators along the value chain. Pöyry estimates the administrative burden for a 10 MW installation could be in the range of €0.7 to €1.3 per MWh, requiring up to 25 days per year of internal staff time. Costs for the supply chain would be lower, as it is expected most operators already have system in place to deliver to larger installations (therefore must already comply with criteria). Option 3 may also indirectly affect local suppliers that provide biomass to smaller plants. For smaller forest owners and agriculture biomass producers, certification costs may be prohibitive, as biomass is a by-product. National authorities are also likely to face some additional monitoring and verification costs associated with the increased number of installations subject to the sustainability criteria.

Options 4 and 5 would lead to more significant administrative impacts for the market, as they cover all quantities and uses of biomass throughout the value chain. All forest fuelwood products will have to be traced and certified to demonstrate compliance with the required quantities and/or dimension, which means establishing a tracking system from forest plot to use points. On average, between 2004 and 2013, 166 Mm^3 of fuelwood was used in the EU. Options 4 and 4.1(stemwood cap / ban), would impose substantial costs associated with the process to manage fuelwood by diameter size, and associated audit fees. The cost of option 5 (cap on quantities) is expected to impose more limited compliance costs, given quantities are a standard measure in a market transaction involving fuelwood. However, as for options 4 and 4.1, the entire supply of biomass from forests will have to comply, which means certification and auditing costs associated to all quantities and operators. It is reasonable to assume

[948] Pöyry. (2018). A Nordic analysis of the proposed EU policy for bioenergy sustainability. Available at: https://www.nordicenergy.org/wordpress/wp-content/uploads/2018/01/A-Nordic-analysis-of-the-proposed-EU-policy-for-bioenergy-sustainability_Final.pdf

that the certification would exclude smaller installations and residential installations; the final audited parties will be the retailers and wholesalers that serve these installations.

In case the implementation of option 4, 4.1 and 5 imposes a monitoring obligation on forest owners, the administrative costs would be much higher and have a much more significant impact. This is because often forest owners are small holders and for them logging is a secondary activity, e.g. providing small percentage of the business' income. Analysis carried out in 2017 with the Green-X model[949] estimates 1.2 million EU forest owners, grouped into 1,452 forest entities would be needed to produce 110 Mtoe of bioenergy. In 2020, bioenergy from forest amounted to 80 Mtoe, which suggests 0.87 million forest owners may be affected. Reliable and wide-ranging estimates on certification costs for forest owner are not available because they depend on a wide range of factors. However, the number of forest owners involved suggest tracking and certifying them could be complex and expensive.

However, it is possible to envisage a solution where the intermediaries are responsible to ensure compliance with either the minimum stemwood size, a ban of all stemwood or a quantity cap. The main obligated party would be the first buyer from forest owners, which would record the quantities of forest biomass and/or the diameters of logs being purchased. The rest of the supply chain, up to the plant final user of biomass, will have to show compliance by obtaining the relevant certificates with the shipment. In case of a short supply chain (forest owners selling directly to a biomass plant), the obligation would fall on the biomass plant. As the supply chain and power plant are often already obligated to comply with sustainability criteria, the additional requirement concerning log size or quantity of forest biomass would increase costs, but probably the only significant cost element will be related to diameter size (options 4 and 4.1). This solution means that forest owners are effectively not directly obligated by options 4, 4.1 and 5, limiting overall administrative costs.

Analysis carried out in 2017[950] suggests ranges of external costs for the certification of solid biomass from agriculture and forest to be around €0.11 - 0.20/tonne.[951] The Sustainable Biomass Program (SBP) currently charges €0.15 and €0.08 per tonne to producers of wood pellets and woodchips respectively. These would be equivalent to €1,600 - €3,000 for a 10MW plant[952] and €12,000 – €22,500 for a large trader (150,000 tonnes/year). According to current estimates, EU bioenergy production of forest bioenergy is expected to range between 40 Mtoes and 50 Mtoes per year[953] in the two scenarios considered (MIX55 and REG55). Assuming a conversion factor of 0.3215 tonnes of fuelwood per toe[954], this is equivalent at an annual production of between 124 Mtonnes and 156 Mtonnes of fuelwood. At a cost varying between €0.08/tonne and €0.20/tonne, administrative costs could amount to between €10 million and €31 million per year. These are the “external” costs, paid to audit the intermediary rather than the final operators, so it is necessary to add the internal costs (staff time to deal with contracts, record system management and audit).

[949] BioBoost. (2013). Biomass based energy intermediates boosting biofuel production – Feedstock costs. Available at: https://www.bioboost.eu/uploads/files/bioboost_d1.1-syncom_feedstock_cost-vers_1.0-final.pdf
[950] PWC. (2017). Sustainable and optimal use of biomass for energy in the EU beyond 2020. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf
[951] SBP is currently charging between €0.8 and €0.15 per tonne; ISCC charges 0.08 to 0.10 per tonne. For comparison, fuelwood sells for €30 to €80 per tonne and woodchips at €100-€130 per tonne.
[952] Assuming a consumption of 2,000 tonnes/year per MW input
[953] This is equivalent to 174 Mm^3 at a conversion factor of 1.5 m^3 per tonne. The JRC (2021) report estimated primary wood used in bioenergy amounted to 166 Mm^3 in 2017, so the two estimates are comparable.
[954] UNECE. (n.d.). Handy Guide to Wood Energy. Available at: https://unece.org/forests/handy-guide-wood-energy

In theory, some of these costs have to be repeated at each step of the supply chain. In practice, large operators already choose to certify via the voluntary schemes approved under RED, and that any new requirement will not determine a doubling in certification costs, but at most a marginal increment.

Under options 4, 4.1, and, to a lesser extent, option 5, national authorities are also likely to face significantly increased administrative costs for setting up national systems and procedures to monitor and verify the type and diameter of stemwood assortments going to the energy sector. In particular, MSs would need to improve the statistics and monitoring systems in order to set up and enforce this option, and take them into account when setting up support schemes for bioenergy.

Social impacts

A quantitative assessment of the social impact has not been undertaken as part of this assignment. Overall, it is assumed that if an option increases costs for operators or poses limitations to the amount of bioenergy, the market will react by reducing the amount of bioenergy as share of Gross Available Energy. Further, while solid biomass currently represents a large shares of renewable energy related employment, the number of jobs per Mtoe produced or consumed are lower than for other technologies (see Table 0-31 for an overview of the direct and indirect jobs created by different renewable technologies[955]). Therefore, the general assumption is that any decrease in employment in the biomass sector would be compensated by an increase in employment associated with other RES, due to a higher labour-intensity of other renewable energy sources. Further, additional administrative burden (expected to various degrees under options 2, 3, 4, 4.1, and 5) would also create jobs, both in market operators and in auditing and certification firms.

Table 0-31 - Comparison of direct and indirect jobs per RES technology in EU27 in 2018. Sources: The state of renewable energies in Europe, Edition 2019, 19th EurObserv'ER Report[956] & Technology Barometers 2020.

Technology	Direct & indirect jobs (FTE)[957]	Generation and/or consumption (Mtoe)	FTE/ktoe
Wind power	242,500	28	8.8
PV	109,000	9	11.5
Heat pumps	222,400	12	18.6
Biogas*	62,700	6	11.2
Biofuels	239,600	15	15.6
Solid biomass**	344,100	93	3.8

**Combining electricity generation and gross heat production.*
***Combining electricity generation and heat consumption as reported.*

Based on the considerations presented above concerning the effect of various options on the output of the biomass sector and on the overall assumptions concerning jobs it is possible to conclude that:

- Option 1 is not expected to significantly alter underlying trends in bioenergy use and production, and therefore minimal social impacts are expected. The more prominent ones would be associated with skills and knowledge of sectoral workers;

[955] Note that jobs in the forestry sector are excluded, given that biomass is often a by-product of forest activities.
[956] EurObserv'ER. (2019). 19th annual overview barometer. Available at: https://www.eurobserv-er.org/19th-annual-overview-barometer/
[957] As per the EurObserv'ER report, employment data is provided in FTE and includes both direct and indirect employment. Direct employment includes renewable equipment manufacturing, renewable plant construction, engineering and management, operation and maintenance, biomass supply and exploitation. Indirect employment refers to secondary activities, such as transport and other services.

- Option 2 will have negligible impacts on jobs; new requirements may reduce bioenergy demand overall, but some jobs may be created to deal with additional certification requirements for GHG savings;
- Option 3 will create a small number of jobs in the newly obligated installations (around 400 plants) and increase request for certification services;
- Options 4, 4.1 and 5 could instead lead to more significant negative employment impacts in the bioenergy sector, because of the increase in prices and significant added burden on the supply chain, which may result in some actors exiting the market. In particular, option 4.1 could have the most direct impacts on primary producers of forest biomass because of the likely reduction in biomass use for energy;
- This would be felt mostly in countries with the largest workforces employed in forestry and logging activities (Poland, Romania, Sweden, Germany and Italy), and where forestry and logging activities occupy the largest share of active population (Latvia, Slovakia, Estonia, Croatia, Lithuania)[958]. However, for all options which would lead to a reduction in bioenergy use, a net increase in employment driven by the growth in other renewable technologies can be expected;
- Social impacts in third countries are expected to be limited, at most affecting some limited areas that currently export to the EU.

○ Environmental impacts

Based on the vast amount of evidence produced in recent years, the Commission considers forest bioenergy a useful and necessary way to achieve the ambition of the EU climate policy. However, the Commission also recognises that an excessive exploitation of forests for biomass is not desirable and may have counterproductive effects on net emissions, biodiversity, and air pollution. In general, adverse effects are proportional to quantities of biomass, but forest management practices also play a great role.

All options considered in this assessment are expected to generate direct positive environmental benefits, either as a result of better implementation guidance (option 1) or because of a reduction in quantities of forest biomass (option 2 to 5). The three main aspects where positive impacts are expected are:

- GHG emissions (biogenic and supply chain);
- Biodiversity protection;
- Air pollution (see Textbox 0-4).

Textbox 0-4 Biomass and air pollutants emissions

The shift to renewable energy has had, overall, a positive effect on air pollutant emissions. However, a negative effect on particulate matter ($PM_{2.5}$ and PM_{10}) and volatile organic compounds (VOC) is observed in countries were biomass burning has increased. The EEA concludes that biomass use led to an increase in EU-wide emissions of 11 % for $PM_{2.5}$, 7 % for PM_{10} and 4 % for VOCs in 2017 respectively, which is estimated to have occurred in all MSs except one, where the use of biomass has decreased. The EEA explains this relative increase by growing bioenergy use over the period in the EU. Since, in most cases, biomass is used for domestic heating, the EEA concludes that this is likely to have led to increases in $PM_{2.5}$ concentrations.[959]

[958] Eurostat, National accounts employment data by industry

[959] According to an analysis by the European Environment Agency (EEA briefing No 13/2019: Renewable Energy in Europe: key for climate objectives but air pollution needs attention), the increase of use of renewable energy led to a decrease of SO_2 and NOx emissions by 6% and 1% respectively in 2017 compared to a 2005 baseline. This is rather

The options considered are targeted at improving the efficiency of biomass use and the sustainability of biomass production, rather than limiting pollutant emissions. This is because air pollution from biomass is specifically addressed through other EU measures and regulations, and it is not considered appropriate to set specific requirements in the context of this policy initiative. Most options considered are also aimed at commercial installations, so will not address health impacts associated with indoor air pollution caused by household installations.[960] However, a reduction in bioenergy use is expected to reduce air pollution and have health benefits, especially in case of installations located in densely populated areas.

Concerning the options considered:

- Option 1 may have limited environmental benefits by helping MSs to implement and monitor sustainability criteria more effectively;
- Options 2 to 5 could negatively affect the supply and/or demand of biomass, reducing the use of biomass and therefore reducing removals of fuelwood and air pollution from bioenergy;
- Among the elements of option 2, the conversion efficiency threshold for power-only biomass installations may avoid further increase in biomass use, if, as a result, further large-scale biomass conversions are averted. Extending GHG criteria to existing installations (option 2) would exclude the most carbon-intensive feedstock pathways, thus achieving a small reduction in GHG emissions associated with the biomass supply chain;
- A minor negative impact on biomass demand (and therefore a positive impact on air quality) is expected under option 3, as the inclusion of sustainability criteria may discourage some new smaller scale installations from coming to the market;
- Option 2 and option 3 are likely to generate overall positive environmental benefits by ensuring better coverage of the sustainability criteria. However, both may have the counterproductive effect of discouraging small, local production, as the administrative burden to demonstrate compliance with GHG and sustainability criteria may be too high. This biomass fuel production is expected to shift to large-scale operators – with likely negative environmental impacts as local supply is often more sustainable than industrial fuelwood supply;
- Options 4 and 5 would have the widest positive effect on biodiversity and emissions because they would limit the quantity of biomass that can be counted under the directive. Further, climate impacts of bioenergy may be reduced because of the limit on stemwood, which has a higher sink capacity than removals of lower size (e.g. branches). As discussed before, the positive impacts are in relation to any increase in bioenergy generation compared to the baseline used to set the limit (either of stemwood or of total forest bioenergy);
- However, option 4 and option 4.1 may also have a counterproductive effect: by limiting or banning the use of stemwood, forest owners may expand the area of exploited forest to provide the missing quantities from removals other than stemwood.

despite of increasing biomass use, which has increased air pollution since 2005 compared to a counter-factual scenario. In contrast

[960] Harmful effects from household installations are also being recognised and addressed in other EU initiatives. However, household installations are currently not covered by sustainability criteria in RED. See also JRC report by Monforti-Ferrario, F., Belis, C., (2018). Sustainable use of biomass in the residential sector. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113417/kjna29542enn.pdf

Annex I - RED II Open Public Consultation

Annex I to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

Executive Summary

The review of the Renewable Energy Directive 2018/2001/EU (RED II) is part of a wider review process to align various directives to the ambition of the European Green Deal, where the Commission proposed to increase the greenhouse gas reduction target of the EU from 40% to at least 50%-55% by 2030, and to achieve climate-neutrality by 2050. The review of RED II considers the interactions that it will have with other EU strategies, such as the Energy System Integration and the Hydrogen Strategies, the Renovation Wave Strategy, the Offshore Renewable Energy Strategy, and the EU Biodiversity Strategy for 2030.

As part of the open public consultation (OPC) process the European Commission launched a questionnaire to collect views and suggestions from stakeholders and citizens concerning the revision of the Directive 2018/2001 on the promotion of the use of energy from renewable sources (REDII). The questionnaire, which consists of 54 closed questions and 42 open questions, was uploaded on the EU Survey Platform at https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12553-Revision-of-the-Renewable-Energy-Directive-EU-2018-2001/public-consultation). The questionnaire was open for 12 weeks, from 17 November 2020 to 9 February 2021.

This report presents the analysis of the responses received to the questionnaire.

Key results

Participants

- The consultation attracted a total of 39,074 participants[961], the vast majority of which responded in a personal capacity (38,404) while the remaining 670 represented an organisation[962]. Only four individuals stated they were not an EU citizen, while 54 organisations are not based in the EU;
- Among the organisations that participated in the questionnaire, the majority reported being business associations and companies (a total of 71%) while NGOs and environmental organisations represented 16% of the respondents;
- Concerning the participation of EU citizens, four countries (Spain, the Netherlands, Germany, and Sweden) submitted over 40% of the responses received, while the UK and the United States were the most represented non-EU countries;
- Central government or central agencies from 13 Member States participated in the survey: Belgium, Czechia, Estonia, France, Germany, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Slovakia, Spain, Sweden. Public Authorities at lower levels (regional and municipal) from France, Germany, Netherlands, Spain and Sweden also replied, and a further response arrived from the Norwegian Ministry of Petroleum and Energy;
- A large number of responses (38,313, 98%) came from a coordinated campaign that only answered questions 9.3 and 9.3.1 (concerning whether limits to the feedstock for biomass should be introduced, where participants from the campaign used an identical reply). During the analysis additional smaller coordinated responses groups were identified. Two further

[961] The consultation initially received 39,046 submissions to the questionnaire. 6 responses were excluded from the analysis because these organisations provided double submissions (one response is kept for each organisation). 9 questionnaire responses were added subsequently after they were submitted via email. There were 34 additional contributions (without questionnaire) via email, 9 of which from participants that had already submitted a questionnaire.

[962] 645 responded to the questionnaire and 25 provided additional contributions.

campaigns involved a total of 25 and 18 participants categorised as NGO and environmental organisations. The analysis of open-ended questions also identified 141 businesses participating in 28 separate coordinated campaigns involving 3 participants or more;

- Excluding the questions on biomass feedstock targeted by the large coordinated campaign, the first four questions of the survey are the most answered closed questions, while the open-ended questions with most answered is Q1.3.2, where participants were asked to explain why they think certain parts of RED II should be amended.

Summary of results from Section I – General questions on the review and possible revision of RED II

EU citizens and all stakeholder groups are in favour of amending RED to be more ambitious, prescriptive and biding, targeting better some sectors that are currently lagging behind:

- The importance of renewable energy is clearly recognised (98% of participants state that renewable energy is either *important* or *very important*). The result is consistent across all stakeholders groups;
- RED needs to be modified to be *more ambitious* and *prescriptive*. There is a clear support for changes also among business organisations. Regarding what to change, and not taking into account the specific case of bioenergy, the *overall target* and the *target for transport* are the two answers with the most votes on this specific question. Changes to the overall target is the most popular answer across all groups except consumer organisations (which expressed more often a preference for the transport target). Other popular answers to what should be amended are: *GO requirements*, *provisions concerning low-carbon fuels*, and *provisions to simplify procedures for developers*. The associated open questions (what else should change) received many and broad answers. Emerging themes include the *exclusion or restriction of bioenergy*, the *do-no-harm principle*, and mixed messages concerning the *role of low-carbon options*;
- *Transport* and *H&C* are the two sectors where additional efforts are requested, with most stakeholder groups selecting either one or the other as their most popular choice;
- All stakeholder groups indicated a preference for an *increased overall RES target*, with 43% stating *it should be in line with the CTP* while 37% saying *it should be higher than the CTP*. All groups expressed a very strong preference (64% or higher) for the target being *binding at both EU and national level*.

Summary of results from Section II – Technical questions on Transversal Energy System Integration Enablers

Stakeholders opinion concerning energy system integration is less clear, with opposite views arriving from different stakeholders groups and with the lack of neat preferences for most of the various measures proposed to support better integration:

- Participants were asked to rate the importance of different measures to build a more integrated energy system. Overall, all options proposed are considered either important or very important, with *RE in buildings* scoring the highest (93% combined) *and biogas/biomethane* the lowest (70% of participants rated it important or very important). The energy efficiency principle should be reflected in RED by *promoting the use of waste heat* and *minimising energy transformation*;

- Electrification of energy consumption would be better supported by i*nvesting in transmission and distribution networks* and by *developing further interconnectors* and *fostering digitalisation*;
- Both individual and professional participants expressed the view that *non-renewable low-carbon fuels should not be promoted* or *should be promoted less*. There is a mixed support for *encouraging the use of hydrogen and e-fuels produced from hydrogen*. The more popular single answer was that *they should not be encouraged*, but the majority of participants are favourable to these with some limitations;
- Concerning the type of support measures for RES and low-carbon fuels, participants expressed a preference for *market based support schemes*. *Supply-side quotas* (the least popular answer) are still supported by the majority (57%) of respondents. Further answers (with fairly neat majorities) indicate that *Monitoring and certification systems should ensure that GHG emissions are fully taken into considerations*, *GOs should be extended to renewable fuels and low-carbon fuels* and *renewable hydrogen should be added to the cooperation mechanisms*;
- CCS should play a prominent role for industry and to generate negative emissions, but participants are split 50/50 concerning whether *RED should be revised to encourage the uptake of CCS and CCU.*

Summary of results from Section III - Technical questions on specific sectors

Electricity

- Concerning measures to tackle the remaining barriers for the uptake of renewable electricity, participants rated *streamlining permitting procedures* as the most appropriate and urgent, with *fostering regional cooperation as the second*. Additional comments suggested increased *support for renewable energy communities* and *self-consumption and demand-side management measures*. The promotion of regional cooperation could instead be promoted by *strengthening connection infrastructure* and *removing barriers to cooperation;*
- In order to promote the use of private renewable power purchase agreements, *removing administrative/legal barriers* is considered the more appropriate measure, followed by *financial solutions/instruments*. Additional measures suggested include the *use of existing certification systems* and the *digitalisation of grid infrastructure*;
- A clear majority of citizens and organisations (60%) think that *all public authorities should be obliged to buy green energy* outright, and a further 24% think they should be obliged but subject to some limitations.

Heating and cooling

- Participants indicate that the more appropriate option to increase the uptake or RES H&C is *the use of district heating integrating waste and renewable heat* (94% indicated it is either *appropriate* or *very appropriate*) and *increase in energy efficiency* (93%). *Renewable gas* is the least chosen answer, but still attracted 71% of positive views. Other options proposed included *System-wide integration and harmonisation across energy carriers*, and *promoting a broad portfolio of technological options;*
- Overall, participants slightly prefer a *non-binding H&C target at MS level* (51% to 49%), with wide variation among categories. However, the majority of participants indicate that *the target should increase* (67%), and that *renewable electricity should be counted towards the target* (79%);

- Environmental organisations and NGOs are the two groups clearly against making the target mandatory, increasing it, or counting hydrogen and synthetic fuels towards the H&C target (majority of 70% in each of the three questions). Although no explanation is provided, from other answers is possible to assume that NGOs and environmental organisations fear that higher and mandatory targets would incentivise further use of biomass and synthetic fuels in heating and cooling;
- Participants expressed a mild preference for *expanding the list of measures* included in the directive (54% yes to 46% no) and similarly (53% yes to 47% no) on making all or some measures binding. The list of measures provided in the Directive should be expanded to g*ive priority to solar and geothermal energy*, *expand details on waste heat and encourage climate-neutral and decentralised solutions*;
- Participants are also divided concerning whether measures to increase the share of renewables in heating and cooling should binding: *no* 47%, *yes* 28%, *yes but only some measures* 26%;
- The measures more appropriate for increasing the share of renewable H&C are *pricing instruments*, *guidance* and *mandatory heat planning*;
- Public authorities should be encouraged to identify renewable H&C potential by *strengthening the obligation in Art. 14 and Art 15* and by *requiring mandatory long-term strategies*.

District heating and cooling

- Participants expressed a mild preference for a binding target for renewable energy in district heating and cooling (53% yes to 47% no) and for increasing the current target (51% yes to 49% no). Environmental organisations and NGOs are distinctly against both propositions (only group of stakeholders expressing this preference), a similar view expressed for the heating and cooling target, because of the effect such a target may have on demand for biomass;
- A clear majority of respondents to the associated open question (level of increase to the current district heating target) suggest an increase of 2 to 3 percentage points;
- The more appropriate measure to encourage the use of waste heat and cold by district heating and cooling networks are *the requirement to encourage cooperation between industrial and service sector companies*, and *the requirement for authorities to prepare the necessary plans*. Further suggestions from stakeholders at this regard concern requiring economic and technical feasibility, and no obligation to use waste heat;
- Participants expressed a clear preference for strengthening third party access (68%), consistent across all groups. This is so to reduce the power of monopolies, increase competition and efficiency;
- Participants also think that consumers rights would be strengthened by *improved information* on energy performance and renewable share and *increased price transparency*, while all measures proposed to support system integration are similarly rated (between 92% and 94% of participants rated them as either *appropriate* or *very appropriate*).

Buildings

- Participants think that Member States should require minimum RES share in new and renovated buildings (78% overall in favour), and 37% suggest a RES share of 50% or higher. Participants clarify in the associated open question that RED should introduce a gradual approach with additional limitations;

- Participants ranked *simplifying permitting and administrative procedures* as the measure that would be most appropriate to facilitate the phasing out of fossil fuels, followed by *strengthening consumer information and accessibility of measures*;
- All measures proposed to improve the replacement of heating systems were rated either *appropriate* or *very appropriate*, with combined approval ranging from 95% to 81%. *Information campaigns* is considered the most appropriate option.

Industry

- The majority of participants are in favour of a RES obligation for industry, either on industry in general (55%) or to specific industries (12%). A substantial share (30% to 40% of those who answered the associated open questions think that *sectors already subject to the EU-ETS should be excluded from the target* and that *obligations should be accompanied by financial support*;
- Measures more appropriate to encourage RES take up in industry are *the simplification of the permitting and administrative procedures*, and *minimum shares in the national building stock*, but all measures proposed are considered appropriate by at least 79% of participants.

Transport

- The majority of participants (86%) are in favour of an increase in the target for transport, with 43% suggesting this should be *more ambitious than the 2030 CTP*, 34% that it should be a*s ambitious as the CTP*, and 9% that it should be less ambitious. NGOs and environmental organisations are the only category where the most popular answer is *no increase to the transport target* (with 33% of answers), mostly due to concerns with increase in biofuel use that may be incentivised by a higher target. Common observations from stakeholders concern the *removal of multipliers* and the *focus on some modes of transport such as road and aviation* (both mentioned by around 25% of responses to the open question);
- Participants think Member States should not count other low carbon fuels (such as low carbon hydrogen) towards the target (45% *yes* to 55% *no*), but also think that these fuels should be encouraged (79%). Among the types of low carbon fuels, the most chosen *are advanced biofuels and other fuels produced from biological waste and residues* (293 responses) and *renewable hydrogen and renewable synthetic fuels* (292 responses). Participants further elaborated on the types of renewables and low carbon fuels that should be specifically promoted by referring also to electrification/batteries and suggesting the exclusion of low-carbon fossil fuels as these would compromise RED;
- An obligation on fuel suppliers should *promote liquid renewable fuels, renewable electricity and gaseous renewable fuel*s, with relative disagreement between stakeholders groups. In the associated open question (which types of renewable and low carbon fuels can be best promoted by an obligation on fuel suppliers), *renewable electricity* is the option with most mentions and *the fuel obligation should be based on GHG emissions targets*;
- An *additional target* would be the most appropriate to encourage the use of hydrogen and hydrogen-derived synthetic fuels in transport, while renewables in general would be encouraged by *ensuring the availability and interoperability of public charging infrastructure* and *the support to the installation of domestic chargers*.

Bioenergy sustainability

- Bioenergy sustainability attracted strong views throughout the questionnaire in related questions, and Q9.3 and Q9.3.1, on limits to the type of feedstock allowed, received 38,786 answers, of which 38,313 thorough a coordinated campaign[963]. The campaign chose not to answer the other questions concerning bioenergy sustainability, but the sentiment towards bioenergy is unambiguous;
- Participants think sustainability criteria for the production of bioenergy from forest biomass should not be modified by a small margin (56% no to 44% yes), with clear splits among different categories.[964] Overwhelming support for stricter criteria is found in NGOs/environmental organisations and individuals;
- A 50-50 split is instead found concerning the extension of criteria to installation below 20MW for solid biomass and 2 MW for biogas;
- The question whether there should be limits to the type of feedstock used for bioenergy production under RED II was answered by 38,786 participants, with 99% stating that RED should be changed to remove biomass from the list of renewable resources, limiting the use for bioenergy to locally-available waste and residues, and that this should be accompanied by a moratorium or a cap on the total amount of solid biomass in electricity and heating, by an accelerated phase-out of high ILUC risk fuels, and by the removal of incentives for bioenergy;
- Excluding the responses provided through the coordinated campaign, most responses provided on behalf of organisations still indicate that the criteria should be amended in some other way. *Businesses* and *others* are the only categories with small majority for no change (53% and 50%);
- The most popular answer to the question concerning the extension of GHG criteria was *NO (232 answers)*. A lower number of responses indicate that the threshold should be increased (81), that the criteria should be extended to existing installations (72) or that other limitations should be introduced. These additional limitations are suggested in the associated open question, where participants predominantly suggested stricter GHG criteria. However, often the message is about the appropriateness of the use of bioenergy in general, and considering biogenic emissions rather than supply chain only;
- Concerning whether the energy efficiency requirements should be made more stringent, the majority of answers (186) are in favour of an amendment (indicating that it should be extended to plants lower than 50MW (103 answers) or that the requirement should be higher (83 answers)). The remaining 167 participants are contrary to a change to the requirement.

[963] www.stopfakegreen.eu, a network of ca 130 environmental and other organisations, also active in the public debate on taxonomy

[964] It should be noted that this split does not take into account the coordinated replies mentioned above as the campaign participants did not reply to this question.

Method of analysis

To process and analyse the responses to the questionnaire, a standardised methodology has been developed. First, a data cleaning exercise was conducted to identify and correct any data errors. This includes the initial identification of any coordinated responses, i.e. multiple entries with very similar responses. Questions were also categorised as closed-ended questions (i.e. questions that limits the number of options for selection), and open-ended questions (i.e. questions that would require more elaboration).

Data cleaning

A total of 39,046 responses were initially received, any duplicate responses were removed. Duplicate responses are responses made by the same organisation. This occurred for six organisations. In these cases, the organisation was contacted and the preferred response was kept while the other were discarded from the analysis. In cases where the organisation cannot be reached, the most recent response is kept. In some cases, respondents had technical difficulties submitting their response. This occurred for nine organisations, where a PDF or Word document of their responses has been received via email. In these cases, their responses are manually transferred to the dataset. Therefore, six responses were removed from the initial dataset and nine were added. In total, 39,049 responses to the questionnaire were processed.

Additionally, 34 stakeholders provided responses to the public consultation via email but without a questionnaire. 9 of these stakeholders already provided a response to the questionnaire while 25 were additional submissions. The content of these additional contributions is summarised in the last chapter.

Closed questions

The closed questions were further categorised into three classifications:

1. *Single answer questions*: questions that allow the respondent to answer with only one response;
2. *Multi-answer questions*: questions that allow the respondent to answer with more than one response; and
3. *Multi-scale questions*: questions that ask the respondent to consider several topics under one question and respond based on a four-point scale (e.g. *(very) important/not (very) important*; *(very) appropriate/ not (very) appropriate)*.

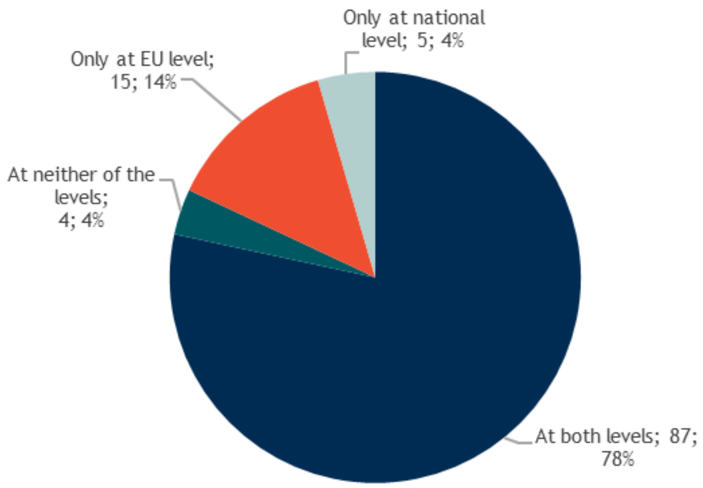
For each classification, a standardised analysis has been developed.

Single answer questions

The analysis of single answer questions was carried out by looking at the total responses received per response option provided in each question.

Figure 1-1 provides an example. For some questions, a bar or column figure is used instead to present data in a more effective way.

Figure 1-1 Example chart to present overall results for single answer questions



Further, this data was also correlated with the type of stakeholder who have provided the response. An example of the correlation analysis of the data is provided in Table 1-1. These tables display the responses provided by each stakeholder type in absolute numbers and relative percentages. As such, the percentages only equal 100% *per row* and not per column. The results are colour coded, such that the highest value per row is shaded red (a lighter shade of red is used when values are tied).

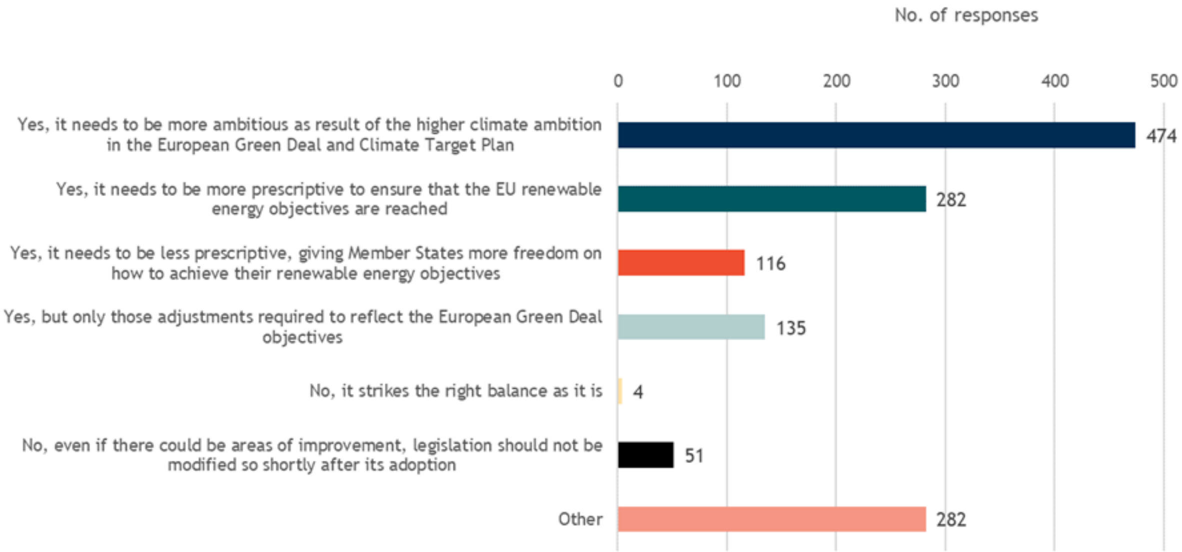
Table 1-1 Example table to present data regarding stakeholder participation for single answer questions

	Response option 1	Response option 2	Response option 3	Response option 4
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	78% (67)	14% (12)	5% (4)	3% (3)
In a professional capacity or on behalf of an organisation	89% (551)	11% (66)	0% (3)	0% (1)
Of which:				
Academic/research institution	*69% (11)*	*25% (4)*	*0% (0)*	*6% (1)*
Business association	*90% (197)*	*10% (22)*	*0% (0)*	*0% (0)*
Company/business organisation	*90% (203)*	*10% (23)*	*0% (0)*	*0% (0)*
Consumer organisation	*88% (7)*	*13% (1)*	*0% (0)*	*0% (0)*
Environmental organisation	*75% (15)*	*15% (3)*	*10% (2)*	*0% (0)*
Non-governmental organisation (NGO)	*92% (72)*	*6% (5)*	*1% (1)*	*0% (0)*
Public authority	*85% (22)*	*15% (4)*	*0% (0)*	*0% (0)*
Trade union	*50% (2)*	*50% (2)*	*0% (0)*	*0% (0)*
Other	*92% (22)*	*8% (2)*	*0% (0)*	*0% (0)*

Multi-answer questions

The analysis of multi-answer questions was carried out by looking at the total responses received per response option provided in each question. This implies that there are more responses than respondents, as each respondent can provide more than one response.
Figure 1-2 provides an example.

Figure 1-2 Example chart to present results for multi-answer questions

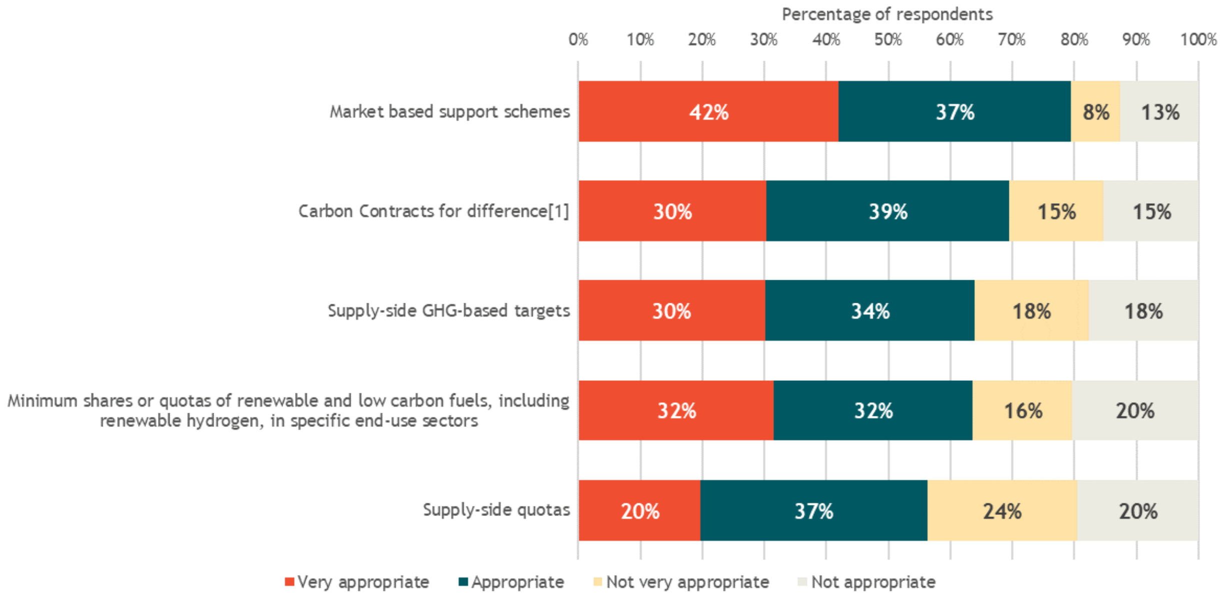


Further, similar to Section 1.2.1, this data was also correlated with the type of stakeholder who have provided the response, and will be presented in a table (example provided in Table 1-1). The relative percentages are a share of the total responses per stakeholder type, *not* total participants.

Multi-scale questions

The analysis of multi-scale questions was carried out by looking at the total responses received per response option provided in each question. Figure 1-3 provides an example of how data will be presented for multi-scale questions. The response options are ranked from most favourable to least favourable (in terms of importance/appropriateness/agreement). This rank is based on the combined share of the two highest points on the four-point scale (e.g. *very appropriate* and *appropriate*).

Figure 1-3 Example chart to present results for multi-scale questions



Open questions

The open questions were further categorised into two classifications:

1. *Follow-up open questions*: open-ended questions that ask the respondent to elaborate on the previous questions; and
2. *Distinct open questions*: open-ended questions that ask the respondent to elaborate on a question, which is not associated with to a previous question.

For both classifications, a similar standardised analysis has been developed.

The analysis of open questions identifies the main argument and (when feasible) quantifies the share of responses that support a certain argument. This is to be considered only an indicative estimate rather than a precise and definitive result, especially as some responses are wide ranging and often stakeholders have their area of focus to which they give more prominence.

Follow-up open question

The analysis of follow-up open questions was carried out by first looking at the total number responses received as well as the total responses for each stakeholder type. In some cases, multiple stakeholders provide the exact same response to an open question. Therefore, for each question, the number of *not-unique* responses is calculated. This is the total number of responses that are not unique, which can comprise of a few or many different responses that are found to have been repeated.

Thereafter, the responses were grouped on the basis of keywords and content, which were used to analyse and summarise the main views for each stakeholder type. The frequency/weight of the main views are also analysed across all stakeholder types. ATLAS.ti, a specialised software, was also used to identify key themes and keywords addressed in the open answers in a more systematic way. The following process was used to analyse these questions:

1. Pre-analysis and verification of keywords and themes;
2. Import the data into ATLAS.ti;

3. Produce descriptive statistics – based on the keyword list, it is determined if an open response refers to such a theme;
4. Deeper analysis of themes – as keywords cannot give deeper meaning to the open responses, e.g. the view on whether it is positive or negative, analysis is carried out per theme on each of the individual responses to compose a short summary of what is understood per theme to refine the key messages and recommendations that can be drawn.

For each question, the most common themes are presented. For these responses, an estimate of the share of responses that provide an answer with the particular theme is provided. Note, these shares are a rough estimate based on the ATLAS.ti analysis, and therefore there is a margin of error.

Distinct open question

The analysis of distinct open questions was carried out by first looking at the total number responses received compared to the number of non-responses to the question for each stakeholder type. In some cases, multiple stakeholders provide the exact same response to an open question. Therefore, for each question, the number of *not-unique* responses is calculated. This is the total number of responses that are not unique, which can comprise of a few or many different responses that are found to have been repeated.

Thereafter, the responses were grouped on the basis of keywords and content, which were used to analyse and summarise the main views for each stakeholder type. The frequency/weight of the main views are also analysed across all stakeholder types. ATLAS.ti, a specialised software, was also used to identify key themes and keywords addressed in the open answers in a more systematic way. The following process was used to analyse these questions:

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For each question, the most common themes are presented. For these responses, an estimate of the share of responses that provide an answer with the particular theme is provided. Note, these shares are a rough estimate based on the ATLAS.ti analysis, and therefore there is a margin of error.

Definition of majority

For the analysis of each question, the frequency and share of different responses are compared to each other. When a response receives more than 50% of the total responses to that question, it is deemed that a *majority* of the respondents provided the same response. It might also be considered a majority within a specific stakeholder group if more than 50% of the specific stakeholders who responded to that question provide the same response. In other cases, where an answer does not have more than 50% of the total responses but has the highest percentage of responses, it can be referred to as the *most popular* or *most selected/chosen* answer. Similarly, if a response receives the least amount of responses, it can be considered the *least popular* or *least selected/chosen*.

Analysis of participating stakeholders

The first section of the questionnaire asked participants to provide general details about themselves, which includes their name, in what capacity they are providing their contributions, the name of the organisation they are representing (if applicable), organisation size (if applicable), language and country of origin.

The consultation received **a total of 39,074 responses, of which 39,049 questionnaires**. The rest of this chapter focusses on the analysis of participants that submitted the questionnaire.

Stakeholder coverage and characteristics

Respondents were asked to declare their stakeholder type as one of the following: EU citizen, Non-EU citizen, or a representative of a: academic/research institution, business association, company/ business organisation, consumer organisation, environmental organisation, Non-governmental organisation (NGO), public authority, trade union or other. In order to simplify the analysis of responses received, business association and company/business organisation categories have been merged to *business organisations* NGO and environmental organisation categories have been merged to *NGO/environmental organisations*.

Figure 2-1 details the distribution of the contribution by individuals from a personal capacity (EU/Non-EU citizens). The largest share of respondents provided their contribution as EU citizens (38,400 responses. Four respondents declared to be a non-EU citizen.

Figure 2-1 Distribution of contribution by the individuals from personal capacity (n=38,404)

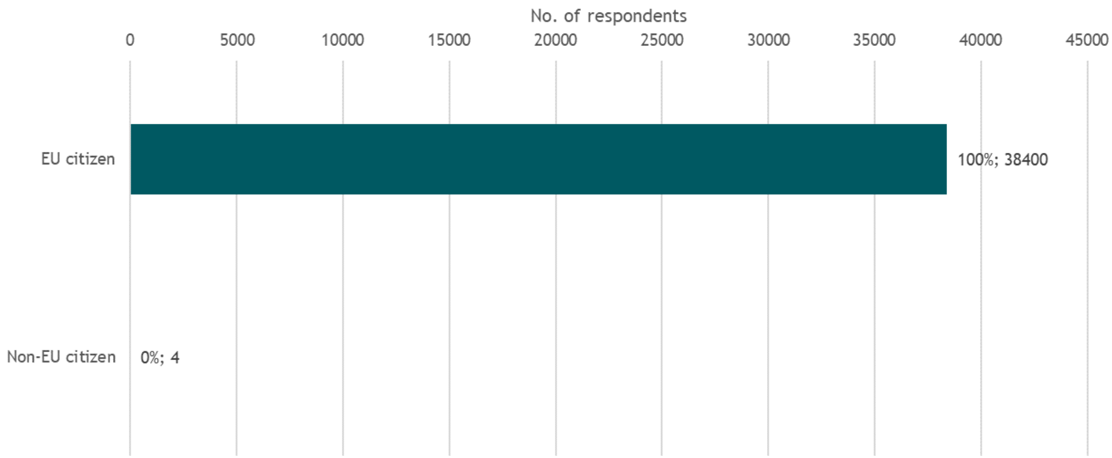
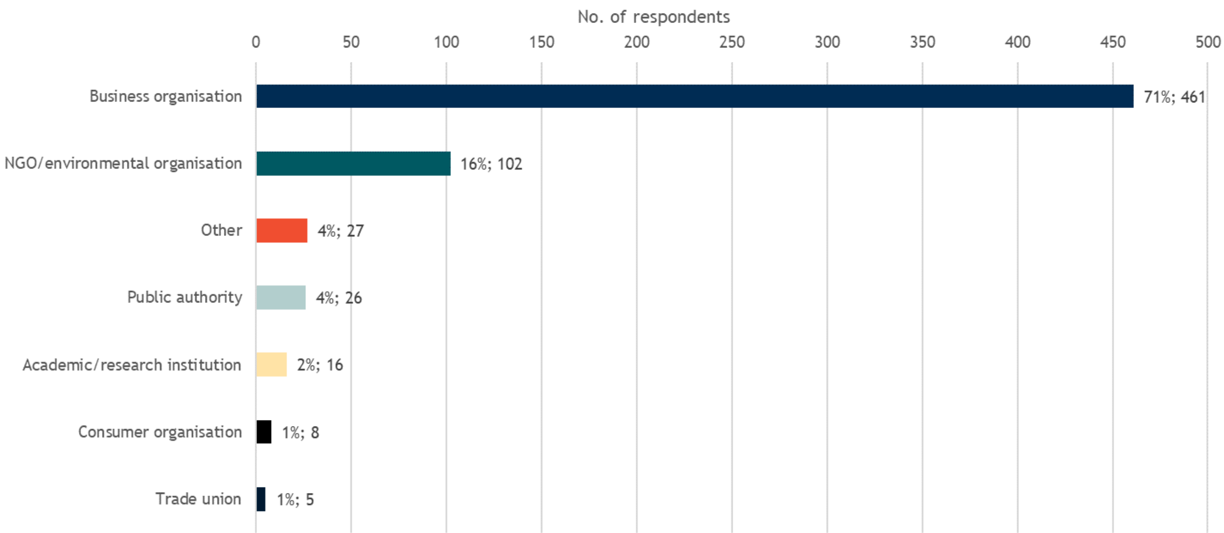


Figure 2-2 presents the distribution of contributions received from professionals or on behalf of an organisation. Most of the responses come from business organisations (461 responses, 71%), followed by non-governmental and environmental organisations (102 responses, 16%). 26 responses are from public authorities (4%), academic/research institutions (16 responses, 2%), consumer organisations (8 response, 1%) and trade union (5 response, 1%). 27 declared as *other* stakeholder type (4%).

Figure 2-2 Distribution of organisations represented (n=645)



Country of origin

Respondents are asked to provide their country of origin. Of the 39,049 respondents who participated, the majority are from within the EU (31,258, 80%), and all EU Member States are represented. Among organisations, 92% of participants are based in the EU.

Fours Member States account for a large share of total contributions: Spain (4,308 respondents, 11%); The Netherlands (4,182 responses, 11%); Germany (3,942 responses, 10%) ; and Sweden (3814 responses, 10%). Further below in terms of participants are Belgium (5%), Italy (5%), France (4%), Ireland (4%), Poland (3%), Denmark (3%), Finland (2%), Portugal (2%), Austria (2%), Slovenia (1%). Participants from the following EU countries amounted to less than 1% each: Greece, Slovakia, Romania, Estonia, Croatia, Bulgaria, Hungary, Czechia, Latvia, Luxembourg, Malta, Cyprus and Lithuania (See Figure 2-3).

However, the consultation saw a large influx of answers from a single coordinated campaign (see above). Once the campaign responses are removed, the most common countries of origin are Belgium (152 participants) and Germany (114 participants) (Figure 2-4).

Figure 2-3 Country of origin, EU respondents (n=31,258)

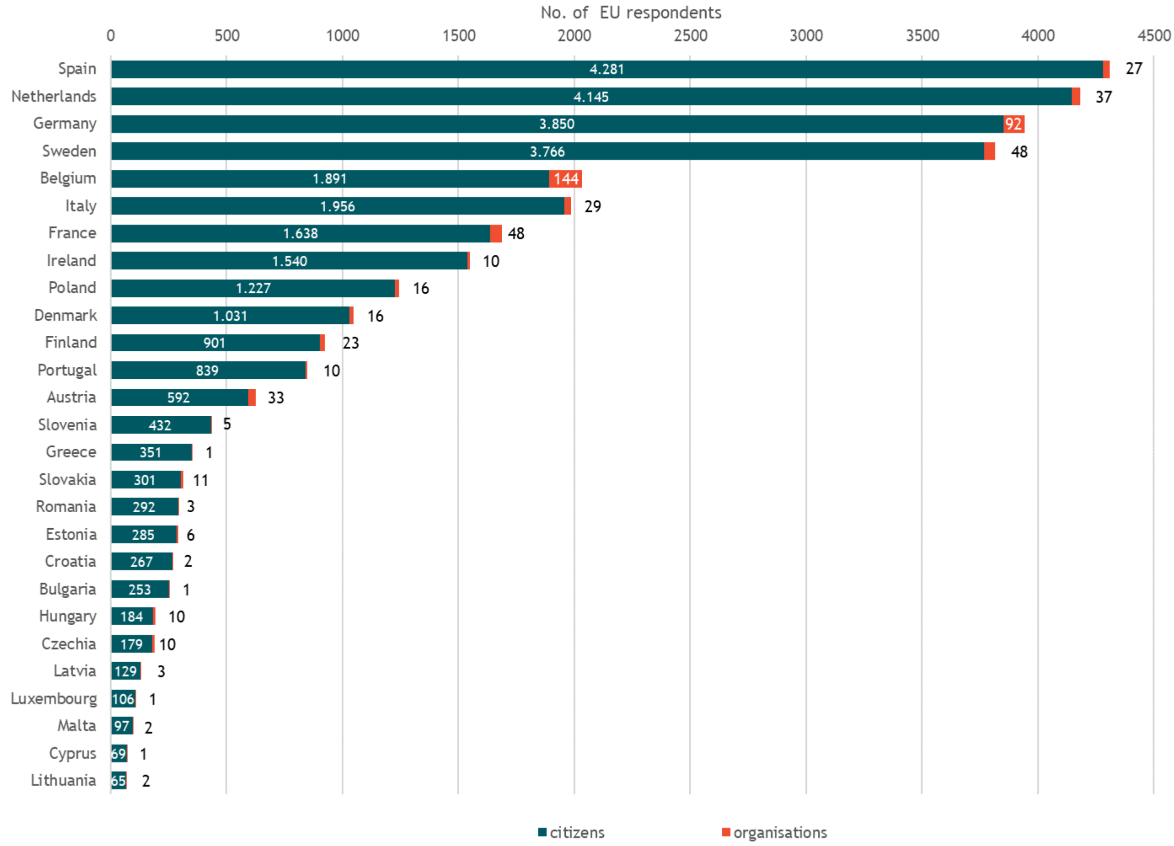
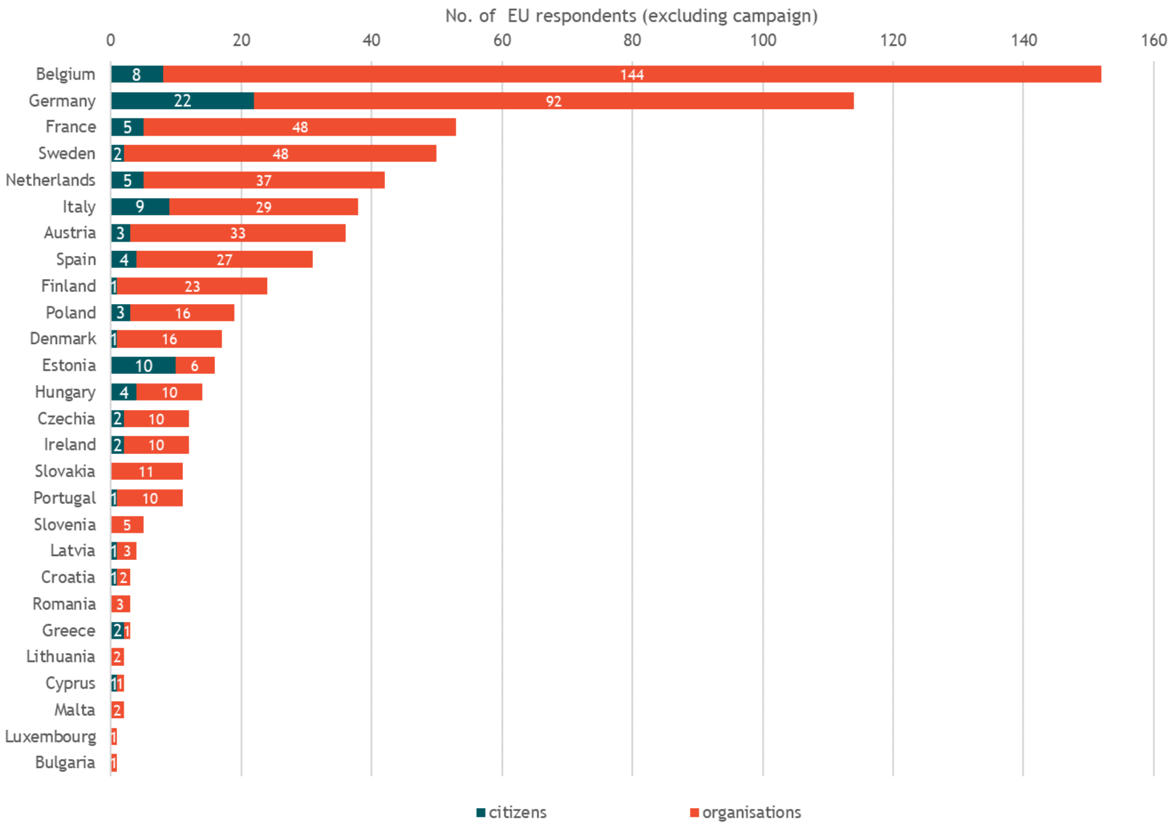


Figure 2-4 Country of origin, EU respondents, excluding campaign (n=678)



About 20% of the respondents (including participants to the coordinated campaign) do not originate from the EU (Figure 2-5). A total of 107 Non-EU countries are represented. 9% of the respondents originate from the United Kingdom (3,491 responses). 1,698 respondents are from the United States (4%). For each of the following countries, about 1% of the respondents are from: Canada (530 responses), India (351 responses), Australia (344 responses), Switzerland (283 responses) and Norway (223 responses). Once the campaign responses are excluded, the number of responses outside of the significantly drops (from 7,791 to 58 responses) (Figure 2-6). Most of these responses are from organisations based in the United Kingdom and the United States.

Figure 2-5 Country of origin, non-EU respondents (n=7,791)

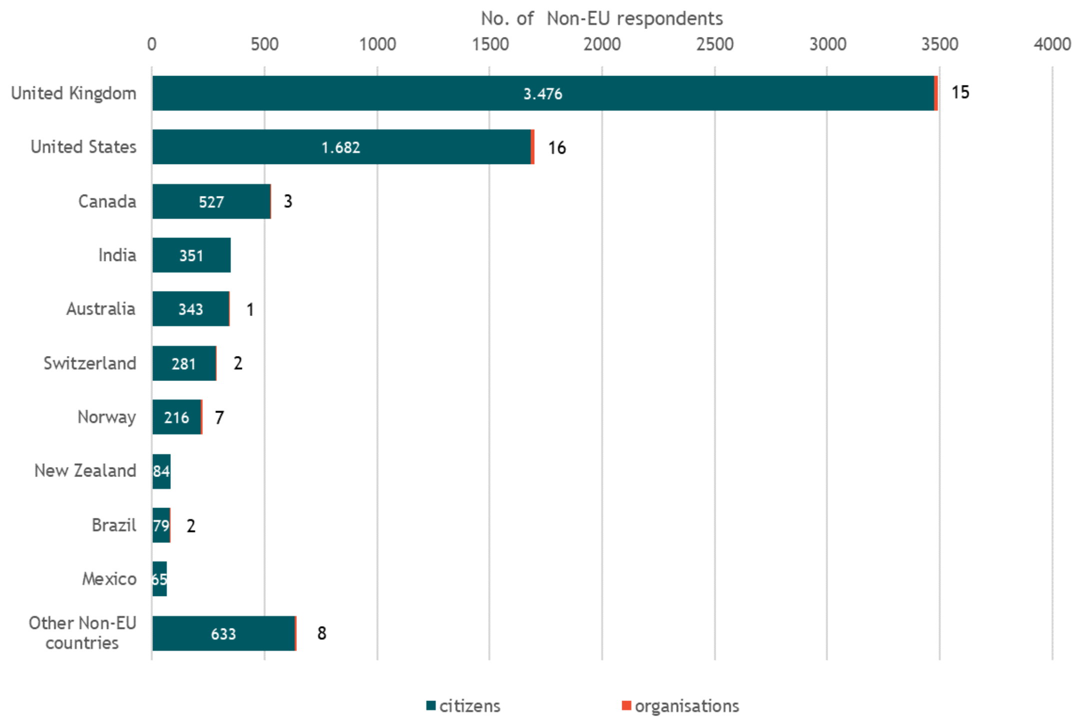
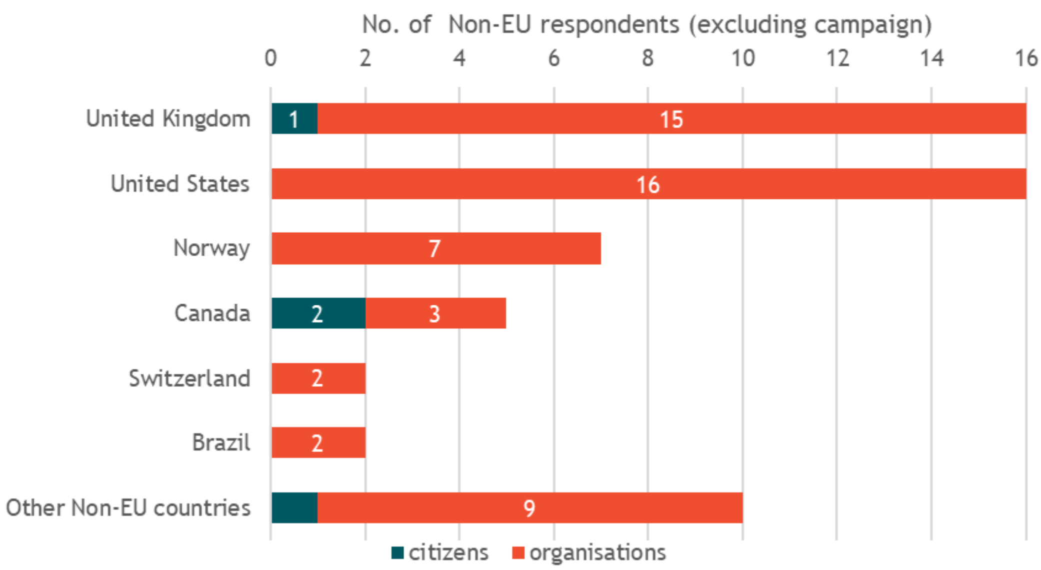


Figure 2-6 Country of origin, non-EU respondents, excluding campaign (n=58)



Public Administrations

A total of 26 public administrations from 14 different countries (13 EU Member States plus Norway) participated in the survey (Table 2-1). Of these, the majority (14) were *national authorities or agencies*, generally ministries in charge of the economy, the environment, climate or energy. Participants from *regional* and *municipal authorities* in general did not specify a particular government area. The country with most participants is Sweden (5), followed by Germany, France, The Netherlands and Spain (3).

Table 2-1 Country and scope of public administrations[965]

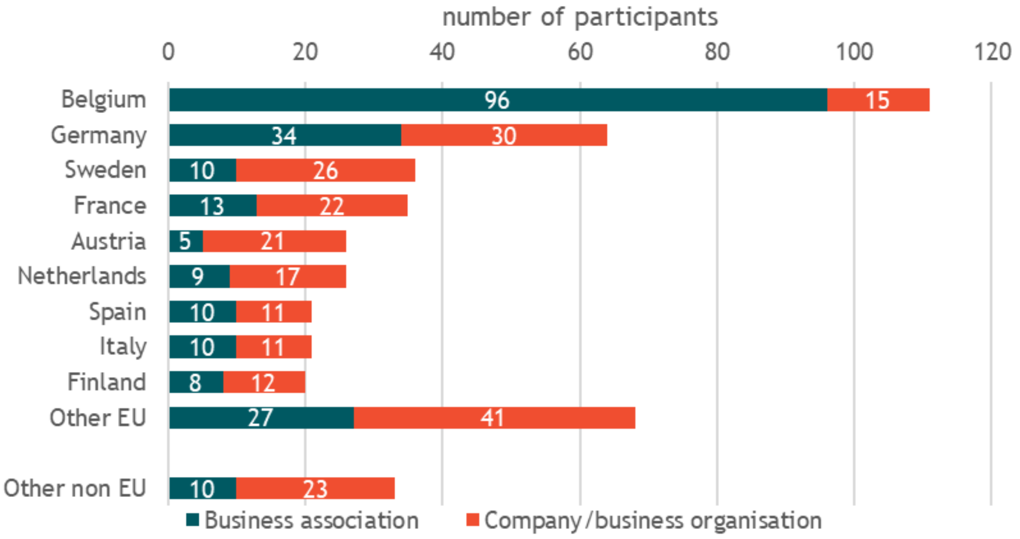
Country	National		Regional			Municipal		Total
	Parliament	Authority/ agency	Parliament	Authority/ agency	Not stated	Authority	Not stated	
Sweden	1		1	1			2	5
Germany		1		1			1	3
France		1		1		1		3
Netherlands		1		2				3
Spain		2			1			3
Belgium		1						1
Czechia		1						1
Estonia		1						1
Italy		1						1
Latvia		1						1
Lithuania		1						1
Luxembourg		1						1
Slovakia		1						1
Norway		1						1
TOTAL	1	14	1	5	1	1	4	26

Business organisations

The category *Business organisations* includes participants that selected either *Business association* or *Company/business organisation*. In total 461 business organisations from 35 different countries participated in the survey, with Belgium the most represented country (Figure 2-7). However, most participants from Belgium are from business associations representing particular groups or industries, rather than single companies. This is also the case for Germany, where *business associations* represented the majority (34 participating as association compared to 30 participating as company/business organisation). A total of 33 *business organisations* are from non-EU countries, predominantly from UK and USA (9 organisations in both cases).

[965] Note that one response was amended from Cayman Islands to Spain

Figure 2-7 Business organisations by country and type (n=461)

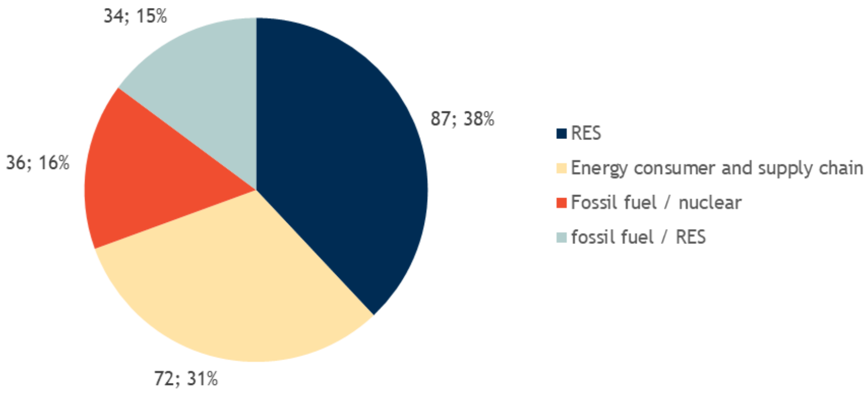


Further analysis has been conducted to differentiate the variety of *companies/business organisations* that particpated (the analysis does not include business associations) in order to understand how they relate to the renewable energy sector. These have been subdivided into the following categories:

- **Fossil fuel/nuclear**: companies predominantly active in the space of traditional fossil and nuclear energy sources;
- **RES**: companies predominantly active in the space of renewable energy sources;
- **Fossil fuel/RES**: companies active in bth traditional and renewable energy sources;
- **Energy consumers and supply chain:** other companies not directly involved in the production of energy. These may have an interest either as part of the supply chain (e.g. manifaturers active in the transport sectors, (Bosch, Volkswagen, Tesla), in services (Veolia), or industrial companies) or more likely as consumers (Ryanair, Lufthansa). This category also includes partipants from organisations that may not strictly fall under a traditional definition of "business" (for example the *European Former Foodstuff Processors Association*, *Colegio oficial de Arquitectos Vasco Navarro*, *CNR*, *Cyprus Telecommunications Authority*).

Figure 2-8 details the distribution of the contribution by individuals representing companies/business organisations. 38% of companies/business organisation that participated could by classified as operating in the renewable sector, 16% in fossil fuels or nuclear, while 15% are active in both sectors. 31% of companies/business organisations can be classified as as energy consumers or supply chain, so not directly involved in commercial-scale energy generation.

Figure 2-8 Distribution of contribution by individuals representing companies/business organisations (n=229)

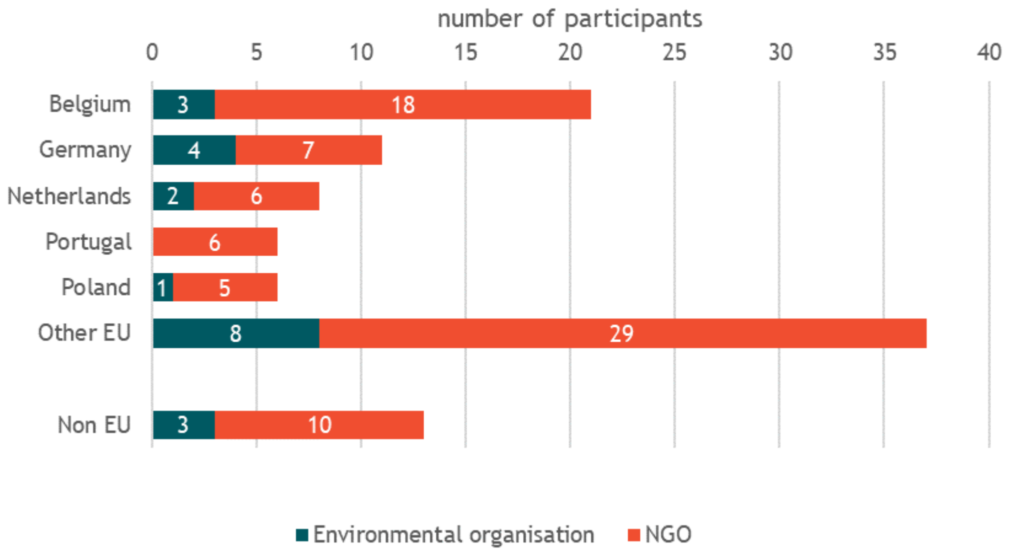


For the remaining of this report, *Business association* or *Company/business organisation* will be treated as a single category.

Non-governmental organisations and Environmental organisations

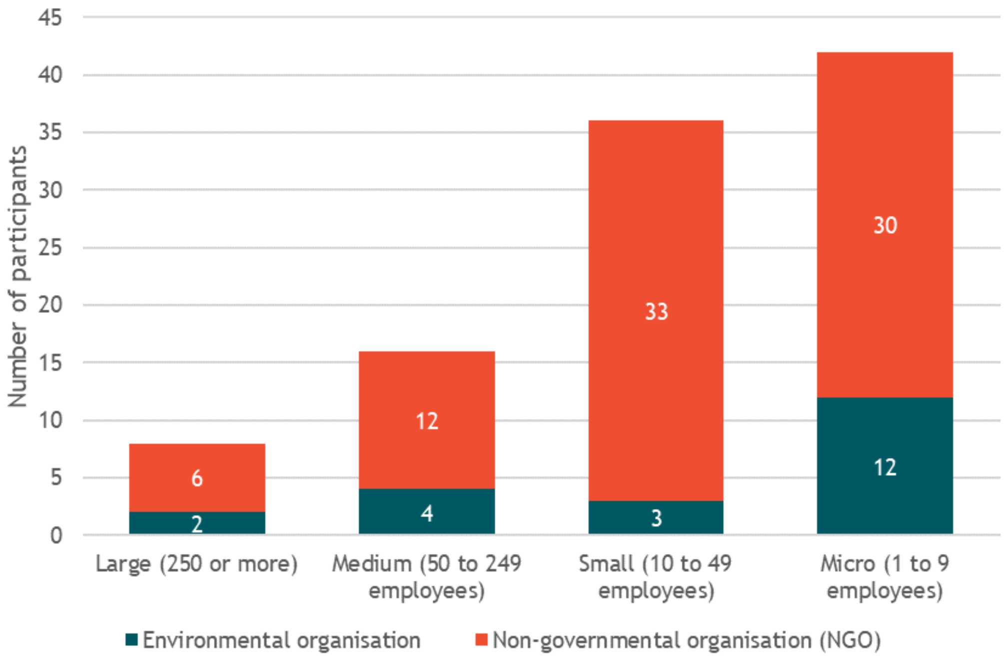
A total of 81 Non-governmental organisations (NGOs) and 21 *Environmental organisations* participated in the survey.[966] The country more often indicated by *NGOs* was Belgium, while Germany is the country in which environmental organisations are more often located (Figure 2-9). The majority of NGOs and Environmental organisations that responded are either small or micro (Figure 2-10).

Figure 2-9 NGOs and Environmental organisations by country and type (n=102)



[966] Large NGOs (>250 employees) include the World Wildlife Fund (WWF), Naturschutzbund Deutschland e.V. (NABU) and the Natural Resources Defense Council (NRDC). Large and medium (between 50 and 249 employees) *environmental organisations* include the WBA (World Biodiversity Association), European Environmental Bureau, European Community Power Coalition and E3G (Third Generation Environmentalism).

Figure 2-10 NGOs and Environmental organisations by size and type



For the remaining of this report, *Environmental organisations* or *NGOs* will be treated as a single category.

Coordinated responses

Some participants responded to the open public consultation in a coordinated fashion. These participants provided the same, or very similar responses for the open/closed questions. Based on an analysis of the open questions[967], 57 groups of coordinated participants were identified (Figure 2-11). Most of these groups are small (1-5 participants), but 7 have more than 10 participants. In particular, a campaign targeting the use of certain biomass feedstock counts 38,313 participants, almost all EU citizens. This campaign only concerned Q9.3 and the subsequent open-ended question Q9.3.1, requesting to remove biomass from the list of renewable resources and limiting the use for bioenergy to locally-available waste and residues. The second largest group consists of 23 participants, mostly environmental NGOs, focussing again on biomass. This group demanded the phasing out of biomass and making forest biomass ineligible as a renewable energy resource, an argument that was repeated in their responses to several questions. This group targeted questions in section 1, 4 and 7 as well as Q2.11.1.

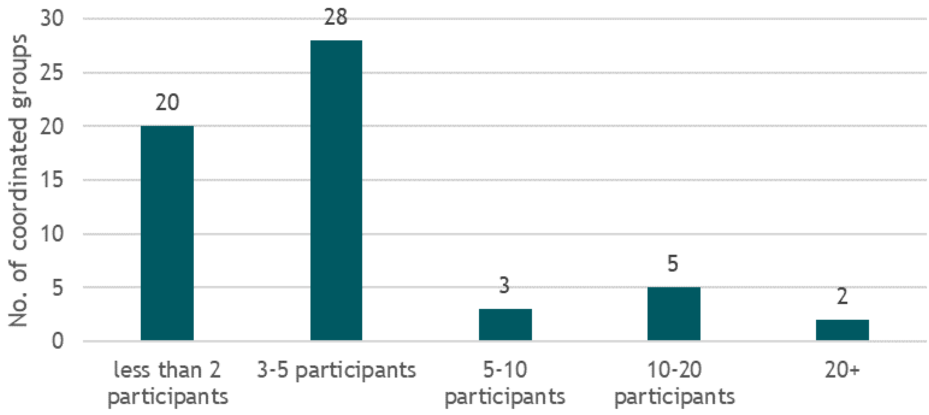
Of the other five larger coordinated groups (greater than 10 participants), three of them are in favour of biofuels (13, 13 and 10 participants respectively, mostly business organisations). One of these groups with 13 participants targeted only Q9.1.1 while the other group of 13 participants targets questions throughout the questionnaire. The group of 10 business organisations targeted questions in sections 1 and 8 as well as Q2.5.1, Q2.6.1, Q3.6.1 and Q9.3.1. A coordinated group of 18 NGOs/environmental organisations emphasise the need to promote sustainable, renewable energy only. This group gave

[967] Respondents with the identical answer for 3+ open questions are considered a coordinated group. There are exceptions, for instance, some groups only answer one question, but are still considered a coordinated group. Many of the participants in coordinated groups also provided unique responses to other uncoordinated questions as well as coordinated questions, in the case where groups provided coordinated responses to multiple questions.

replicated responses throughout the entire questionnaire. A group of 14 business organisations, NGOs, academics and EU citizens campaign for tidal energy and targeted questions in the first three sections of the questionnaire.

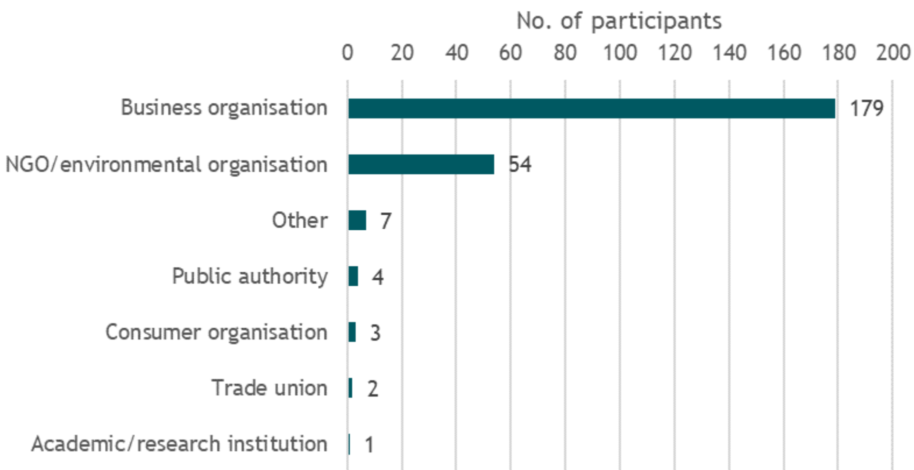
In total, the analysis of open-ended questions identified 141 business organisations participating in 28 separate coordinated campaigns involving 3 participants or more.

Figure 2-11 Size of groups of coordinated groups of stakeholders



Most of these stakeholders participating in coordinated responses are EU citizens (from the large coordinated group). Of the stakeholders participating in a professional capacity, business organisations are the most involved in coordinated responses, followed by NGOs (Figure 2-12). Of the companies (*not business associations*) involved in coordinated responses, about 42% are involved in the renewable sector, 22% are energy consumer/supply chain, 22% are involved in both fossil fuel and renewable and 13% are involved in fossil fuel/nuclear. Of the NGOs involved in coordinated responses, most are dedicated to sustainable development or environmental protection. Many of the participants who coordinated responses (excluding the campaign) originate from Belgium (22%), Germany (13%), Sweden (9%), France (7%) and the Netherlands (6%).

Figure 2-12 Types of professional stakeholders involved in coordinated responses



Where relevant, the contributions received as part of the major coordinated campaigns is distinguished in the analysis.

Participation

On average, participants responded to 60% of the closed questions and 26% of the open-ended questions. Response rates varies among different stakeholder groups (

Figure 2-13). On average, EU citizens (excluding participants to the large campaign) (77%) and public authorities (76%) responded to the most questions. For the open-ended questions, the highest average response rate is among NGOs/environmental organizations. As those who participated in the large campaign only responded to two questions, the response rate for these participants is less than 1%.

Figure 2-13 Response rate for open and close questions by stakeholder type

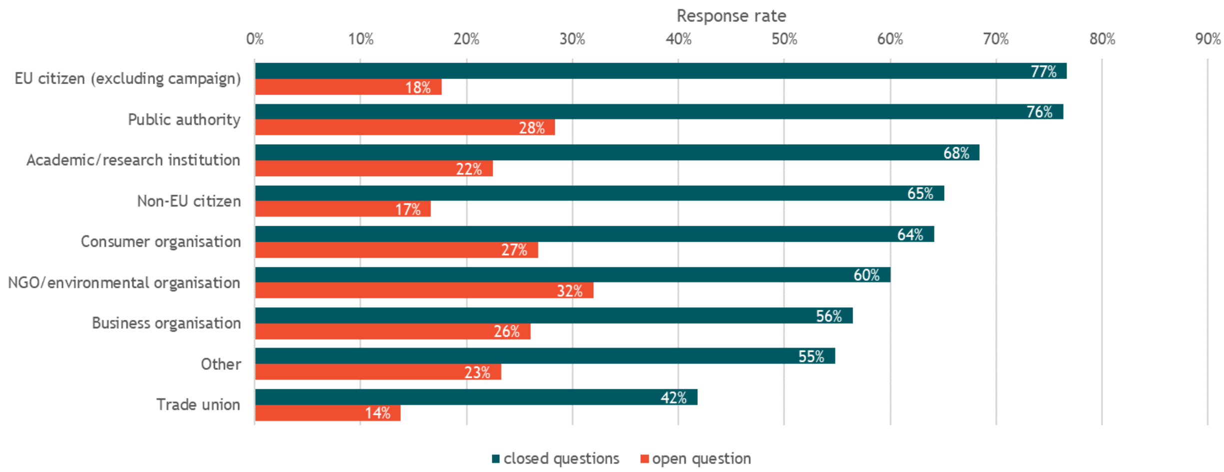


Table 2-2 lists the top five closed and open-ended questions from the open public consultation, in terms of number of responses. As mentioned, Q9.3 and the subsequent open-ended question, Q9.3.1, received over 38,000 responses, concerning the type of feedstock limits on bioenergy production, by far the higher response compared to the other questions. These responses mainly came from EU citizens, from the campaign, who requested to remove biomass from the list of renewable resources and limiting the use for bioenergy to locally-available waste and residues.

Following Q9.3, the first four questions of the survey are the most frequently answered closed questions. The second most answered question is Q1.2, which asks participants if RED II needs to be modified. 66% of the participants who responded to this question think that *RED II needs to be more ambitious*. The third is Q1.1, where 98% of the respondents say that renewable energy will be *important* or *very important* in delivering the EU's climate ambition for 2030 and carbon neutrality by 2050. The fourth most responded closed question is Q1.3, where 71% of the respondents to this question say that there needs to be an *overall Union target of at least 32% for renewable energy for 2030* and 52% think that there needs to be *a target of at least 14% for renewable energy in transport by 2030*. The fifth most frequently responded question is Q1.4, where about three-quarters of the respondents think that additional efforts to increase the use of renewable energy are most needed in *transport* (78%) and *heating and cooling* (72%).

For the open questions, following Q9.3.1, Q1.3.2 is the second most frequently responded open-ended question, where participants provide a variety of explanations of why they think certain parts of RED II should be amended. The third most answered open-ended question is Q2.1.1, where the most common ideas given to build a more integrated energy system are: *scaling up renewable/low-carbon* *technologies* and *smart technologies and digitalisation*. The fourth most responded open-ended question is Q2.3.1, where many participants think that *increasing system efficiency*, *strengthening capacity of transmission and distribution* and *fostering demand-side response and harnessing local and decentralised solutions* are important to support electrification of energy consumption. Lastly, Q2.6.1 is the fifth most answered open-ended question, where many participants think that in order to support the uptake of RES and low-carbon fuels, special attention is needed to *hydrogen and e-fuels in hard-to-abate sectors* and *targeting climate-friendly technologies*.

Table 2-2 Top five open and closed questions based on response rate

		Academic/ research institutions	Business organisations	Consumer organisations	NGO/env.	Public authority	Trade union	Other	EU citizen	Non-EU citizen	Total
Closed questions											
1.	*Q9.3 Do you think that there should be limits on the type of feedstock to be used for bioenergy production under REDII?*	11	261	2	86	22	2	17	38,384	3	**38788**
2.	*Q1.2 Do you think REDII needs to be modified?*	16	453	8	101	26	5	25	81	4	**719**
3.	*Q1.1 How important do you think renewable energy will be in delivering the EU's higher climate ambition for 2030 and carbon neutrality by 2050?*	16	445	8	100	25	4	26	82	4	**710**
4.	*Q1.3 Which parts of RED II do you think should be amended?*	13	431	7	94	24	5	23	76	4	**677**
5.	*Q1.4 In which sectors do you think additional efforts to increase the use of renewable energy are most needed for a potentially higher renewables target for 2030?*	15	415	8	88	23	5	23	80	4	**661**
Open questions											
1.	Q9.3.1 Please explain your answer *(type of feedstock limit for bioenergy production)*	1	66	1	52	5	0	2	38,314	1	**38462**
2.	Q1.3.2 Please explain your answer *(about which parts of RED II that need to be amended)*	5	272	5	51	16	2	15	40	2	**408**
3.	Q2.1.1 Any other view or ideas related to the use of renewables that could contribute to building a more integrated energy system? Please specify.	6	266	7	48	14	3	13	33	1	**391**
4.	Q2.3.1 Other? Please specify *(appropriate measures to support electrification of energy consumption)*	6	207	4	44	11	1	8	16	0	**297**
5.	Q2.6.1 Other? Please specify *(effective measures to support the uptake of RES and low-carbon fuels)*	5	204	3	44	10	0	7	12	0	**285**

Detailed responses to questions

Section I - General questions on the review and possible revision of the Renewable Energy Directive

The first section of the questionnaire comprises of 7 questions which focus on the importance and objectives of the Renewable Energy Directive.

Analysis of responses received for Section I

Q1.1 How important is RE in delivering EU's higher climate ambition for 2030 and carbon neutrality by 2050?

Question 1.1 received a total of 707 responses (Figure 3-1). The majority of respondents (98%) answered that RE is either very important (621 responses, 87%) or important (78 responses, 11%). The remaining 2% (11 respondents in total) replied that it was not very important or not important. Across all stakeholder types, overall, there is a consensus concerning the importance of renewable energies in delivering EU's higher climate ambitions for 2030 and carbon neutrality by 2050 (Table 3-1).

Figure 3-1 How important is RE in delivering EU's higher climate ambition for 2030 and carbon neutrality by 2050? (n=710)

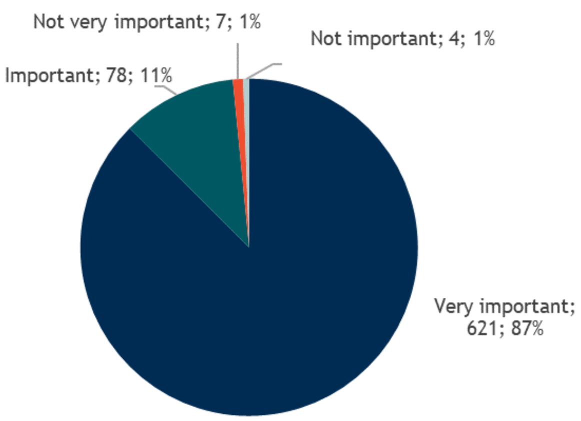


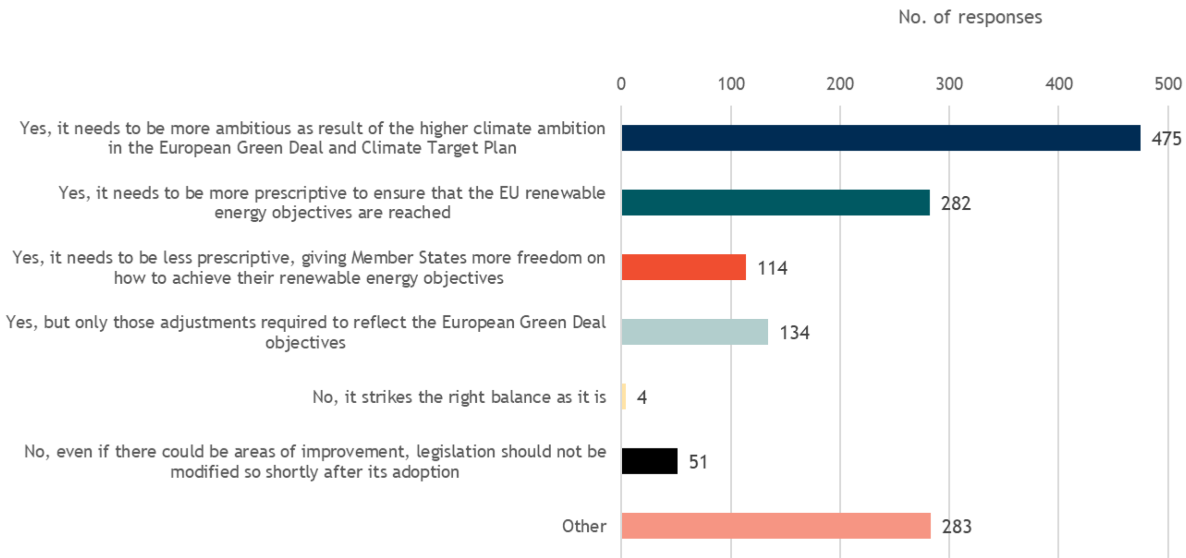
Table 3-1 Stakeholder correlation analysis for Q1.1

	Very important	Important	Not very important	Not important
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	78% (67)	14% (12)	5% (4)	3% (3)
In a professional capacity or on behalf of an organisation	89% (554)	11% (66)	0% (3)	0% (1)
Of which:				
Academic/research institution	*69% (11)*	*25% (4)*	*0% (0)*	*6% (1)*
Business organisation	*90% (400)*	*10% (45)*	*0% (0)*	*0% (0)*
Consumer organisation	*88% (7)*	*13% (1)*	*0% (0)*	*0% (0)*
NGO/environmental organisation	*89% (89)*	*8% (8)*	*3% (3)*	*0% (0)*
Public authority	*84% (21)*	*16% (4)*	*0% (0)*	*0% (0)*
Trade union	*50% (2)*	*50% (2)*	*0% (0)*	*0% (0)*
Other	*92% (24)*	*8% (2)*	*0% (0)*	*0% (0)*

Q1.2 Does RED II need to be modified?

Q1.2 received a total of 1,343 responses from 719 respondents (multiple answers possible). Respondents could choose from 7 options and selected about 2 options on average (Figure 3-2). Many participants think that RED II needs to be *more ambitious* to be aligned with the higher climate ambition adopted in the European green Deal and the Climate Target Plan (475 responses). 282 participants think that RED II needs to be *more prescriptive* to ensure that the EU renewable energy objectives are reached. On the other hand, 114 participants believe that it needs to be *less prescriptive*, giving Member States more freedom on how to achieve their renewable energy objectives. 134 participants think that adjustments to RED II are necessary, but only to reflect the objectives of the European Green Deal. 4 respondents think that the current RED II strikes the right balances and needs no further modification. 51 respondents think that the legislation should not be modified so shortly after the adoption. 283 Participants chose the *other* option.

Figure 3-2 Does REDII need to be modified? (n=719; 1,343 responses)



Across all stakeholder groups, the majority agrees that RED II needs to be modified, and that it needs to be *more ambitious* as a result of the higher climate ambition in the European Green Deal and Climate Target Plan (Table 3-2; percentages are in terms of total responses, *not* participants). Notably, amongst participants from trade unions, the *other* option is the one most frequently chosen.

Table 3-2 Stakeholder correlation analysis for Q1.2

	Yes, more ambitious	Yes, more prescriptive	Yes, less prescriptive	Yes, to reflect the European Green Deal objectives	No, it strikes the right balance as it is	No, should not be modified so shortly after adoption	Other
	% (frequency)	% (frequency)	% (frequency)	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	40% (59)	35% (51)	7% (11)	4% (6)	1% (1)	4% (6)	9% (13)
In a professional capacity or on behalf of an organisation	35% (416)	19% (231)	9% (103)	11% (128)	11% (128)	4% (45)	23% (270)
Of which:							
Academic/research institution	34% (10)	21% (6)	10% (3)	14% (4)	14% (4)	7% (2)	10% (3)
Business organisation	34% (285)	18% (153)	9% (79)	12% (97)	12% (97)	3% (27)	23% (192)
Consumer organisation	40% (6)	20% (3)	0% (0)	7% (1)	7% (1)	7% (1)	27% (4)
NGO/environmental organisation	38% (82)	26% (56)	4% (9)	6% (12)	6% (12)	4% (8)	22% (48)
Public authority	36% (16)	11% (5)	16% (7)	14% (6)	14% (6)	5% (2)	18% (8)
Trade union	11% (1)	11% (1)	11% (1)	22% (2)	22% (2)	11% (1)	33% (3)
Other	33% (16)	14% (7)	8% (4)	12% (6)	12% (6)	8% (4)	24% (12)

Table 3-3 Summary of results from Q1.2.1

Summary of results from Q1.2.1, open ended question concerning Q1.2, where participants were asked to specify whether RED II needs to be modified.
In total, Q1.2.1 received 278 responses of which 17 are not unique[968]. Participants were primarily business organisations (190 responses), NGOs (46 responses), and EU citizens (12 responses). Other stakeholder groups responded in smaller frequencies ranging from 1 to 11 responses. A broad summary of the key discussions points is presented below. • About 25% of respondents share the view that the targets should be revised to reflect the increase in climate ambitions in the European Green Deal and Climate Target Plan for 2030, although some of them also highlight the need for time to assess the effectiveness of the existing RED II; • Respondents who think that RED II should be more prescriptive (~15%), mainly referred to the need for clearer classification of sustainable feedstock, which should exclude forest biomass. The need for higher targets to decarbonise the transport sector was also mentioned. On the other hand, a group of respondents (~8%) think that it is important to incentivise market-based, cost-effective pathways to decarbonisation, therefore leveraging more on the EU Emissions Trading System (ETS); • On the other hand, a smaller group of respondents (~5%) opined that RED II should be less prescriptive, and be more technology neutral. They also share the view that freedom should be given to Member States to apply flexibility in selecting the decarbonisation pathways, taking into account national characteristics.

Q1.3 Which parts of RED II should be amended?

Q1.3 is an extension of Q1.2, asking respondents who answered *yes* to Q1.2 to expand on which parts of RED II should be amended. Q1.3 received a total of 3,272 responses from 677 respondents (multiple answers possible). 12 potential amendments (plus *other*) to RED II were available for the respondents to select from:

A. Overall Union target of at least 32% for renewable energy for 2030;
B. Target of at least 14% for renewable energy in transport by 2030;
C. Requirements on guarantees of origin for energy from renewable sources;
D. Provisions on sustainable low carbon fuels such as low-carbon hydrogen and synthetic fuels with significantly reduced full life-cycle greenhouse gas emissions compared to existing production;
E. Provisions simplifying administrative procedures for renewables project developers;
F. Provisions on how to promote renewable energy in buildings;
G. Indicative target of an annual increase of 1.3% point for renewable energy used in heating and cooling;
H. Sustainability and GHG emission saving criteria for energy produced from biomass;
I. Provisions on how to design support schemes for electricity from renewable sources;
J. Indicative target of an annual increase of 1% point for renewable energy used in district heating and cooling and provisions on access to district heating networks;
K. Provisions on cooperation mechanisms between Member States;
L. Provisions on self-consumption and renewable energy communities; and/or
M. Other.

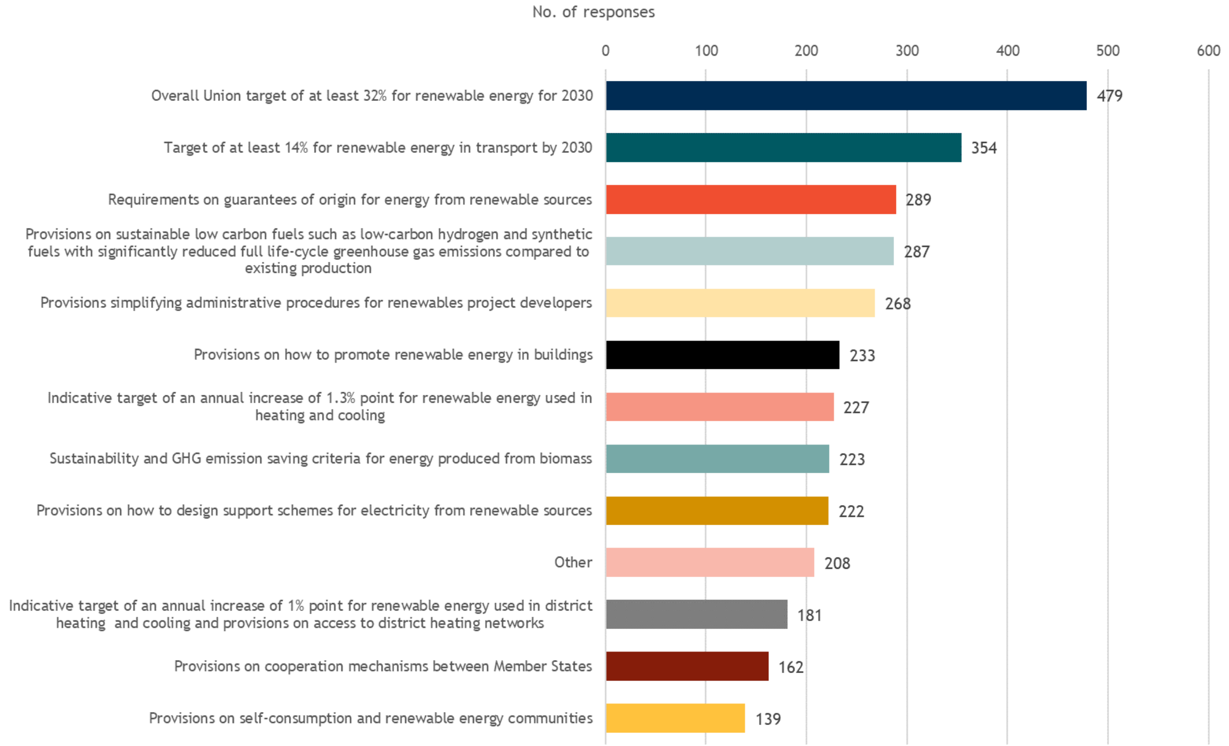
Participants chose 4.8 options on average.

In Figure 3-3, responses are listed in order of popularity, from the most selected at the top to the least selected. The most popular amendment suggested is Option A, an *overall union target of at least 32% for renewable energy for 2030* (479 responses). The second most popular option is Option B, *a target of at least 14% for renewable energy in transport by 2030* (354 responses). This is followed by Option C (289 responses), Option D (287 responses), Option E (268 responses), Option F (233 responses), Option G

[968] A not unique answer does not necessarily indicate a coordinated response.

(227 responses), Option H (223 responses), Option I (222 responses) and Option J (181 responses). Provisions on cooperation mechanisms between Member States (Option K) and Provisions on self-consumption and renewable energy communities (Option L) were the least popular options. 208 participants chose Option M, *other*.

Figure 3-3 Which parts of RED II should be amended? (n=674; 3,263 responses)



Amongst different stakeholders, Option A, *an overall Union target of at least 32%*, is the most frequently chosen option (Table 3-4; percentages are in terms of total responses, *not* participants). Notably, option B, a *renewable energy target in transport*, is popular amongst consumer organisations and public authorities. Amongst environmental organisations, Option K, *a provision on cooperation mechanisms between Member States*, is the more popular.

Table 3-4 Stakeholder correlation analysis for Q1.3

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.
	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)
As an individual in a personal capacity	13% (49)	9% (33)	7% (26)	6% (23)	8% (32)	6% (22)	8% (32)	10% (37)	10% (37)	7% (26)	10% (37)	7% (25)	4% (17)
In a professional capacity or on behalf of an organisation	16% (430)	12% (321)	7% (201)	6% (158)	7% (190)	5% (140)	7% (201)	9% (231)	9% (252)	4% (113)	7% (186)	10% (262)	7% (191)
Of which:													
Academic/ research institution	13% (10)	9% (7)	9% (7)	8% (6)	7% (5)	9% (7)	7% (5)	9% (7)	7% (5)	5% (4)	8% (6)	9% (7)	7% (5)
Business organisation	16% (302)	13% (244)	7% (123)	5% (89)	7% (120)	6% (101)	6% (115)	9% (170)	10% (181)	5% (85)	5% (97)	11% (204)	7% (127)
Consumer organisation	13% (5)	15% (6)	8% (3)	5% (2)	10% (4)	3% (1)	5% (2)	10% (4)	8% (3)	5% (2)	8% (3)	10% (4)	5% (2)
NGO/ environmental organisation	15% (77)	7% (36)	10% (48)	9% (46)	10% (48)	4% (18)	11% (55)	7% (34)	9% (44)	2% (10)	12% (62)	5% (23)	8% (42)
Public authority	14% (17)	14% (17)	9% (11)	7% (8)	5% (6)	5% (6)	7% (9)	7% (8)	7% (9)	6% (7)	7% (9)	12% (14)	5% (6)
Trade union	25% (3)	8% (1)	8% (1)	8% (1)	8% (1)	8% (1)	8% (1)	0% (0)	8% (1)	0% (0)	8% (1)	8% (1)	8% (1)
Other	15% (16)	10% (10)	8% (8)	6% (6)	6% (6)	6% (6)	13% (14)	8% (8)	9% (9)	5% (5)	8% (8)	9% (9)	8% (8)

Table 3-5 Summary of results from Q1.3.1 and Q1.3.2

Summary of responses to Q1.3.1 and Q1.3.2, two open-ended questions concerning Q1.3, where participants that answered “yes” to Q1.3 were asked to specify which parts of RED II they think should be amended, and to explain their response.

Collectively, Q1.3.1 and Q1.3.2 received 659 responses of which 23 are not unique. Responses are primarily from business organisations (431 responses), NGOs (99 responses), and EU citizens (57 responses). Other stakeholder groups responded in comparatively smaller frequencies ranging from 2-26 responses. The main messages from the analysis are summarised below.

Discussion on acceptance of biomass as a renewable energy source (~10% of respondents)

The comments on the use of biomass broadly fall into the following two sets of discussions:

- In general, they agree with the use of biomass produced sustainably. However, the Renewable Energy Directive should provide provisions to exclude the use of forest / woody biomass. Further, the usage of biomass should be subject to:
  - more stringent sustainability and greenhouse gas emissions reduction criteria, including imports into of feedstock from third countries into the EU;
  - a more robust monitoring and verification processes, including the establishment of robust measures to trace and certify the origin of biofuels.
- In minor numbers, respondents suggest that the promotion of the use of biomass is unsustainable and should not be considered entirely, or should be very limited in its use as a renewable energy source in the Renewable Energy Directive.

Further, the type of feedstock that can be considered as “sustainable” sources in the Renewable Energy Directive should be clarified, including clarity on the classification of waste. A robust review of the feedstocks listed on the Annex IX-Part A has been suggested, so as to take into account the availability of the various feedstocks, and their share of pre-existing use other than energy recovery.

Do-no-harm principle should be adopted (~5% of respondents)

About 5% of respondents suggest that the Renewable Energy Directive should uphold the ‘do-no-harm’ principle. The Directive should be in harmony with other environmental protection legislation of the EU, such as the Habitats Directive, which also includes the prevention of damage to protected areas and species within the Natura 2000 network. Projects which are environmentally damaging and unsustainable should not be considered as renewable energy sources.

Other

- **Increase targets in building, heating and cooling sectors and transport.** The targets for renewable energy uptake in buildings, the heating and cooling sectors, as well as the transport should be adjusted upwards to reflect the increased climate ambitions of the EU. This could include specific sub-sector targets for especially hard-to-abate sectors to incentivise and speed up the decarbonisation rate.
- **Technology-neutrality.** In order to achieve EU’s ambitious targets through rapid decarbonisation across all sectors, the Renewable Energy Directive should be technology neutral. This principle should also extend to the support schemes that are available. Member States should be given the freedom to employ the most cost-effective options in order to reduce greenhouse gases emissions. Meanwhile, the Renewable Energy Directive can improve transparency regarding the various energy technologies. Providing information about the characteristics and potentials of the various types of renewable energy, and low-carbon technologies is important, but it does not inform the actual environmental impact of their production. The Renewable Energy Directive could include a common classification criterion implemented at the EU level to distinguish the differences in the levels of greenhouse gases emissions of producing energy per technology. This could be implemented in harmony with the development of

European terminology for the various energy technologies, and a certification system based on the full life-cycle greenhouse emission savings potential and other sustainability criteria.

- **Low-carbon options.** Comments on low-carbon options broadly fall into the following sets of discussions:
  - Low-carbon technologies are not sustainable in the long run, and the promotion of such technologies is not compatible with EU's 2050 goal of achieving a net-zero greenhouse gas emission economy. This view is shared by NGOs;
  - Business organisations are in favour of encouraging low-carbon technology. The deployment of low-carbon options has an important role in achieving a more ambitious RES target, allowing a -55% greenhouse gas emission reduction in 2030. In order to be consistent with EU's 2050 target of achieving a climate-neutral economy, specific pathways could be set out, while also ensuring that these low-carbon energy technologies should also be subject to stringent greenhouse gases emission reduction, and other sustainability criteria. This could be implemented through the issuance of Guarantees of Origin (GO). In particular, specific targets for climate-neutral, and low-carbon gases should be established in the Renewable Energy Directive, so as to stimulate investments in the development of these technologies and their associated infrastructure.
- **Low-carbon technologies in the transport sector.** Decarbonising the transport sector is also a topic that has been frequently mentioned by the respondents. The key comments are:
  - respondents are against the notion of promoting low-carbon technologies in the transport sector, even in hard-to-abate sectors such as in maritime and aviation sectors;
  - respondents are supportive of the use of low-carbon fuels to decarbonise the transport sector, which represents almost a quarter of Europe's greenhouse gas emissions. The rapid decarbonisation of the sector would be essential for EU to meet its 2030 climate targets. While the development and promotion of carbon-neutral energy technologies in the transport sector are important, the widespread rate of deployment of these technologies will need a longer time. Most of the existing fleet of road vehicles will continue to be running with combustion engines in the foreseeable future. Therefore, the adoption of low-carbon fuels can be readily applied to the existing vehicle fleet, and help to expedite the decarbonisation of the transport sector. Further, the use of such low-carbon options can already contribute to reducing emissions of air pollutants, thus improving air quality in a shorter-time frame. A clear roadmap could provide clarity on the deployment and application of these sustainably produced low-carbon fuels.
- **Coherence with other pieces of legislation.** The revision of the Renewable Energy Directive should also be in accordance with other relevant EU legislations, such as the Energy Efficiency Directive, the Energy Performance in Buildings Directive, the Fuel Quality Directive, the Alternative Fuels Infrastructure Directive etc. The revision of other directives, such as the Energy Taxation Directive, should also be considered, to ensure consistency in achieving the end goal.
- **Leverage on market-based mechanisms.** In order to achieve the decarbonisation goals in the most cost-effective way, market-based instruments should be used to incentivise abatement actions. This includes the application of carbon taxes, and leveraging on the existing system of the EU Emissions Trading System (ETS).
- **Internal Market.** The EU should strengthen the coherence of the internal market, and improve cooperation mechanisms between Member States in order to provide a clear framework for cooperation, for issues including shared governance and shared infrastructure. This can improve the effectiveness and cost-efficiency in achieving rapid decarbonisation.
- **Legislative and administrative barriers** and burdens should be minimized in order to accelerate the development of renewable and low-carbon technologies. This includes aspects such as permitting and licensing, and the establishment of cross-border and/or multi-stakeholder Power Purchase Agreements.

Q1.4 Which sectors would require additional efforts to achieve a potentially higher renewables target for 2030?

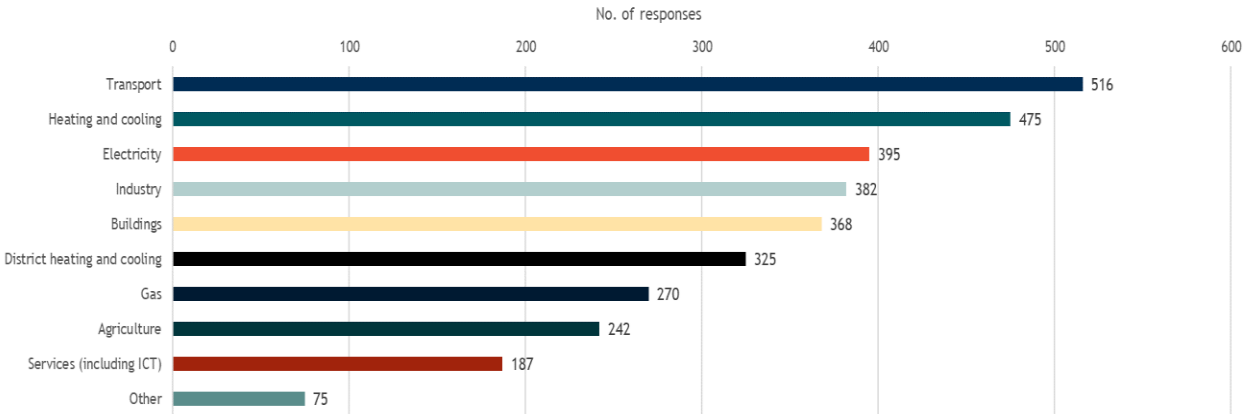
Q1.4 received a total of 3,226 responses from 661 respondents (multiple answers possible). Respondents could select multiple answers from the following ten sectors:

A. Electricity;
B. Gas;
C. Heating and cooling;
D. District heating and cooling;
E. Buildings;
F. Services (including ICT);
G. Industry;
H. Transport;
I. Agriculture;
J. Other.

On average, participants selected 5 options.

In Figure 3-4, the responses are ranked from most popular to least popular. *Transport* sector ranks first in the list (516 responses), followed by the *heating and cooling* sector (475 responses), and *electricity* sector (395 responses). The *buildings* sector (368 responses), which account for 40% of Europe's energy consumption, ranks fifth. *Services (including ICT)* (187 responses) ranks last among the sectors. 75 participants chose a sector not listed (*other*).

Figure 3-4 Which sectors would require additional efforts to achieve a potentially higher renewables target for 2030. (n=661; 3,226 responses)



Transport, *heating and cooling*, and the *electricity* sectors have been ranked as the top three sectors across most stakeholder types (Table 3-6 percentages are in terms of total responses, *not* participants). Respondents representing academic and research institutions ranked *heating and cooling sector* (C) as the first, followed by both *buildings* (D) and *transport* (H) as the most important. As the *heating and cooling* sector is also closely related to the building sector, it highlights their view on the need to address heating and cooling performance of buildings, followed by that of the *transport* sector. The *heating and cooling* (C) sector was frequently chosen also by NGOs/environmental organisations, trade unions and those identifying as *other* organisation.

Table 3-6 Stakeholder correlation analysis for Q1.4

	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)
As an individual in a personal capacity	13% (51)	5% (19)	16% (62)	9% (37)	12% (48)	6% (23)	13% (51)	15% (58)	10% (41)	3% (10)
In a professional capacity or on behalf of an organisation	12% (344)	9% (251)	15% (413)	10% (288)	11% (320)	6% (163)	12% (329)	16% (455)	7% (199)	2% (64)
Of which:										
Academic/ research institution	10% (6)	10% (6)	22% (13)	7% (4)	15% (9)	5% (3)	8% (5)	15% (9)	7% (4)	2% (1)
Business organisation	12% (235)	10% (202)	14% (277)	9% (182)	11% (208)	5% (96)	12% (232)	17% (330)	7% (128)	2% (43)
Consumer organisation	12% (5)	7% (3)	12% (5)	12% (5)	10% (4)	7% (3)	7% (3)	19% (8)	10% (4)	5% (2)
NGO/ environmental organisation	13% (68)	4% (19)	15% (80)	13% (68)	12% (65)	9% (49)	11% (60)	13% (69)	9% (48)	2% (11)
Public authority	11% (13)	10% (12)	14% (16)	11% (13)	11% (13)	5% (6)	12% (14)	17% (20)	7% (8)	3% (3)
Trade union	14% (2)	7% (1)	21% (3)	7% (1)	7% (1)	0% (0)	21% (3)	14% (2)	0% (0)	7% (1)
Other	12% (15)	7% (8)	16% (19)	12% (15)	16% (20)	5% (6)	10% (12)	14% (17)	6% (7)	2% (3)

Table 3-7 Summary of results from Q1.4.1

Summary of results from Q1.4.1, open-ended question concerning Q1.4, where participants were asked to specify in which sectors they think additional efforts to increase the use of renewable energy are most needed for a potentially higher renewables target for 2030.
In total, Q1.4.1 received 212 responses of which 12 are not unique. Participants were primarily business organisations (135 responses), NGOs (39 responses), and EU citizens (17 responses). Other stakeholder groups responded in smaller frequencies ranging from 1 to 7 responses. The main messages from the analysis are summarised below. **Sectors** The key sectors that were mentioned are the transport sector including aviation and maritime sectors (~15%), heating and cooling sector (~7%), agriculture sector (~5%), which includes non-road mobile machineries. In fewer numbers (less than 5%) participants mentioned the telecommunications sector and the service sector (<1%). In general, participants suggest sectors that are not included in the EU Emissions Trading System (ETS). For the heating and cooling sector, a group of 17 coordinated responses representing EU citizens, business organisations, environmental organisations, public authority and others highlighted the need to make reduction in energy demand a priority, followed by the use of other renewable energy technologies excluding biomass. About 5% of respondents emphasized that *all sectors* would need to decarbonise rapidly in order to meet the raised climate targets for 2030. In addition, electrification across sectors is also seen as an important factor to increase the share of renewable energy in the energy mix, and to support energy efficiency. **Energy technologies** Some of the energy technologies that were mentioned more often by the respondents includes renewable and low-carbon technologies (including gases) (~7%) and bioenergy (~4%). Participants also suggested: Power-to-X, nuclear, including small modular reactors (SMRs), energy storage, heat pumps, hydroelectric energy, pyro-gasification, renewable molecules, solar heat, and geothermal. A group of six coordinated responses representing EU citizens, business associations and NGOs raised concerns on the use of particular energy technologies, relating to the environmental damage arising from the construction of new hydropower facilities, and the use of biomass in heating and cooling systems. **Others** • Respondents also mentioned the need for the Renewable Energy Directive to be technology neutral, where all renewable energy should be supported equally in order to reach the 2030 targets. The responses provided include a mix of sectors and energy technologies; • While not related to any particular sector or energy technologies, respondents also suggested other measures which could be relevant. These include increasing demand-side management, energy efficiency measures, modal shifts, reducing overall energy demand and consumption, and the need to establish a strong, integrated renewable energy network across sectors.

Table 3-8 Summary of results from Q1.5

Summary of results from Q1.5, open question where participants were asked if they see scope for simplifying RED II or reducing regulatory burdens, including administrative burdens.
In total, Q1.5 received 396 responses of which 25 are not unique. Participants were primarily business organisations (280 responses), NGOs (40 responses) and EU citizens (35 responses). Other stakeholder groups responded in smaller frequencies ranging from 1 to 15 responses. The main messages from the analysis are summarised below. **Simplify and shortening permitting and administrative procedures— Article 15 & 16 (~10% of respondents)** The removal of permitting and administrative barriers to achieving the renewable energy targets. While provisions are currently available in Article 15, they should be reviewed and strengthened to remove unnecessary administrative barriers and burdens, such as permitting procedures for demonstration projects, renewable energy communities (RECs) and repowering plants, the retention and retirement of Guarantees of Origin (GOs) and for cross-border and multi-party Power Purchasing Agreements (PPAs). Shortening these procedures could help to promote investments and to expedite the realisation of clean energy projects. Some general suggestions include: • Fixing a maximum duration for the processing time of permits; • Ensuring clarity and transparency on the conditions for approving permits; • Setting up of one-stop shops in each Member State to provide advice and process permits; • Digitalising of these procedures to enhance efficiency, and improve the resilience of the administrative processes against threats such as in a pandemic situation; • Increasing the volume of competent manpower working on these permitting and administrative procedures; • Sharing of best practices amongst Member States, where bottlenecks are often experienced. Suggestions for specific elements were also received: • **On GOs**: The establishment of a single market for GOs that is regulated at the EU level could promote consistency, quality and accountability across the EU, and would also help to overcome the differences which exist between different market regulations between Member States, although double counting should be avoided. The creation of a robust and transparent system can reduce barriers for companies; • **On RECs:** More efforts can be taken to support RECs by reducing administrative burdens for them to obtain grid connection and to participate in auctions and tenders. Procedures for planning and

Summary of results from Q1.5, open question where participants were asked if they see scope for simplifying RED II or reducing regulatory burdens, including administrative burdens.

permitting procedures, and to gain access to funding, could be simplified. Basic service standards for grid operators to follow-up with grid connection requests within a stipulated time period can also be established. Further barriers to RECs should be removed, such as the administrative burdens between landlords and tenants, as well as a review of the taxation for the production and consumption of renewable energy produced on-site. A provision of one-stop shops to support RECs could be useful to assist them in overcoming these barriers, and to ensure basic service delivery standards are met.

Establish transparency criteria and definitions—developing an EU taxonomy for renewable energy technologies and calculation formulas (~3% of respondents)

The creation of a European taxonomy for renewable energy carriers and technologies based on life-cycle assessment principles, and databases on the life-cycle greenhouse gas calculations would provide clarity and greater transparency, minimize administrative burdens, and could help expedite the certification processes. This view was also shared by five coordinated responses representing business organisations. Further, suggestions were made for the EU to provide a list of default values of the life-cycle greenhouse gases emission savings for the different energy carriers and technologies. This could help to overcome heavy administrative burdens which may arise due to the lack of standardized calculation formulas, and a lack of quality data is expected to create heavy administrative burdens.

Harmonising of EU legislations (~2% of respondents)

About 2% of respondents commented that the review of the Renewable Energy Directive should also include the harmonising of the Renewable Energy Directive with other pieces of EU legislation. This would entail streamlining of procedures and removal of any overlaps between the Renewable Energy Directive and other directives including the Energy Efficiency Directive and the Fuel Quality Directive. This could not only provide clarity, but also reduce administrative burdens on companies. Additionally, there could also be interactions between the different EU legislations, which would require additional clarity, such as the treatment of waste heat, and the link between Article 24(1) of the Renewable Energy Directive and Annex VIIa(3) in the Energy Efficiency Directive (EU) 2018/2002 regarding the required information provided in energy bills. There should also be greater clarity and harmonisation regarding the assessment and planning for heating and cooling (also covered across multiple directives, such as the Energy Efficiency Directive, Energy Performance of Buildings Directive and the Renewable Energy Directive).

Article 27, Recital 90(3) (~2% of respondents)

The four conditions, namely, renewable origin, additionality, geographical and temporal correlation could potentially impose barriers to the ramp-up of synthetic fuels and of hydrogen.

- **On the condition of 'renewable origin'**
  Some respondents, including a coordinated group of three responses, opine that power purchase agreements (PPAs) and Guarantees of Origin (GOs) should be sufficient to ensure that the energy is produced from renewable sources.
- **On the condition of 'additionality'**
  While 'additionality' is highly relevant for the goal of increasing the uptake of renewables, this could also be discriminatory and counter-productive, for example, in the case of electrolysers. Investors are disincentivised by this criterion as the energy consumed by the electrolysers can only be obtained from additional energy production capacities that are built—which often takes a longer time to construct than electrolysers. This can undermine the transition to clean and renewable energy.
- **On the conditions of geographical and temporal correlation**
  These conditions would likely have little effectiveness in increasing the share of renewables in the energy mix. These restrictions may also disincentivise private investments in the renewable energy sector, and obstruct the ramping up of additional renewable electricity capacities and energy storage infrastructure.

Minimize changes concerning bioenergy (~2% of respondents)

Further changes to the requirements concerning bioenergy would lead to additional administrative burdens and create uncertainty amongst investors, and should therefore be minimized. The sustainability criteria, which have been established after an extensive discussion, should be given time to prove their effectiveness. With regards to Annex IX, some stakeholders were of the view that the list should be removed, and that the application of the sustainability criteria and greenhouse gas emission savings system should be sufficient, while others called for an expansion of the list to include other feedstock types. The need to minimize changes to all Articles concerning bioenergy has been highlighted by two sets of coordinated responses, accounting for 15 responses in total, representing companies, business associations, environmental groups, and NGOs.

Other

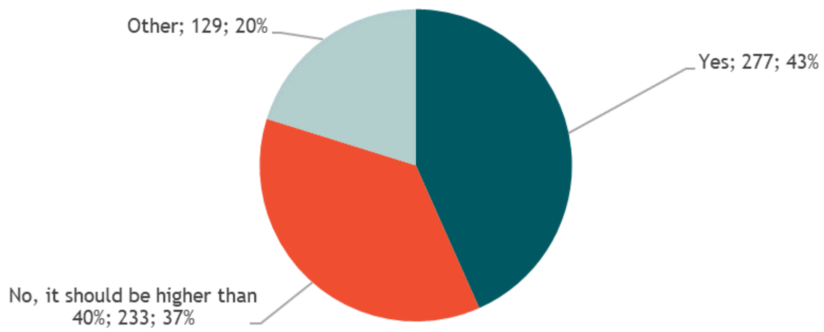
- The application of multiplication factors may be counterproductive and slow down the possibility to increase actual renewable energy deployment, especially for the transport sector. Further, multiplication factors provide preferential treatment for certain energy technologies. In addition, this may also lead to additional administrative burdens;
- The establishment of a transparent process and criteria of approving grid access, for example by setting a hierarchy for prioritisation of grid access allocation based on the benefits it could bring to the energy system, could be an option to expedite the transition to renewable energy in a cost-effective way;
- Clarification of Article 30 regarding the concept of mass balancing is required, especially for energy carriers such as bio-LNG and liquid synthetic methane, taking into consideration their logistical requirements. Further, about 1% of respondents are of the view that the European gas infrastructure

Summary of results from Q1.5, open question where participants were asked if they see scope for simplifying RED II or reducing regulatory burdens, including administrative burdens.
system should be considered as one single logistical facility so as to incentivise cross-border trade of sustainable gas; • A group of four coordinated responses representing business associations and companies also mentioned the need for clarification on how Articles 28 and 29 should be applied in Article 3(3) of RED II; • Regarding the introduction of a greenhouse gas emission reduction system to decarbonise the transport sector, a group of nine coordinated responses was received to request for retention of the existing renewable energy obligation instead.

Q1.6 Do you think the level of the 2030 Union target for renewable energy should be raised within the range indicated in the 2030 Climate Target Plan (38 - 40%)?

Q1.6 received a total of 639 responses (Figure 3-5). 43% of participants agree that the 2030 Union target for renewable energy should be raised to match the ambition in the 2030 Climate Target Plan of achieving 38-40% of renewables in the gross final energy consumption. 36% of the respondents indicated that the 2030 Union target should go beyond 40%. 20% of the Participants chose *other*.

Figure 3-5 Do you think the level of the 2030 Union target for renewable energy should be raised within the range indicated in the 2030 Climate Target Plan (38 - 40%)? (n=639)



There is also a difference in opinion between participants who have responded in their personal capacities and those who have done so in a professional capacity or on behalf of an organisation (Table 3-9). Many individuals think that the 2030 Union target should be raised higher than the 38-40% in the 2030 Climate Target Plan (48%). Whereas, among those responding in a professional capacity, most think that it should be raised within the 2030 Climate Target Plan range (44%). However, this does not apply to those responding for environmental and non-governmental organisations. From these stakeholder types, most participants prefer the target to be higher than 40%.

Table 3-9 Stakeholder correlation analysis for Q1.6

	Yes	No, it should be higher	Other
	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	37% (31)	48% (40)	14% (12)
In a professional capacity or on behalf of an organisation	44% (246)	35% (193)	21% (117)
Of which:			
Academic/research institution	50% (7)	36% (5)	14% (2)
Business organisation	49% (192)	30% (116)	21% (84)
Consumer organisation	50% (4)	0% (0)	50% (4)
NGO/environmental organisation	17% (15)	70% (62)	13% (12)
Public authority	42% (10)	29% (7)	29% (7)
Trade union	60% (3)	20% (1)	20% (1)
Other	63% (15)	8% (2)	29% (7)

Table 3-10 Summary of results from Q1.6.1

Summary of results from Q1.6.1, open-ended question concerning Q1.6, where participants were asked to specify if they think the level of the 2030 Union target for renewable energy should be raised within the range indicated in the 2030 Climate Target Plan (38 - 40%).

In total, Q1.6.1 received 122 responses of which 3 are not unique. Participants were primarily business organisations (80 responses), NGOs (12 responses) and EU citizens (11 responses). Other stakeholder groups responded in smaller frequencies ranging from 1 to 6 responses. The main messages from the analysis are summarised below.

Opinions on renewable energy technologies (~20% of respondents)

Approximately 19% of respondents provided comments on renewable energy technologies. About 7% of respondents are positive about the potential of renewable and low-carbon gases to achieve the decarbonisation targets, and are therefore in favour of raising the 2030 Union target for renewable energy. The suggestion to set binding targets for renewable and low-carbon gases has also been raised. Another group of respondents representing business associations and NGOs (~7%) mentioned explicitly against the use of biomass, or cautioned against raising the targets which could lead to a rapid increase in biomass demand and/or usage. This could not only cause a strain on the environment but also on the other hand, about 5% of respondents hold the view that maintaining technology neutrality would be necessary to achieve the greenhouse gas emission reduction targets. In addition, it would also allow flexibility for regions and Member States to develop a pathway which can take into consideration the level of market maturity for different renewable energy sub-sectors and the local economic capabilities.

Need for an impact assessment (~10% of respondents)

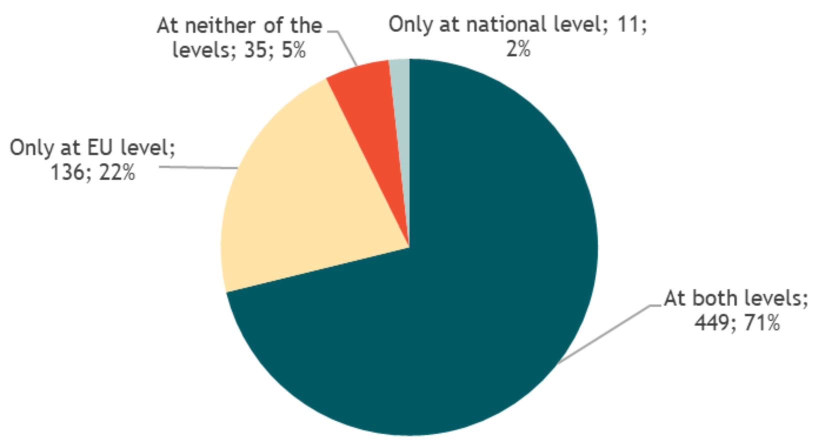
Decisions concerning overall level of ambition should be made only after an impact assessment has been completed. Thorough assessments on the achievability of set targets, the potentials that are available per sector would be necessary before making a decision on the revision of targets. In addition, it would also be important to assess the impacts of raising the 2030 Union target at the Member States level, to better understand the possible impact on their national energy systems and the effect on its economy. Nonetheless, about 5% of respondents indicated that binding targets should be placed at the Member State level, while others suggested more flexibility for Member States to make a decision on their targets.

Summary of results from Q1.6.1, open-ended question concerning Q1.6, where participants were asked to specify if they think the level of the 2030 Union target for renewable energy should be raised within the range indicated in the 2030 Climate Target Plan (38 - 40%).
Set reduction targets based on greenhouse gas emission instead (~10% of respondents) The main overarching goal is to reduce greenhouse gas emissions. Therefore, it would be more appropriate to shift the focus to increasing the ambitions and targets for the reduction of greenhouse gases rather than setting sector-specific renewable targets. Putting targets on renewable energy sources and technology may lead to dilemmas between them, which may impede the achievement of climate neutrality. **Use market-based mechanisms (~10% of respondents)** Rather than raising the renewable energy target, some respondents support the use of market-based mechanisms, such as EU Emissions Trading System (ETS), and carbon pricing for non-ETS sectors instead. Increasing the ambition of the EU ETS could also help achieve renewable energy targets in a cost-effective way. **Energy efficiency first principle (~5% of respondents)** Respondents across various stakeholder groups also highlight the importance on pursuing energy efficiency alongside the strategies to increase the renewable share. **Other** • Raising these targets could also exacerbate Issues of carbon leakage, an area which is not sufficiently addressed in the Renewable Energy Directive; • Considerations for the costs that would ultimately be borne by energy consumers must be given, as the support of EU citizens for the energy transition is also essential; • At the EU level, the focus should be placed on reviewing the NECPs, remove existing barriers and provide support to Member States to fully implement their plans.

Q1.7 Should the overall renewable target be binding at EU level or at national level?

Q1.7 received a total of 631 responses (Figure 3-6). Respondents could select one from four options: *at both levels*, *only EU level*, *only at national level* or *at neither level*. The majority of respondents (449 responses, 71%) think that the overall renewable target should be binding at both the EU level, as well as at the national level. 22% of respondents believe that the target should binding only at the EU level. 2% of the respondents think it should be binding at the national level. 6% of the respondents think it should not be binding at either level.

Figure 3-6 Should the overall renewable target be binding at EU level or at national level? (n=631)



Across all stakeholder types, most respondents believe that the overall renewable target should be binding at both levels (Table 3-11). This consensus is highest amongst EU/Non-EU citizens (87%) and NGOs (87%).

Table 3-11 Stakeholder correlation analysis for Q1.7

	At both levels	Only at EU level	At neither of the levels	Only at national level
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	87% (75)	5% (4)	6% (5)	2% (2)
In a professional capacity or on behalf of an organisation	69% (374)	24% (132)	6% (30)	2% (9)
Of which:				
Academic/research institution	*64% (9)*	*21% (3)*	*7% (1)*	*7% (1)*
Business organisation	*64% (246)*	*29% (110)*	*6% (22)*	*2% (6)*
Consumer organisation	*75% (6)*	*25% (2)*	*0% (0)*	*0% (0)*
NGO/environmental organisation	*87% (79)*	*10% (9)*	*3% (3)*	*0% (0)*
Public authority	*67% (16)*	*17% (4)*	*13% (3)*	*4% (1)*
Trade union	*80% (4)*	*0% (0)*	*20% (1)*	*0% (0)*
Other	*74% (14)*	*21% (4)*	*0% (0)*	*5% (1)*

Section II - Technical questions on Transversal Energy System Integration Enablers

Section II included a total of 11 main questions, plus additional open questions.

Analysis of responses received for Section II

Q2.1 How important do you consider the following measures to build a more integrated energy system?

Q2.1 asked respondents to rate the importance of ten measures along a four point scale. In Figure 3-7, the measures are ranked from most important to least important, based on the combined percentage of *very important* and *important* responses. More than 90% of respondents think that the *accelerating the use of renewable energy in buildings* and *accelerating digitalisation in the energy system* are *(very) appropriate* to build a more integrated energy system.

Figure 3-7 How important do you consider the following measures to build a more integrated energy system?

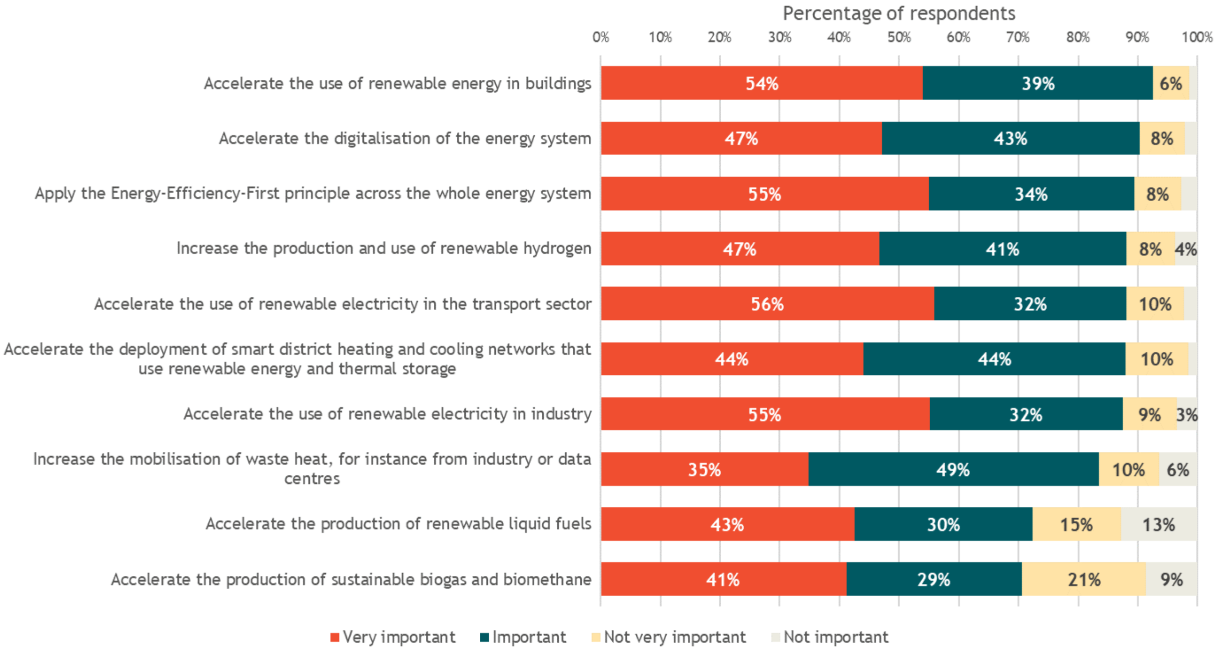


Table 3-12 Summary of results from Q2.1.1

Summary of results from Q2.1.1, an open-ended question concerning Q2.1, where participants were asked to specify any other views or ideas related to the use of renewables that could contribute to building a more integrated energy system.
In total, Q2.1.1 received 391 responses, of which 18 are not unique. Responses are primarily from business organisations (266 responses), NGOs (48 responses) and EU citizens (33 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-14 responses. The main messages from the analysis are summarised below. **Scale up renewables and low carbon technologies (~20% of respondents)** Stakeholders stress the utility for the energy system of scaling renewables and low-carbon energy for hydrogen, synthetic fuels, power-to-x, e-fuels. They debate the role to be played by bioenergy, where proponents emphasize, for example, the need for it as a transition fuel, while opponents are sceptic about the overall climate impact. **Smart technologies and digitalisation (~20% of respondents)** Stakeholders state accelerating the digitalisation of the energy system should be a priority. Deploying smart metering systems for gas and electricity has many benefits, including energy efficiency, consumer empowerment and network management. **Technology neutrality and market-based solutions (~15% of respondents)** Stakeholders back a technology neutral approach and the use of market-based instruments (ETS, carbon taxation). Through a coordinated response from 7 business stakeholders, carbon pricing is a favoured method due to cost-effectiveness and for treating technologies neutrally. Some stakeholders say bioenergy does not fit into the technology neutral approach enshrined in RED. **Local, flexible, and decentralised energy system integration (~15% of respondents)** Stakeholders emphasize how the development of local flexibility markets will play an important complementary role to organised markets. Some stakeholders suggest network operators should have a decreasing role in generation, storage, conversion, distribution, load management and system services. **Energy efficiency first principle (~5% of respondents)** Scaling renewables is often discussed by stakeholders together with the energy efficiency first principle. The idea of an energy hierarchy tailored to the local context is proposed which can reduce goal conflicts, generally with efficiency at the top followed by recycling of waste heat, wind/solar, other renewables and low carbon energy, fossil fuels. A coordinated group of 5 business stakeholders argue the energy efficiency first principle can help advance a more circular energy system. **Ocean energy should be scaled up (~5% of respondents)**

Summary of results from Q2.1.1, an open-ended question concerning Q2.1, where participants were asked to specify any other views or ideas related to the use of renewables that could contribute to building a more integrated energy system.
A coordinated group of 12 business stakeholders argue flexible renewable energy such as ocean energy is cost-effective and should be scaled up now as it will be an important addition to the European grid beyond 2030. **Other suggestions (<5% of respondents)** A coordinated group of 5 NGO stakeholders state direct electrification is key and only hard-to-abate sectors (including steel and chemicals industries, aviation, long-distance shipping and heavy-duty transport) should rely on e.g., hydrogen from surplus electricity generation. Another coordinated group of 5 NGO stakeholders say hydrogen from waste-to-energy plants should not be regarded renewable as incinerated waste largely have fossil origins, which may threaten the circular economy.

Q2.2 How do you think the energy efficiency first principle should be reflected in the Renewable Energy Directive?

Q2.2 asked respondents to rate the appropriateness of nine suggestions along a four point scale. In Figure 3-8, the suggestions are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. Reuse of waste heat is rated the most appropriate option, but *prioritising the use of available renewable energy carriers in those end use sectors where they have the greatest decarbonisation impact for each unit of energy consumed* is the option that received the higher share of *very appropriate*. Notably, although not the highest ranking suggestion, prioritising the RE carriers with the greatest decarbonisation impact was ranked *very appropriate* by 58% of the participants.

Figure 3-8 How do you think the energy efficiency first principle should be reflected in the Renewable Energy Directive?

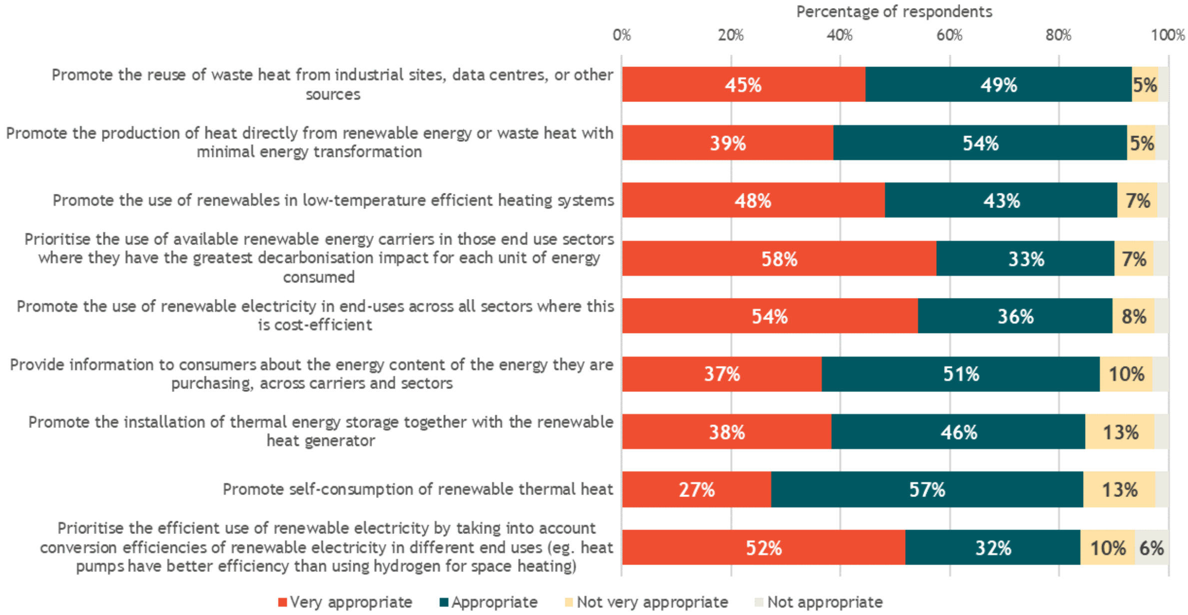


Table 3-13 Summary of results from Q2.2.1

Summary of results from Q2.2.1, an open-ended question concerning Q2.2, where participants were asked to specify other ways in which the energy efficiency first principle should be reflected in the Renewable Energy Directive.
In total, Q2.2.1 received 239 responses, of which 20 are not unique. Responses are primarily from business organisations (148 responses), NGOs (40 responses) and EU citizens (10 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-12 responses. The main messages from the analysis are summarised below. **Technology neutrality and market-based solutions (~25% of respondents)** Stakeholders, including 5 coordinated business stakeholders, suggest all low carbon energy sources that can drive emission reduction should be promoted according to the technology neutrality principle and regardless of their specific use (i.e., as energy carrier or as reducing agent). Another group of 9 coordinated business stakeholders argue energy efficiency measures should be decided by the market actors and consumers, while following prioritised policy at Member State level. Others say regulators should be careful to rank renewable energy technologies based on efficiency, and instead focus on system efficiency. Markets can steer towards most efficient practices given the right price signals. **Apply principle to efficiency prone technologies (~15% of respondents)** Stakeholders mention specific technologies RED can support via the energy efficiency principle, including but not limited to EV batteries for transport, combined heat and power, and district heating and cooling - all relatively efficient technologies. This includes a group of 9 coordinated responses from business stakeholders that strongly support investments in district heating and combined heat and power. **Biomass is at edge with efficiency principle (~15% of respondents)** Stakeholders mention that biomass is inefficient relative to other technologies, and as such regulators should take this into account when renewing RED. **Direct electrification (~10% of respondents)** Stakeholders suggest the principle should boost direct electrification (especially transport) since this is more efficient than converting electricity into other carriers. Yet, stakeholders emphasize direct electrification should not be at the expense of other technologies such hydrogen, as they have storage and transport benefits. **Decentralised and local application of principle (~10% of respondents)** Energy efficiency should be fostered through decentralised sources of flexibility, instead of network expansion. The principle should promote heating and cooling measures which can be leveraged also for power system efficiency such as heat pumps with thermal storage for demand response. Moreover, Member States have different conditions, and the principle should not limit their opportunities on how to meet objectives. **Other suggestions (<5% of respondents)**

Summary of results from Q2.2.1, an open-ended question concerning Q2.2, where participants were asked to specify other ways in which the energy efficiency first principle should be reflected in the Renewable Energy Directive.
• 5 coordinated business stakeholders suggest emission reduction in the steel sector are only possible with the roll out of breakthrough technologies including steel recycling, CCUS, process integration, and electricity/hydrogen-based metallurgy; • 5 coordinated NGO stakeholders argue energy efficiency brings a variety of benefits, e.g., reduced GHG emissions, increased renewable energy share in the energy mix, reduced demand for imports, and cost reduction; • 6 coordinated business/NGO stakeholders suggest renewable gases will remain a scarce and/or scarce resource and that only hard-to-abate sectors such as steel and chemicals, aviation, long-distance shipping, and heavy-duty road transport could partly rely on non-fossil gases; • 4 coordinated NGO stakeholders argue reduced energy consumption is vital to reach the 1.5 degrees target in the Paris Agreement, and which requires efforts targeting community and citizen engagement.

Q2.3 How appropriate do you think the following measures would be in supporting the electrification of energy consumption?

Q2.3 asked respondents to rate the appropriateness of ten measures along a four point scale. In Figure 3-9, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. Although aligning taxation of energy products/electricity with EU Climate and Energy Policy goals is not ranked as the most appropriate, 57% of participants think that this measure is *very appropriate*.

Figure 3-9 How appropriate do you think the following measures would be in supporting the electrification of energy consumption?

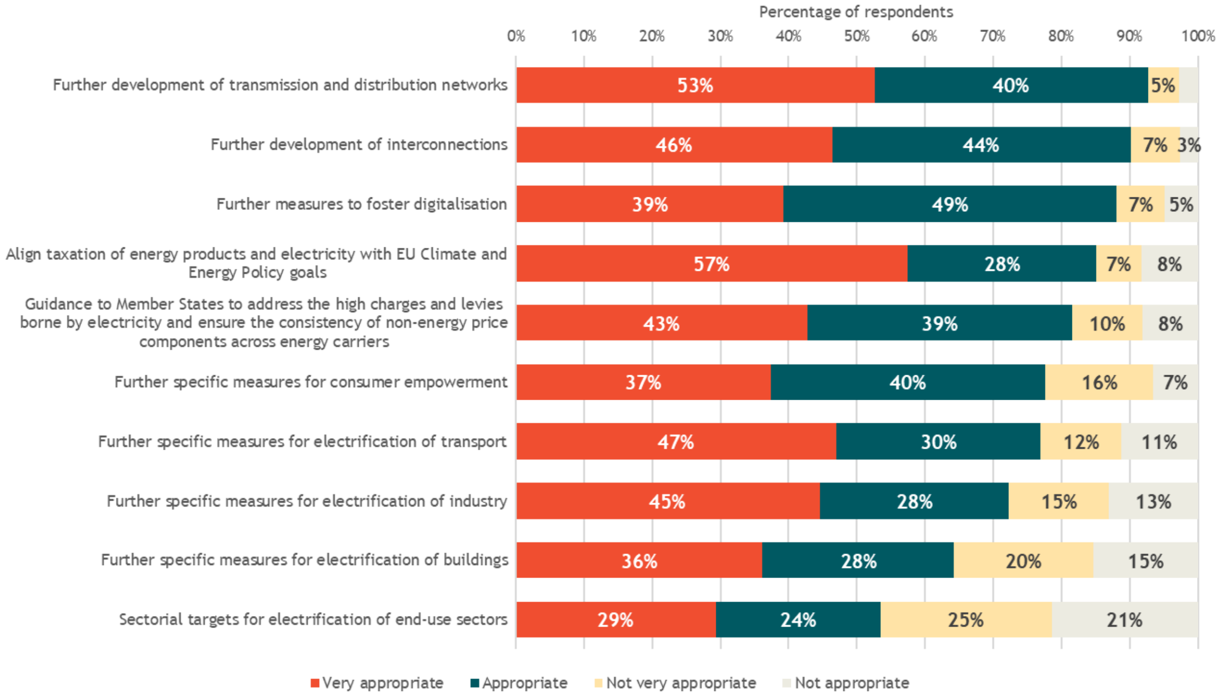


Table 3-14 Summary of results from Q2.3.1

Summary of results from Q2.3.1, an open ended question concerning Q2.3, where participants were asked to specify other appropriate measures to support the electrification of energy consumption.
In total, Q2.3.1 received 297 responses, of which 18 are not unique. Responses are primarily from business organisations (207 responses), NGOs (44 responses) and EU citizens (16 responses). Other stakeholder groups responded in much smaller frequencies ranging from 1-11 responses. The main messages from the analysis are summarised below. **Measures should support system efficiency (~40% of respondents)** Stakeholders suggest steering towards energy efficiency at system level, which includes focusing on storage systems and the development of grid infrastructure to manage an evolving electricity system with greater attention to smart grids at local level. **Need to strengthen capacity of transmission and distribution (~25% of respondents)** Electricity transmission and distribution networks are the backbone of Europe's energy system. To support electrification, stakeholders see it vital to increase their capacity. 5 coordinated NGO stakeholders argue for a wider focus on investments in electricity transmission and distribution networks beyond just interconnections, to ensure that the grid functions effectively and guarantees security of supply for a more decentralised electricity system. Investments should be directed towards new points of supply from prosumerism, scaling of storage facilities and demand control measures. Another group of 7 coordinated NGO stakeholders argue for further development of interconnections, demand side response and storage solutions (including heat storage), and that there has been a too dominant focus on interconnections and expansion of networks in energy infrastructure planning. **Foster demand-side response and harness local and decentralised solutions (~25% of respondents)** Stakeholders suggest measures should support demand-side response, with a particular focus on local storage and innovations for energy system flexibility.

Summary of results from Q2.3.1, an open ended question concerning Q2.3, where participants were asked to specify other appropriate measures to support the electrification of energy consumption.

Carbon pricing to level the technology playing field (~20% of respondents)

Market-based solutions (ETS, taxation) should ensure that all energy carriers are treated equally and should apply to all sectors to avoid the need for dedicated sub-targets in individual sectors.

Scale up flexible renewable energy (~5% of respondents)

A coordinated group of 9 business stakeholders argue for the creation of routes to market for flexible renewables to ensure greater renewables penetration post 2030.

Other suggestions (<5% of respondents)

7 coordinated business stakeholders suggest a broad portfolio of technologies is imperative for sustainable electrified transport (including the production and recycling of batteries, and biofuels) and the need to go beyond a sole focus on e-mobility which could be counterproductive to achieve climate goals.

5 coordinated NGO stakeholders argue bioenergy leads to high external costs notably due to GHG emissions, air pollution and related health costs. Bioenergy external costs should be priced in rather than receiving support through national schemes or through tax exemptions in the Energy Taxation Directive.

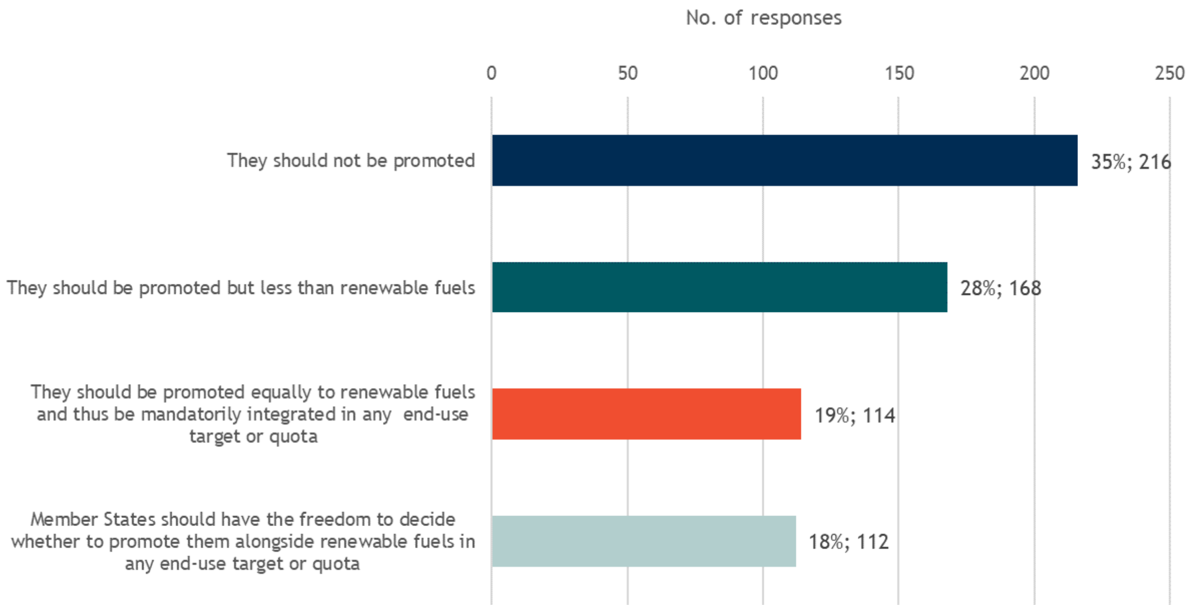
5 coordinated NGO stakeholders suggest CO2 standards for cars and trucks are highly effective and should be further increased to help bring zero-emission cars and trucks to the market. They also suggest a revision of the Alternative Fuels Infrastructure Directive to accelerate the deployment of publicly accessible recharging points and the charging infrastructure for electric vehicles. In the RED, fuel suppliers should be enabled, via an accounting/crediting mechanism at EU level regarding the renewable electricity share in the electricity mix, to meet renewable transport fuel targets.

5 coordinated business stakeholders suggest emission reduction in the steel sector are only possible with the roll out of breakthrough technologies including steel recycling, CCUS, process integration, and electricity/hydrogen-based metallurgy. To drive the electrification of some production processes stakeholders are in favour of improved compensation of indirect costs under the EU ETS, extended exemptions for energy intensive sectors from renewable levies and other regulatory costs under the Environmental and Energy Aid Guidelines, and carbon contracts for difference.

Q2.4 How do you consider that “low-carbon” fuels that are not renewable but provide significant GHG emissions reduction compared to fossil fuels, such as non-renewable hydrogen and synthetic fuels with significantly reduced full life-cycle greenhouse gas?

Q2.4 received a total of 610 responses (Figure 3-10). Overall, there is some hesitancy to promote non-renewable “low-carbon” fuels. 35% of the respondent think that they should not be promoted and 28% believe that they should be promoted but less than renewable fuels. 19% believe they should be promoted equally to renewable fuels. 18% think that Member States should make this decision independently.

Figure 3-10 How do you consider that "low-carbon" fuels that are not renewable but provide significant GHG emissions reduction compared to fossil fuels, such as non-renewable hydrogen and synthetic fuels with significantly reduced full life-cycle greenhouse gas (n=610)



The response amongst different stakeholders varies greatly (Table 3-15). Those responding as a citizen, consumer organisation or NGO/environmental organisation, tend to think that non-renewable low-carbon fuels should not be promoted.

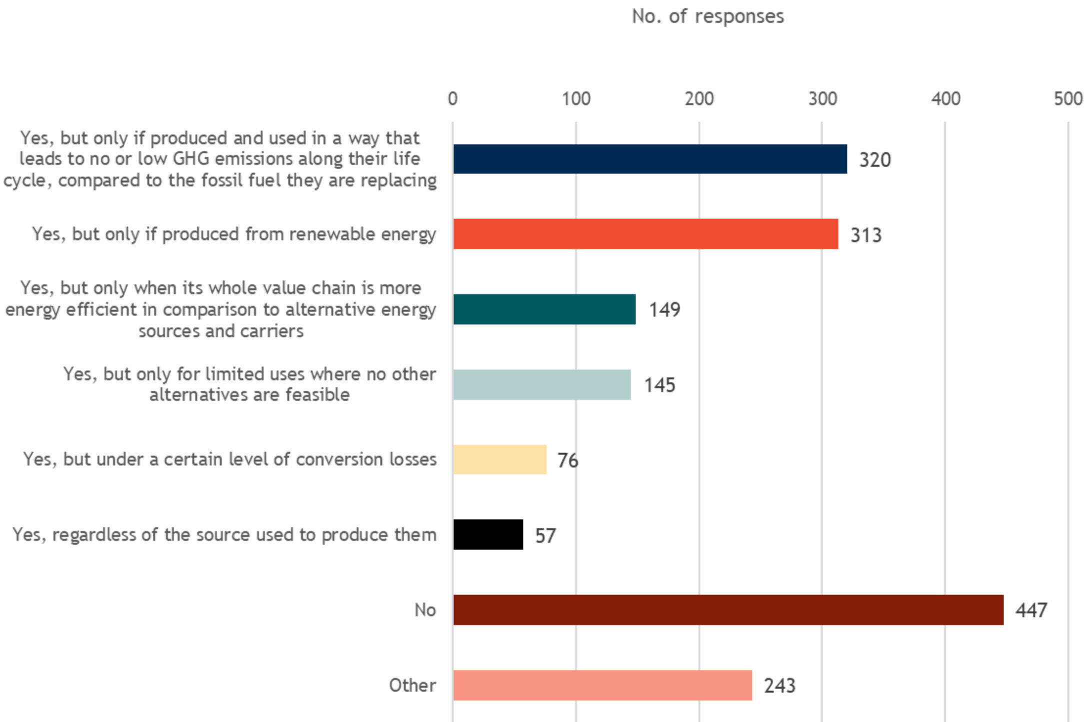
Table 3-15 Stakeholder correlation analysis for Q2.4

	Should promoted equally to renewable fuels	Should promoted but less than renewable fuels	Up to Member States to decide	Should not be promoted
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	7% (6)	31% (26)	13% (11)	48% (40)
In a professional capacity or on behalf of an organisation	20% (108)	27% (142)	19% (101)	33% (176)
Of which:				
Academic/research institution	*31% (4)*	*38% (5)*	*15% (2)*	*15% (2)*
Business organisation	*24% (91)*	*30% (117)*	*20% (77)*	*26% (102)*
Consumer organisation	*17% (1)*	*33% (2)*	*17% (1)*	*33% (2)*
NGO/environmental organisation	*8% (6)*	*9% (7)*	*8% (6)*	*76% (59)*
Public authority	*8% (2)*	*24% (6)*	*36% (9)*	*32% (8)*
Trade union	*0% (0)*	*0% (0)*	*67% (2)*	*33% (1)*
Other	*27% (4)*	*33% (5)*	*27% (4)*	*13% (2)*

Q2.5 Do you think the use of hydrogen and e-fuels produced from hydrogen should be encouraged (multiple answers possible)?

Q2.5 received 1750 responses from 641 participants (multiple answers possible). Participants could choose from eight options, and they responded with about 2.7 responses on average. Figure 3-11 presents the overall result of the respondents' choices. The option of encouraging hydrogen and e-fuels only if produced in a way that leads to no or low GHG emissions along their life cycle is the most chosen *yes* options (320 responses). The second most chosen option is encouraging hydrogen/e-fuels produced from renewable sources (313 responses). This is followed by the option to encourage hydrogen/e-fuels only when the whole value chain is more energy efficient compared to alternative energy sources (149 responses). 145 participants chose the option to encourage hydrogen/e-fuels only for limited uses where no other alternatives are feasible. 76 participants chose the option to encourage hydrogen/e-fuels under a certain level of conversion losses. 57 participants chose the option to encourage hydrogen/e-fuels regardless of the source. 447 participants think that hydrogen/e-fuels should not be encouraged. 243 participants chose *other*.

Figure 3-11 Do you think the use of hydrogen and e-fuels produced from hydrogen should be encouraged (multiple answers possible)? (n=641, responses=1,750)



Amongst different stakeholder types, not encouraging the use of hydrogen/e-fuels is the most popular option, with the exception of NGOs (Table 3-16). With the NGO stakeholder type, encouraging hydrogen/e-fuels from renewable energy sources is the most popular option.

Table 3-16 Stakeholder correlation analysis for Q2.5

	Yes, all sources	Yes, RE only	Yes, low conversion losses	Yes, only no/low GHG emissions	Yes, energy efficient whole value chain	Yes, limited use only	No	Other
	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)
As an individual in a personal capacity	2% (5)	18% (42)	6% (14)	15% (36)	13% (31)	10% (23)	25% (58)	11% (26)
In a professional capacity or on behalf of an organisation	3% (52)	18% (271)	4% (62)	19% (284)	8% (118)	8% (122)	26% (389)	14% (217)
Of which:								
Academic/ research institution	4% (2)	10% (5)	10% (5)	20% (10)	12% (6)	8% (4)	24% (12)	10% (5)
Business organisation	4% (40)	17% (190)	4% (46)	21% (232)	8% (84)	6% (67)	26% (287)	13% (146)
Consumer organisation	0% (0)	6% (1)	0% (0)	24% (4)	18% (3)	6% (1)	29% (5)	18% (3)
NGO/ environmental organisation	2% (5)	24% (57)	3% (7)	6% (15)	4% (10)	18% (42)	23% (55)	20% (47)
Public authority	5% (3)	17% (11)	6% (4)	17% (11)	15% (10)	6% (4)	23% (15)	12% (8)
Trade union	0% (0)	14% (1)	0% (0)	14% (1)	14% (1)	14% (1)	29% (2)	14% (1)
Other	4% (2)	13% (6)	0% (0)	24% (11)	9% (4)	7% (3)	28% (13)	15% (7)

Table 3-17 Summary of results from Q2.5.1

Summary of results from Q2.5.1, an open ended question concerning Q2.5, where participants were asked to specify their reasons for why the use of hydrogen and e-fuels produced from hydrogen should be encouraged.
In total, Q2.5.1 received 257 responses, of which 18 are not unique. Responses are primarily from business organisations (180 responses), NGOs (38 responses) and EU citizens (17 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-8 responses. The main messages from the analysis are summarised below.
Hydrogen and e-fuels are especially needed in hard-to-abate sectors (~40% of respondents) Stakeholders say support is needed to effectively decarbonise aviation, shipping, heavy industry, and heavy-duty transport. 10 coordinated business stakeholders argue e-fuels are the prime example of sustainable aviation fuel to decarbonise the aviation sector, which should be at the core of the ReFuelEU proposal, with complementary promotion in the RED. Several of the stakeholders state that for buildings, other technologies such as heat pumps are more efficient.
Support is necessary but should target climate friendly technologies (~40% of respondents) Stakeholders suggest technology openness in a spectrum of climate friendly technologies. A few argue there should be room for hydro power and nuclear to support production. Monitoring climate effectiveness of sought technologies based on viability and sustainability criteria would be useful (~20% of respondents).
Market incentives can prove effective instruments for support (~25% of respondents) Stakeholders back market mechanisms including carbon pricing and other financial incentives / support schemes to foster these critical technologies. 9 coordinated business stakeholders suggest hydrogen and e-fuels should compete with other renewable fuels based on the same carbon pricing scheme and sustainability conditions.
Current production of hydrogen and e-fuels relies too heavily on fossil fuels (~25% of respondents) Fossil fuel-based production should not be supported unless emissions can be drastically reduced. Focus should be on supporting green hydrogen.
Hydrogen and e-fuels are necessary and will provide system flexibility (~20% of respondents) Support is rational from the perspective of system flexibility, including that hydrogen and e-fuels complement intermittent renewables. Stakeholders further acknowledge their utility from a European strategic value chain perspective (~5% of respondents).

Q2.6 asked respondents to rate the appropriateness of five measures along a four point scale. In Figure 3-12, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. *Market based support schemes* is considered the most appropriate measure of the measures listed.

Figure 3-12 How effective do you think the following measures would be in supporting the uptake of RES and low-carbon fuels?

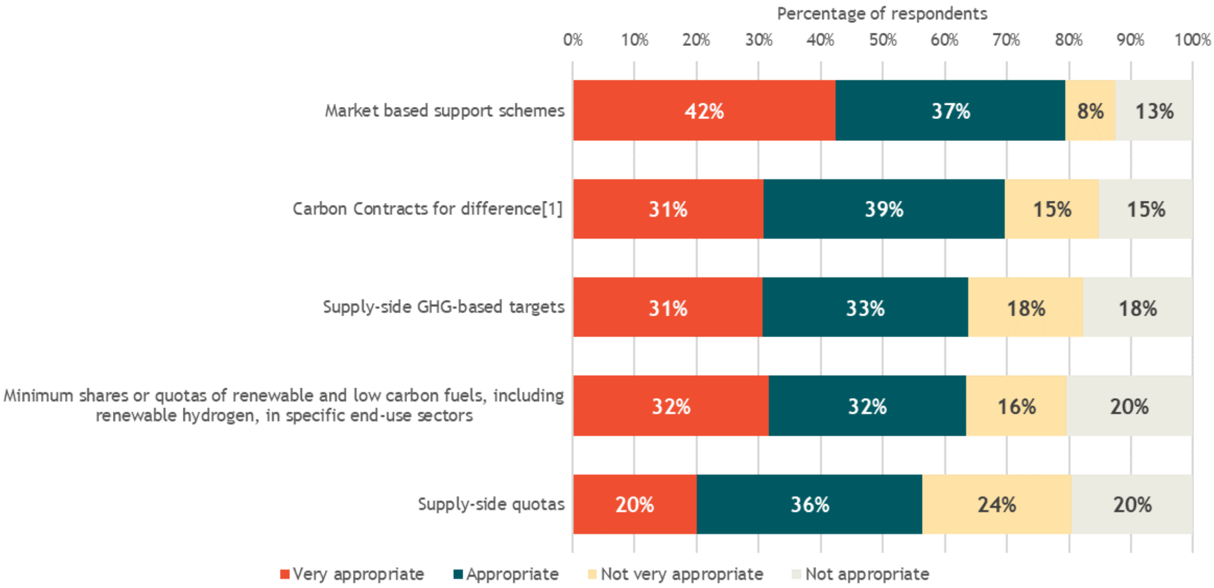


Table 3-18 Summary of results from Q2.6.1

Summary of results from Q2.6.1, an open ended question concerning Q2.6, where participants were asked to specify other measures that can be effective to support the uptake of RES and low carbon fuels.
In total, Q2.6.1 received 285 responses, of which 23 are not unique. Responses are primarily from business organisations (204 responses), NGOs (44 responses) and EU citizens (12 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-10 responses. The main messages from the analysis are summarised below. **Carbon pricing (~45% of respondents)** Stakeholders see a need for improved internalisation of external costs either via the ETS (improved price signal and/or including new sectors) or through energy taxation. This will level the playing field for renewable and low carbon energy, increasing their uptake. 12 coordinated business stakeholders argue carbon taxation must be preferred, which can be complemented by carbon contracts for difference, and quotas for markets where carbon taxation is not an option or difficult to implement (e.g., international aviation/shipping). **Improved access to finance and insurance (~10% of respondents)** Stakeholders suggest public funds be made increasingly available for promising technologies, as it can catalyse private finance. 10 coordinated business stakeholders suggest cost of capital for emerging renewable technologies is a main challenge and see a need for a European Insurance and Guarantee Fund. **Fossil-based low carbon fuels should not be supported (~10% of respondents)** Coordinated responses from five groups amounting to a total of 33 stakeholders (mostly NGOs but also businesses) suggest fossil-based low-carbon fuels should not be supported. Most of these are in favour of dedicated support schemes for additional renewable generation capacities to feed electrolysers. **Support for mandates / minimum shares (~10% of respondents)** Akin to minimum shares, stakeholders suggest mandates for specific technologies requiring uptake for market actors. 10 coordinated business stakeholders argue minimum share quotas for specific end-use sectors could be appropriate if they are compatible with the upcoming proposals on sustainable aviation

Summary of results from Q2.6.1, an open ended question concerning Q2.6, where participants were asked to specify other measures that can be effective to support the uptake of RES and low carbon fuels.
fuels and maritime fuels. Furthermore, these same 10 stakeholders argue any quotas for aviation fuel should avoid that waste lipids in parts A and B of annex IX are prioritised for aviation at the detriment of road and maritime sectors. Finally, these 10 stakeholders argue supply side quotas for fuel suppliers are a good instrument for the promotion of sustainable biofuels. **Uniform approach to market-based support (~5% of respondents)** Several stakeholders, including coordinated responses from 5 business stakeholders, suggest market-based support should be part of an EU-wide strategy. Stakeholders mention that any quotas / target percentages should be mandatory only at EU level, whilst implementation should be left for Member States. **Phase-out and end dates for fossil fuel technologies (~5% of respondents)** To support the uptake of renewables and low carbon energy, stakeholders suggest more ambitious phase out of fossil fuel technologies (e.g., vehicles) including setting targeted end-dates for their application. **Other suggestions (<5% of respondents)** 5 coordinated responses from a mix of stakeholders, argue carbon contracts for difference are not appropriate because the CO2 price in the ETS is not a proper benchmark for CO2 abatement costs in transport. The stakeholders suggest the obligation to decrease the carbon intensity of transport fuels set by Art. 7a of the Fuel Quality Directive should be progressively increased. Another group of 5 coordinated NGO stakeholders are against binding quotas or minimum targets for RFNBOs as a suitable tool for decreasing GHG-emissions in transport. They claim it is necessary to specify transport modes without any alternatives (e.g., aviation) for minimum quotas for RFNBOs to have an added value for GHG reduction. A third group of 5 coordinated business stakeholders argue for measures to enhance access to energy at competitive prices (e.g., carbon contracts for difference). They argue supply-side measures like quotas or targets are not appropriate as they result in increased prices for consumers due to the cost pass through by generators.

Q2.7 How important do you think the following principles are for a robust and comprehensive certification and verification system covering all renewable and low carbon fuels?

Q2.7 asked respondents to rate the appropriateness of eight measures along a four point scale. In Figure 3-13, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. 92% of participants find that *the certification and verification system should ensure that the GHG impact of energy conversions along the value chain are fully taken into consideration, while avoiding double counting* is the most appropriate principle. The last principle is very unpopular: 66% of participants think that it is *not (very) appropriate*.

Figure 3-13 How important do you think the following principles are for a robust and comprehensive certification and verification system covering all renewable and low carbon fuels?

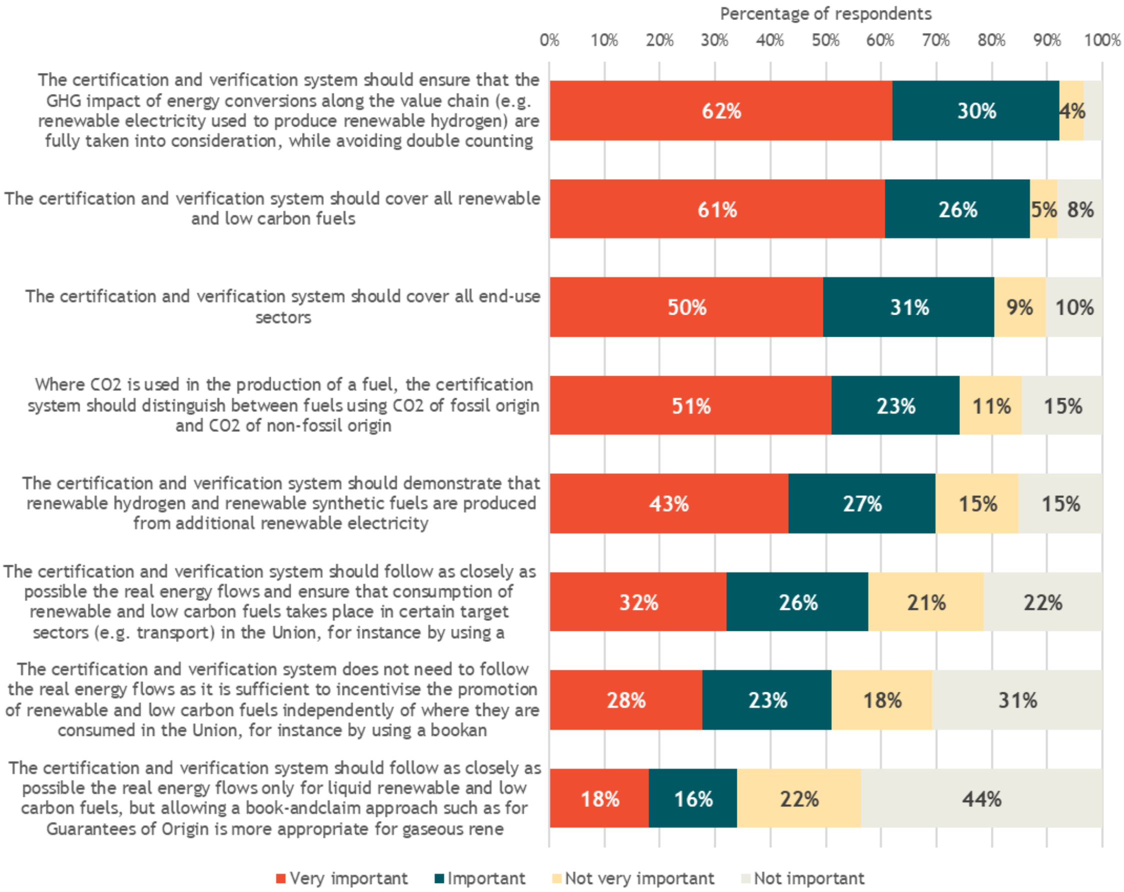


Table 3-19 Summary of results from Q2.7.1

Summary of results from Q2.7.1, an open ended question concerning Q2.7, where participants were asked to explain other principles that can be important for a robust and comprehensive certification and verification system covering all renewable and low carbon fuels.
In total, Q2.7.1 received 222 responses, of which 14 are not unique. Responses are primarily from business organisations (145 responses), NGOs (39 responses) and EU citizens (13 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-10 responses. The main messages from the analysis are summarised below. **Consumer knowledge and transparency (~20% of respondents)** Stakeholders suggest a core principle of the certification mechanism should be to foster consumer knowledge (e.g., in form of strengthened GOs) and full transparency of how energy is produced. Coordinated responses from 5 NGOs argue the transparency clause in the RED under which operators must inform about the origin and type of biofuels used, should be extended to all renewable fuels in transport across the EU and include information about the feedstocks used in the production of imported biodiesel and bioethanol. The same 5 stakeholders argue data on the climate impact on the fuels should be included, with accompanying mechanisms to ensure the veracity and compliance of the information submitted to the database – based on a segregated approach instead of a “mass-balance” approach. Proposed mechanisms include conformity checks and due diligence by national authorities along the supply chain, with subsequent reporting the outcomes of this evaluation. **EU-wide certification (~10% of respondents)**

Summary of results from Q2.7.1, an open ended question concerning Q2.7, where participants were asked to explain other principles that can be important for a robust and comprehensive certification and verification system covering all renewable and low carbon fuels.
Certification and verification must be an EU-wide strategy, e.g., where GOs should support cross-border trade. In some instances (e.g., aviation fuels), a global approach to certification and verification may be effective. **Levelling and minimising the administrative burden (~5% of respondents)** Several stakeholders suggest the regulatory framework should come with a minimum administrative burden. GOs also for fossil fuels can level the administrative burden vis-à-vis renewable and low carbon energy, which is currently skewed at the latter's expense. 4 coordinated business stakeholders mention that regulations should avoid administrative burden and minimise the financial impact on energy consumers. **Technology neutrality (~5% of respondents)** Stakeholders emphasize that the certification and verification system should not significantly disfavour any technologies. **Improved definitions and criteria (~5% of respondents)** Some stakeholders suggest a need for stronger definitions and sustainability criteria. For example, defining more clearly renewable versus low carbon, and assess which low carbon fuels that could be included into RED. **Certification should be voluntary (~5% of respondents)** 8 coordinated business stakeholders argue certification should be up to the market actors and be voluntary, including because such book and claim systems distort local and regional markets when there is no connection between the physical use and the physical production. **Unclear how the established possibility for certification systems under RED II would fit with new approach / principles (~5% of respondents)** 7 coordinated business stakeholders state the RED II has already established the possibility of certification systems for bioenergy and find it difficult to answer this question on the grounds of how this would fit in with the proposed new approach without knowing the details of the principles which seem like tools. **Other suggestions (<5% of respondents)** 5 coordinated NGO stakeholders argue biofuels certification schemes in Europe must account for the full life cycle impacts by considering also indirect land use change. More broadly, they argue the schemes should address the additionality of renewables produced and the origin of CO2 if CO2 is needed as a raw material to determine the renewable nature of the energy carrier and its eligibility under the RED targets.

Q2.8 In the current system, only electricity suppliers are required to certify to consumers the share of energy from renewable sources by guarantees of origin. Do you think that this obligation shall be extended to suppliers of renewable fuels (such as biogas, biomethane or renewable hydrogen) as well, and possibly of "low carbon" fuels?

Q2.8 received 585 responses (Figure 3-14). The majority of respondents (64%) agree that this obligation for electricity suppliers should be extended to both renewable fuels and low-carbon fuels. This view is shared consistently across all stakeholder types (see Table 3-20).

Figure 3-14 In the current system, only electricity suppliers are required to certify to consumers the share of energy from renewable sources by guarantees of origin. Do you think that this obligation shall be extended to suppliers of renewable fuels (such as biogas, biomethane or renewable hydrogen) as well, and possibly of "low carbon" fuels? (n=585)

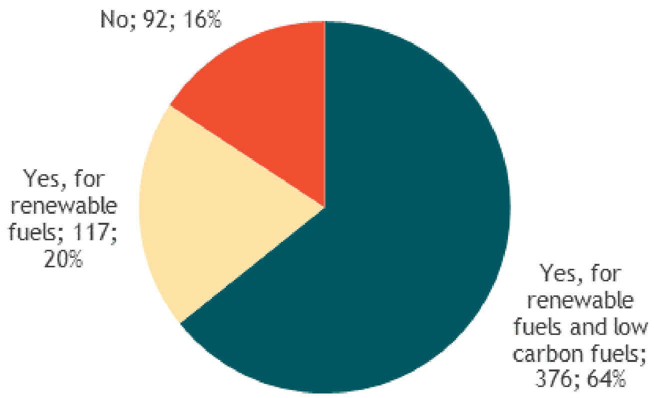

No; 92; 16%
Yes, for renewable fuels; 117; 20%
Yes, for renewable fuels and low carbon fuels; 376; 64%

Table 3-20 Stakeholder correlation analysis for Q2.8

	Yes, for renewable fuels	Yes, for renewable fuels and low carbon fuels	No
	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	20% (16)	63% (52)	17% (14)
In a professional capacity or on behalf of an organisation	20% (101)	64% (324)	16% (78)
Of which:			
Academic/research institution	*10% (1)*	*70% (7)*	*20% (2)*
Business organisation	*19% (69)*	*68% (251)*	*14% (50)*
Consumer organisation	*25% (2)*	*75% (6)*	*0% (0)*
NGO/environmental organisation	*35% (24)*	*35% (24)*	*30% (21)*
Public authority	*14% (3)*	*73% (16)*	*14% (3)*
Trade union	*0% (0)*	*100% (4)*	*0% (0)*
Other	*10% (2)*	*80% (16)*	*10% (2)*

Q2.9 Do you think the cooperation mechanisms set out in RED II should be extended to cover renewable hydrogen regardless of its end use, so that Member States can support renewable hydrogen projects in other Member States and in third countries while counting the energy produced as their own?

Q2.9 received 501 responses (Figure 3-15). Participants could reply *yes* or *no*. The majority of respondents (60%) think that cooperation mechanisms set out in RED II should be extended to cover renewable hydrogen regardless of its end use, to allow Member States to support renewable hydrogen projects in other Member States and in third countries while counting the energy produced as their own. However, this view is not shared by all stakeholder types – academic/research institutions, NGOs/environmental organisations, and trade unions more often do not agree with this (Table 3-21). A large majority from these three stakeholder types (55%, 73% and 67% respectively) selected *no* as a response.

Figure 3-15 Do you think the cooperation mechanisms set out in RED II should be extended to cover renewable hydrogen regardless of its end use, so that Member States can support renewable hydrogen projects in other Member States and in third countries while counting the energy produced as their own? (n=501)

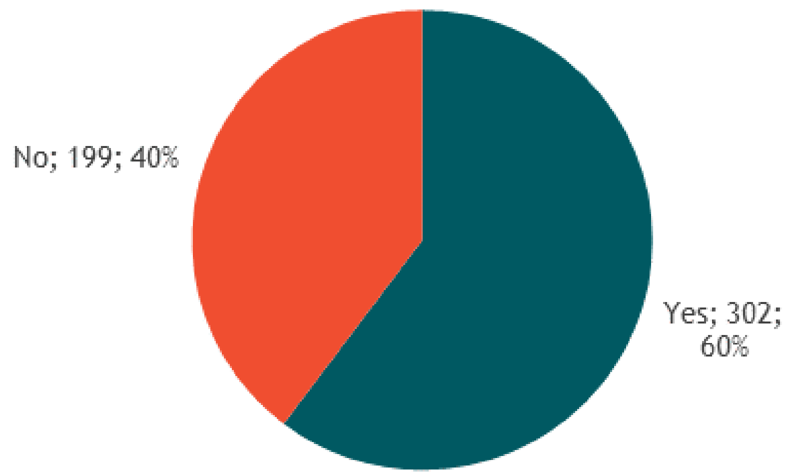


Table 3-21 Stakeholder correlation analysis for Q2.9

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	56% (41)	44% (32)
In a professional capacity or on behalf of an organisation	61% (261)	39% (167)
Of which:		
Academic/research institution	*45% (5)*	*55% (6)*
Business organisation	*67% (202)*	*33% (99)*
Consumer organisation	*57% (4)*	*43% (3)*
NGO/environmental organisation	*27% (19)*	*73% (51)*
Public authority	*82% (18)*	*18% (4)*
Trade union	*33% (1)*	*67% (2)*
Other	*86% (12)*	*14% (2)*

Table 3-22 Summary of results from Q2.9.1

Summary of results from Q2.9.1, an open ended question concerning Q2.9, where participants were asked to explain why they think that the cooperation mechanism set out in RED II should or should not be extended to cover renewable hydrogen regardless of its end use, so that Member States can support renewable hydrogen projects in other Member States and in third countries while counting the energy produced as their own.

In total, Q2.9.1 received 220 responses, of which 15 are not unique. Responses are primarily from business organisations (138 responses), NGOs (32 responses) and EU citizens (18 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-13 responses. The main messages from the analysis are summarised below.

Collaboration mechanisms will foster cost efficiency for hydrogen technologies (~20% of respondents)

Stakeholders are attracted to the cost benefits and system efficiency of this idea. 4 coordinated NGOs state that cooperation mechanisms to scale up hydrogen and other e-fuels will be much needed to drive down their price. Another 3 coordinated business stakeholders argue they can be a tool contributing to more efficiency and cost optimisation.

Innovation and competitiveness (~10% of respondents)

Collaborating for hydrogen within and beyond the EU will strengthen technological development and the industry's competitiveness.

International approach to hydrogen for a global fuel switch (~10% of respondents)

Stakeholders stress that collaboration mechanisms can accelerate GHG emission reduction internationally while harnessing diverse technological opportunities.

Hydrogen production should not be pursued regardless of end use (~10% of respondents)

Expanding the scope without considering the potential in end-use sectors would unnecessarily increase system costs. 17 coordinated stakeholders (predominantly NGOs) suggest hydrogen should be developed for hard-to-abate sectors including heavy industry, heavy duty transport, shipping, and aviation.

Security of supply and energy sovereignty (~10% of respondents)

Some stakeholders suggest the EU should reduce reliance on energy imports. Energy sovereignty and security of supply are best achieved from hydrogen production within and close to the EU market.

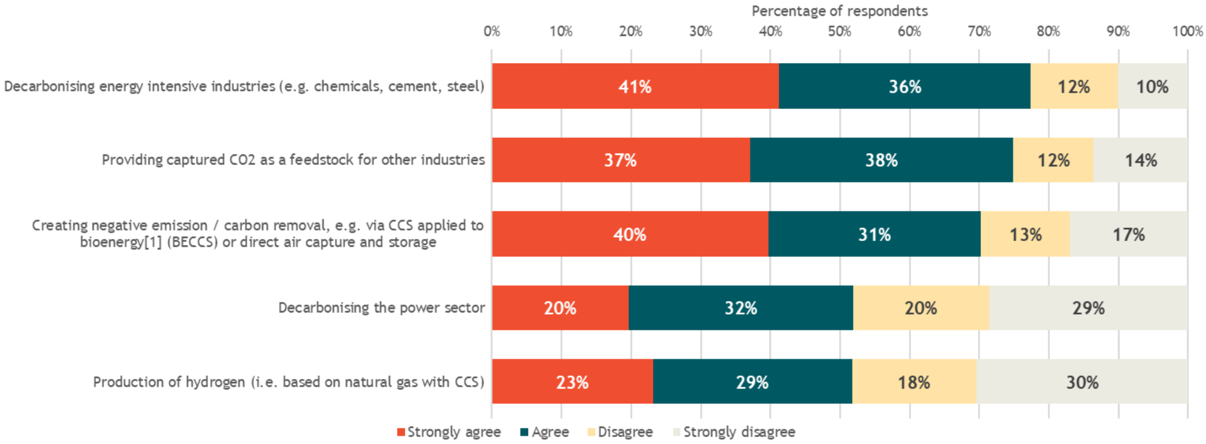
Other suggestions (<5% of respondents)

5 coordinated business stakeholders argue the consideration should also refer to climate neutral hydrogen which can be made available in larger quantities in the medium term (by means of pyrolysis). 5 other coordinated business stakeholders support cooperation mechanisms and the EU renewable fund as instruments to trigger collaboration between Member States and accountability of renewable energy shares attributable to each country for target compliance. The stakeholders suggest Article 5 of RED II should be extended to cover renewable and low carbon gas produced in other non-EU Member States.

Q2.10 Carbon-capture and storage/usage in the EU should play a prominent role in...

Q2.10 asked respondents provide their level of agreement with five statements along a four point scale. In Figure 3-16, the measures are ranked from most agreed to least agreed, based on the combined percentage of *strongly agree* and *agree* responses. *Decarbonising energy intensive industries*, *providing captured CO2 as feedstock* and *creating negative emission* are considered the prominent roles of CCS/U, while *decarbonising the power sector* and *production of hydrogen* are not.

Figure 3-16 Carbon-capture and storage/usage in the EU should play a prominent role in...



Q2.11 In addition to how CCS and CCU are treated in other EU legislation, do you think REDII should be revised to encourage the uptake of CCS and CCU?

Q2.11 received 509 responses (Figure 3-17). Participants could choose *yes* or *no*. The views concerning the encouragement of the uptake of CCS and CCU within RED II is split. Half of the participants think that RED II should be revised to encourage CCS/CCU uptake (254 responses) while the other half think that it should not (255 responses).

Figure 3-17 In addition to how CCS and CCU are treated in other EU legislation, do you think REDII should be revised to encourage the uptake of CCS and CCU? (n=509)

However, the views vary across the various stakeholder types, as see in Table 3-23. While the majority of participants representing academic/research institutions, business organisations and *other* organisations agree that the revision of RED II to encourage the uptake of CCS and CCU should be necessary, the rest of the stakeholder types do not share the same view. Representatives from trade union, with a sample size of two, had split views about this.

Table 3-23 Stakeholder correlation analysis for Q2.11

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	38% (26)	62% (43)
In a professional capacity or on behalf of an organisation	52% (228)	48% (212)
Of which:		
Academic/research institution	*67% (8)*	*33% (4)*
Business organisation	*60% (186)*	*40% (126)*
Consumer organisation	*25% (1)*	*75% (3)*
NGO/environmental organisation	*16% (12)*	*84% (63)*
Public authority	*48% (11)*	*52% (12)*
Trade union	*50% (1)*	*50% (1)*
Other	*75% (9)*	*25% (3)*

Table 3-24 Summary of results from Q2.11.1

Summary of results from Q2.11.1, an open ended question concerning Q2.11, where participants were asked to specify why they think RED II should or should not be revised to encourage the uptake of CCS and CCU.
In total, Q2.11.1 received 284 responses, of which 26 are not unique. Responses are primarily from business organisations (181 responses), NGOs (56 responses) and EU citizens (20 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-10 responses. The main messages from the analysis are summarised below. **CCS and CCU technologies would have an important role to play (~15% of respondents)** CCS and CCU can help to decarbonise hard-to-abate sectors, and produce negative emissions. These include Bioenergy CCS (BECCS) and Direct Air Carbon Capture/Storage/Use (DACC/DACCS/DACCU) technologies. There

Summary of results from Q2.11.1, an open ended question concerning Q2.11, where participants were asked to specify why they think RED II should or should not be revised to encourage the uptake of CCS and CCU.
should also be accompanying support schemes to promote the development of these technologies, clarity in the terminology for the various CCS and CCU technologies, as well as accounting and reporting rules, if these technologies are to be included in the scope of the Renewable Energy Directive. **The Renewable Energy Directive should remain focused (~8% of respondents)** The Renewable Energy Directive should focus on renewable energy—this view is shared across business organisations, NGOs and environmental groups. A group of 13 coordinated responses representing NGOs and environmental organisations are of the view that CCS should not compete with renewable energy for public support, and should remain out of scope for the Renewable Energy Directive. Another group of 14 coordinated responses representing business organisations, environmental organisations and NGOs opine that the revision of RED II should focus on promoting renewable energy sources, and not incentivise or encourage the use of fossil-based fuels. Further, NGOs have also warned that the current credibility of the sustainability of bioenergy sources has yet to be established, and the support for these technologies could lead to an increase in demand for bioenergy, which could become unsustainable. In addition, although CCS and CCU have the potential to reduce greenhouse gases emissions, these technologies are not renewable energy sources, and should therefore be treated separately. Other respondents have also expressed concern that the technologies are not mature and would be difficult to access its effectiveness in reducing greenhouse gases. **Other** The creation of a voluntary market, through the EU Emissions Trading System (ETS), Guarantee of Origins certificates (GOs), or carbon credits could help to stimulate and incentivise investments to develop these technologies. Keep the reporting system between the actual greenhouse gas savings, and the negative emissions that have been achieved separate. The application of CCS and CCU technologies should only be focused to target hard-to-abate sectors, as well as waste-to-power plants. A group of 9 coordinated responses mainly representing business organisations agree that even though CCS and CCU technologies are not technically renewable energy, BECCS presents a strong argument for using bioenergy as a renewable energy source as a cost-effective measure to reduce greenhouse gas emissions, and should be applied wherever feasible, and in a sustainable manner.

Section III - Technical questions on specific sectors

Renewables in Electricity

There are a total of 5 main questions in this section of the questionnaire. Results are presented below.

Q3.1 How would you rank the appropriateness of the following measures in tackling the remaining barriers for the uptake of renewable electricity that matches the expected growth in demand for end- use sectors?

Q3.1 asked respondents to rate the appropriateness of five measures along a four point scale. In Figure 3-18, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. About 91% of the participants who responded think that *further streamlining permitting procedures* is a *(very) appropriate* measure to tackle remaining barriers to renewable electricity uptake (391 responses). 88% of the participants who responded think that *fostering regional cooperation* and *supporting uptake of private renewable PPAs* are *(very) appropriate* measures (391 and 380 responses, respectively).

Figure 3-18 How would you rank the appropriateness of the following measures in tackling the remaining barriers for the uptake of renewable electricity that matches the expected growth in demand for end- use sectors?

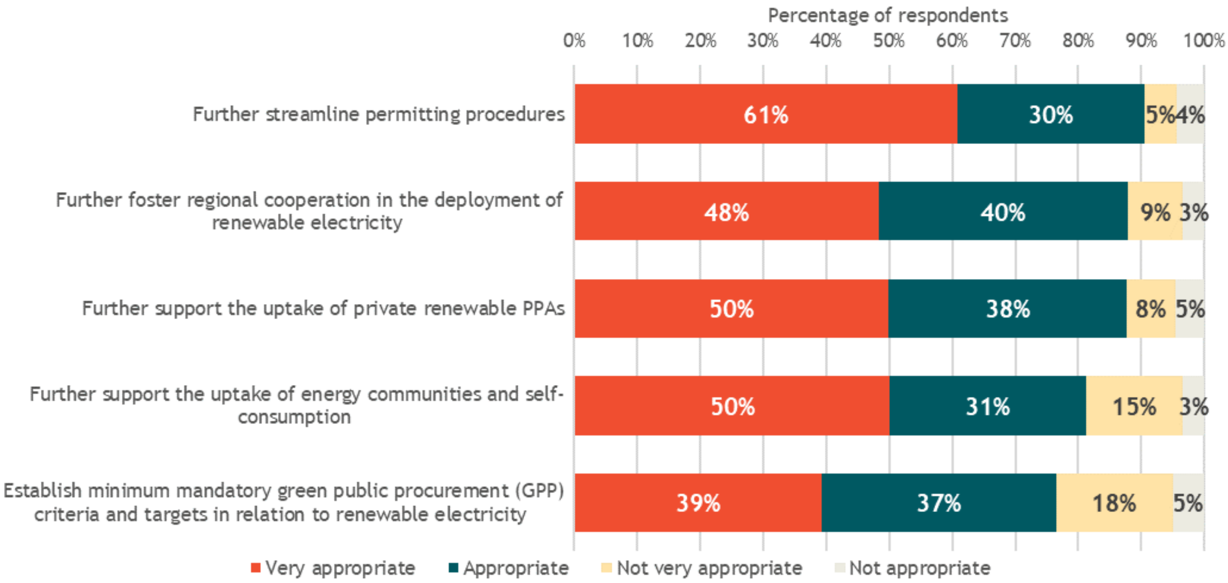


Table 3-25 Summary of results from Q3.1.1

Summary of results from Q3.1.1, an open ended question concerning Q3.1, where participants were asked to specify other measures that could be appropriate to tackle the remaining barriers for the uptake of renewable electricity to match the expected growth in demand for end-use sectors.
In total, Q3.1.1 received 171 responses of which 23 are not unique. Responses are primarily from business organisations (119 responses), NGOs (27 responses) and EU citizens (12 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-6 responses. The main messages from the analysis are summarised below. **Support renewable energy communities (RECs) and self-consumption (~10% of respondents)** Proper transposition of Articles 21 and 22 of Renewable Energy Directive 2018/2001 in Member States is important to support the development of RECs and to promote self-consumption. This would entail the removal of barriers, such as the landlord/tenant dilemma, high network charges and fees, and administrative burdens, etc. A proper assessment and evaluation of the existing and potential barriers faced by RECs and self-consuming consumers would also be necessary. Further, regulatory reforms in Member States, as well as an alignment with the Internal Market in Electricity Directive at the EU level may also be necessary, according to the results of the H2020 PROSEU project which looked into the business models for operating self-consumption. In addition, other supporting measures, such as the rolling out of smart infrastructure, such as smart meters and electric vehicle charges would help provide support RECs and self-consuming consumers. **Grid and storage capacities (<10% of respondents)** The increase in the share of renewables in the future energy mix entails a need for forward planning for the grid and to ensure sufficient energy storage. Business associations raised issues on the need to strengthen the resilience of the grid, to encourage sustainable usage of the grid, and to ensure sufficient grid and storage capacity in anticipation of increasing share of renewables in the energy mix. This would require the early involvement of various parties, such as DSOs, for example. Other comments include the need to keep the costs of the grid reasonable, and to establish a minimum service delivery standards and criteria on grid usage across the EU. **Removing barriers to PPAs (~10% of respondents)**

Representations from business associations strongly highlighted the need to remove any remaining barriers to the uptake of long-term PPAs. Such barriers include the difficulties in obtaining financial guarantees, and the lack of long-term vision for long-term PPAs by the counterparties. In addition, support for corporate PPAs, and the extension of such PPAs to include other renewable energy technologies such as electrolysers, heating, renewable fuels of non-biological origin, has also been mentioned by business associations. A group of 9 coordinated responses representing business associations shared the view that innovative PPAs can promote the development of, and acceleration of the commercialisation of innovative technologies. The EU could provide guidance to Member States on how to set up such PPAs, while also being compliant to state-aid rules.

Streamlining, simplifying and shortening permitting procedures (~5% of respondents)

The streamlining of permitting procedures for all renewable energy technologies should be implemented. In addition, the provision of additional support, such as the setting up of one-stop-shops, can enable companies and businesses to attain the necessary approvals efficiently. The digitalisation of processes could increase efficiency and facilitate information exchange between various parties. There should also be a maximum period set for the processing of permit applications. Nonetheless, there should also be minimal safeguards in place, such as the requirement to conduct environmental impact assessments.

Promoting GOs (<5% of respondents)

The creation of a robust and reliable system should be developed to promote the uptake of renewable electricity. GOs should be promoted for new plants across the EU. This could also help to partially remove the barriers to the uptake of PPAs.

Other (<5% of respondents)

- Demand-side management measures, such as dynamic pricing contracts, could help consumers adjust their energy consumption habits to facilitate uptake of renewable electricity;
- Review of the Energy and Environmental State Aid Guidelines (EEAG) to provide a clear framework for cross-border cooperation could improve cooperation between Member States to encourage further uptake of renewable electricity;
- Policy coherence with other EU legislation and measures, such as the Energy Taxation Directive and EU Emissions Trading Scheme (ETS), energy label and eco-design could stimulate uptake of renewable energy;
- Mandating the share of renewable energy in electricity production on a Member State level, which can be encouraged through green public procurement;
- Measures to ensure the low cost of renewable electricity for energy consumers could also help to facilitate an increase in the demand for renewable electricity in end-use sectors. Further, public engagement and consultation must also continue to be strengthened, to ensure a continued support towards renewable energy projects.

Table 3-26 Summary of results from Q3.2

Summary of results from Q3.2, an open ended question where participants were asked how they think regional cooperation in deploying renewable electricity could be further promoted.
In total, Q3.2 received 218 responses of which 13 are not unique. Responses are primarily from business organisations (131 responses), NGOs (31 responses) and EU citizens (25 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-14 responses. The main messages from the analysis are summarised below. **Physical connection infrastructure (~10% of respondents)**

Strengthening of energy transmission and distribution networks between Member States is an important factor to facilitate regional cooperation. Trans-European Networks for Energy (TEN-E) would play an important role in regional cooperation, and should also be supported in tandem with the expected growth in regional cooperation. Further, infrastructure to support regional balancing, such as energy storage and regional combined heat and power plants could also be an area for regional cooperation. The implementation of smart energy grid at the regional level could also improve management and monitoring of the grid across borders. The provision of cost-competitive grid services, and the appropriate involvement of transmission system operators (TSOs) at the regional level could stimulate cross-border cooperation.

Removing barriers for regional cooperation between Member States (~10% of respondents)
Creating a level playing field for companies participating in regional tenders / auctions would help to promote regional cooperation. This would also require, among others, the streamlining and coordination of permitting processes, addressing differences in connection charges, and the alignment of the environmental standards and taxes. Further, an efficient and effective channel to share information and statistics between Member States would also be required—this may require a harmonised digitalisation of processes across Member States. Additionally, state aid rules, as well as other related legislation, such as the Electricity Directive for example, should also be revised to facilitate the implementation of renewable energy and/or energy efficiency projects. A group of five coordinated responses representing business organisations also agree on the need to streamline and standardise permitting procedures and requirements, and facilitate simplified statistical transfers between Member States.

Establish regional renewable energy strategies (~5% of respondents)
Creating a cross-border, integrated renewable energy plan, taking into account the long-term regional needs for electricity infrastructure, identifying the potentials, and mapping the pathways to implementation, could help to stimulate and foster regional cooperation. In addition, the promotion of spatial planning, including marine spatial planning at a regional level would facilitate regional cooperation. In this regard, a group of 5 coordinated responses representing the NGOs also highlighted the need to take into account nature conservation principles in the spatial planning processes from the conception phase to avoid any further delays to the realisation of renewable energy projects. In addition, a group of 14 coordinated responses, representing business associations, environmental groups and NGOs also suggest that regional cooperation should become the guiding principle for the effective planning and development of off-shore renewable energy and grid infrastructure across borders. This includes regional spatial planning at sea basin level, including marine spatial planning. Nonetheless, participation in cross-border cooperation should remain voluntary for Member States, and the promotion of such strategies should remain open to all renewable energy technologies. Further, the suggestion of strengthening cross-border support schemes was also made.

Other

- Strengthening the EU RES financing mechanism could stimulate regional cooperation and can be activated as a gap-filling measure in case national contributions fall short of the overall EU target. Besides its application in the Offshore Renewable Energy Strategy, the financing mechanism should also be open to other renewable energy technologies. In addition, the financing mechanisms should also be available to Member States who may wish to exceed their RES targets, and to take advantage of the opportunities from participating in regional projects;
- Active promotion and stimulation of regional cooperation through conducting cross-border tenders / auctions, and cross-sectoral collaboration across borders. The European Commission should also provide guidance and clarity in role and benefits for Member States involved in such cross-border tenders. The application of circular economy principles across sectors could also help promote regional collaboration;
- Providing support for energy communities could also foster regional cooperation;

- The provision of incentives at the EU level for regional cooperation, raising of awareness, and development of an information sharing network, as well as training and education programme could help to support the implementation of cross-regional projects;
- There were also remarks from some respondents that regional cooperation is not the priority for RED II, and should remain voluntary. It should also be technology neutral, and stimulated through market-based solutions instead.

Q3.3 How appropriate do you think the following measure would be in promoting the use of private renewable power purchase agreements?

Q3.3 asked respondents to rate the appropriateness of four measures along a four point scale. In Figure 3-19, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. 90% of participants think that *removing administrative barriers* is *appropriate* or *very appropriate, and 80%* think the same about *financial solutions/instruments*. Only 19% of participants think that *no action* is *appropriate* or *very appropriate*.

Figure 3-19 How appropriate do you think the following measure would be in promoting the use of private renewable power purchase agreements?

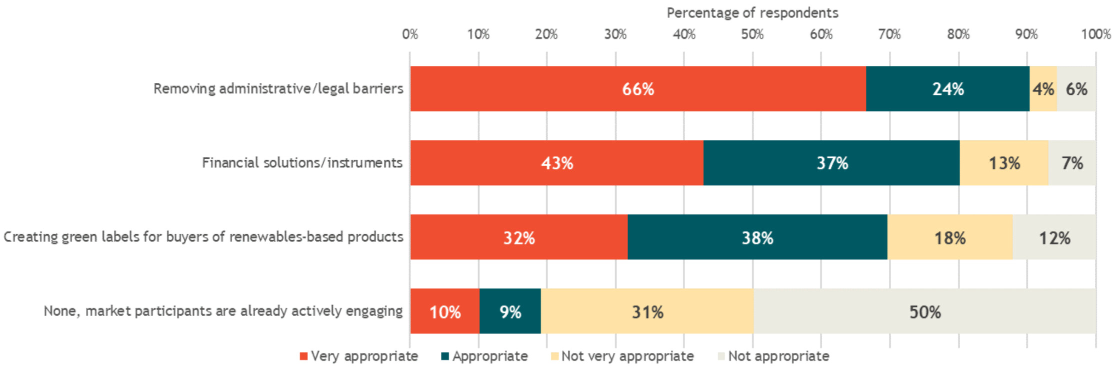


Table 3-27 Summary of results from Q3.3.1

Summary of results from Q3.3.1, an open ended question concerning Q3.3, where participants were asked to specify other appropriate measures to promote the use of private renewable power purchase agreements.
In total, Q3.3.1 received 134 responses of which 9 are not unique. Responses are primarily from business organisations (92 responses), NGOs (17 responses) and EU citizens (11 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-5 responses. The main messages from the analysis are summarised below. **Address legal, administrative and financial barriers (~20% of respondents)** There is currently a lack of evaluation in many Member States to assess, and to remove any unnecessary regulatory and administrative barriers to long-term renewable PPAs, as per Article 15(8) of RED II. In addition, the removal of such barriers is not always addressed in the National Energy and Climate Plans (NECPs) of all Member States. Existing barriers include regulatory barriers preventing projects which are beneficiaries of public support schemes to be bundled as corporate PPAs, and administrative burdens in the retention and retirement of Guarantees of Origin (GOs). Further, administrative procedures could also be simplified and accelerated without compromising on technical and safety standards. In this respect, Distribution System Operators (DSOs) should be appropriately involved in the approval process. In addition, suggestions were also made on risk mitigation and barrier removal measures. These include the provision of guarantees, guidance for buyers, standardising the

contractual templates for PPAs to include interaction with the electricity market, and the creation of shorter-term, tradable products instead of long-term PPAs. The European Commission could also facilitate a platform to allow Member States to share best practices from Member States who have taken concrete measures to encourage the uptake of PPAs.

Regarding financial barriers, measures should also be taken to eliminate any market distortions that could hinder the take up of PPAs. Member States could also strengthen their support by putting in place mechanisms to safeguard energy producers against buyers' default, and the risk of energy price fluctuations. Relieving PPAs from taxes and fees could also encourage buyers financing new renewable projects.

- Encourage small-medium enterprises (SMEs) to take up PPAs
  The removal of administrative and financial barriers and burdens could also help to promote the uptake of PPAs amongst small-medium enterprises (SMEs), an area with potential for growth. In addition, further risks-sharing mechanisms could be provided by Member States to reduce the financial risks for taking up PPAs, such as the provision of state-backed credit guarantees.

Use existing certification systems (~10% of respondents)

The use of existing green labels, and GOs are preferred, as the market and consumers already have a sense of familiarity with these existing mechanisms. A group of respondents from business organisations opine that the application of GOs is sufficient. There is thus no need for no new green labels are required, and should remain optional. On the other hand, some respondents are supportive of a green label. These would be complementary to GOs, and would help to provide guidance for consumers on the market. Nonetheless, such schemes should be subjected to standardization across the EU level to increase its effectiveness, increase transparency, minimize confusion and increase the take-up rate of PPAs.

Support for market-based mechanisms (~10% of respondents)

Respondents representing business organisations, NGOs, consumers and others support the adoption of market-based approaches to stimulate the uptake of PPAs. The agreements should be voluntarily, and made freely based on a well-functioning market with minimal interventions, such as in the provision of subsidies.

Other

- Supporting energy communities and prosumers by financial means, and by extending the perimeter of where they can sell their energy could also promote the uptake of local private PPAs;
- Several respondents across stakeholder types, including companies, business associations, Eu citizens, NGOs and others, also support a more market-based approach to PPAs. On the other hand, another group of respondents, including a group of five coordinated responses representing NGOs and environmental organisation, call for more intervention in the form of financial support, such as the Contracts for Difference Scheme, to increase viability for new renewable energy projects;
- While some respondents agree that the take up of PPAs should be on a voluntary basis, a handful of respondents suggested fixing targets for PPAs, especially in specific sectors, include transport, industry and heat supply;
- A group of respondents, including a group of seven coordinated responses representing companies, business associations and EU citizen opine that PPAs should promote additionality, and increasing renewable energy capacities rather than reallocating existing renewable energy production capacities;
- A group of four coordinated responses representing business organisations, NGO and public authority shared the view that the uptake of PPAs could also be promoted in the public sector, where energy consumption is often high;
- The expansion and digitalisation of grid infrastructure can further support the infrastructure for increased uptake of PPAs. The need for digitalisation is a view shared by a group of six coordinated responses representing business associations and companies;

- There were also remarks from respondents, including a group of five coordinated responses, that ensuring energy prices remain at competitive rates should also be kept in view. In addition, energy consumers rights to transparency and information should be observed.

Q3.4 Should there be specific obligations for public authorities to contribute to achieving a high level of renewable energy (multiple answers possible)?

Q3.4 received 571 responses from 441 participants (multiple answers possible). Participants could choose from five options and chose 1.3 answers on average. Figure 3-20 presents the results of the participants' responses. The most chosen response was *Yes, all public authorities should be obliged to buy green energy*, with 276 responses. 120 participants chose *yes, but only if the green tender is likely to trigger investment in additional green energy generation*. 43 participants chose the option *yes, but only if it does not cost more*. The least chosen *yes* option concerned green energy obligations only for large public authorities (35 responses). 97 participants think that there should not be specific obligation for public authorities to contribute to achieving a high level of renewable energy. These views are quite uniform across the different stakeholder types (Table 3-28).

Figure 3-20 Should there be specific obligations for public authorities to contribute to achieving a high level of renewable energy (multiple answers possible)? (n=441; 571 responses)

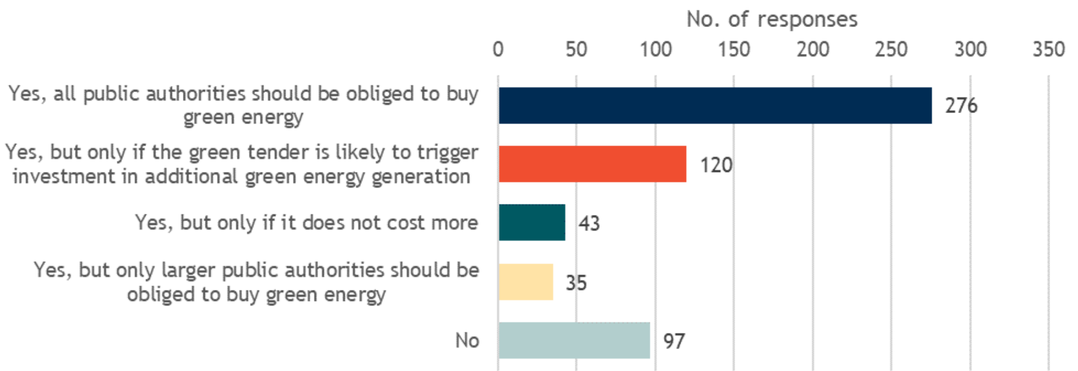


Table 3-28 Stakeholder correlation analysis for Q3.4

	Yes, all public authorities	Yes, only larger public authorities	Yes, but only if it does not cost more	Yes, but only if it triggers investment	No
	% (frequency)	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	60% (55)	5% (5)	5% (5)	12% (11)	16% (15)
In a professional capacity or on behalf of an organisation	*46% (221)*	*6% (30)*	*8% (38)*	*23% (109)*	17% (82)
Of which:					
Academic/ research institution	*38% (6)*	*13% (2)*	*13% (2)*	*13% (2)*	25% (4)
Business organisation	*45% (142)*	*8% (24)*	*9% (28)*	*19% (60)*	25% (4)
Consumer organisation	*50% (2)*	*0% (0)*	*25% (1)*	*0% (0)*	19% (61)

NGO/ environmental organisation	*54% (52)*	*0% (0)*	*2% (2)*	*37% (36)*	25% (1)
Public authority	*33% (11)*	*6% (2)*	*12% (4)*	*30% (10)*	7% (7)
Trade union	*100% (1)*	*0% (0)*	*0% (0)*	*0% (0)*	18% (6)
Other	*50% (7)*	*14% (2)*	*7% (1)*	*7% (1)*	0% (0)

Table 3-29 Summary of results from Q3.4.1

Summary of results from Q3.4.1, open ended question concerning Q3.4, where participants were asked to explain why there should be specific obligations for public authorities to contribute to achieving a high level of renewable energy.

In total, Q3.4.1 received 174 responses, of which 12 are not unique. Responses were primarily from business organisations (112 responses), EU citizens (21 responses) and NGOs (19 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-7 responses. The main messages from the analysis are summarised below.

Public authorities should lead by example (~20% of respondents)
9 coordinated business stakeholders suggest public authorities should be at the forefront of the energy transition. Another 6 stakeholders (businesses and EU citizens) state in their coordinated responses that public authorities should lead by example through long-term contracts that provide visibility to renewable developers. 3 more coordinated responses from a third group of business stakeholders suggest public authorities should be role models of public green procurement including district heating, green gas and green power. Finally, a fourth group with 5 business stakeholders suggest public authorities should lead by example as their building stock (including e.g., schools and hospitals) are substantial energy consumers.

Public procurement of renewable energy can trigger investments (~15% of respondents)
2 coordinated business stakeholders suggest the relevant investments will be triggered only if the technology neutrality principle prevails. From another 5 coordinated business stakeholders, new investments in renewable energy sources like bioenergy could create local jobs and additional streams of revenue for local communities. 2 public authority stakeholders argue public procurement obligations are desirable but should not crowd out private investments.

Obligations for renewable procurement are rational from a cost perspective (~10% of respondents)
Many stakeholders, including 9 coordinated business stakeholders argue that renewable energy is often the cheapest source of energy and hence could decrease energy bills. The same 9 stakeholders say it will further bring down the cost. Another 6 business stakeholders argue public procurement obligations will enable a higher share of renewable energy while reducing the cost.

Public procurement will create positive tensions for Guarantee of Origin market (~5% of respondents)
Several stakeholders suggest this will be good for the GO market. Some argue it will help strengthen the role of GO market as a meaningful market-based source of income for renewable energy producers. Other stakeholders argue it will create more investment signals for new projects.

Other (~5% of respondents)
Several stakeholders, including 5 coordinated business stakeholders argue obligations to procure renewable energy can convey a strong signal to develop renewable solutions. Others state that public authorities have a moral obligation, while some state that preconditions for such obligations should embed technology neutrality or provide additionality in renewable energy deployment.

Table 3-30 Summary of results from Q3.5

Summary of results from Q3.5, open ended question where participants were asked if they think that modifying RED II would be appropriate to further promote offshore renewable energy, following the adoption of the EU Offshore Renewable Strategy.
In total, Q3.5 received 245 responses, of which 15 are not unique. Responses are primarily from business organisations (151 responses), EU citizens (34 responses) and NGOs (29 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-10 responses. The main messages from the analysis are summarised below. **Offshore renewables will progress via market forces and technology neutrality (~20% of respondents)** Stakeholders that do not support RED modification for offshore renewable energy most frequently argue for market-driven development and technology neutrality. 7 coordinated business stakeholders answer explicitly "no" due to the technology neutrality principle. Two groups of altogether 8 coordinated business stakeholders emphasise the technology neutrality principle without explicitly answering "no". **Align RED with marine spatial planning and biodiversity protection (~20% of respondents)** When modifying RED II to promote offshore renewable energy, it needs to align with the Marine Strategy Framework Directive, EU-Nature Directives, Birds Directive, Habitats Directive and the Maritime Spatial Planning Directive. 11 coordinated responses from business stakeholders argue the Commission should set up forums on marine spatial planning. **RED should promote joint and hybrid projects, and regional cooperation (~20% of respondents)** Regulations should promote cross-border projects through joint and hybrid projects, and similarly, regional cooperation enabling interconnection of the coastal regions. 13 coordinated NGO stakeholders argue regional cooperation should be the guiding principle to guarantee effective joint and cross-Member States marine spatial planning. With regards to joint tendering and support schemes, the same 13 NGO stakeholders argue the Commission should provide guidance to this process while ensuring that all Member States involved enjoy clear benefits in the form of employment, technical development, or income. **Permitting processes should be improved (~10% of respondents)** Reducing complexity in permitting and administrative procedures would enable greater stakeholder cooperation and speed up processes. 11 coordinated business stakeholders argue the Commission should set up forums on permitting to accelerate project development. **Use Union funds to reduce the cost of capital for offshore renewable energy (~5% of respondents)** 11 coordinated business stakeholders argue the Commission must use Union funds to reduce the cost of capital and enable development of offshore renewable energy in all European sea basins.

- *Renewables in Heating and Cooling*

There are a total of 9 main questions in this section of the questionnaire. Results are presented below.

Q4.1 How appropriate do you consider the following options for increasing the uptake of renewable energy in heating and cooling?

Q4.1 asked respondents to rate the appropriateness of five measures along a four point scale. In

Figure 3-21, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. The option considered the most appropriate is the use of *district heating and cooling networks with waste and renewable heat*. *Increased energy efficiency* is believed to be *very appropriate* by 64% of the respondents.

Figure 3-21 How appropriate do you consider the following options for increasing the uptake of renewable energy in heating and cooling?

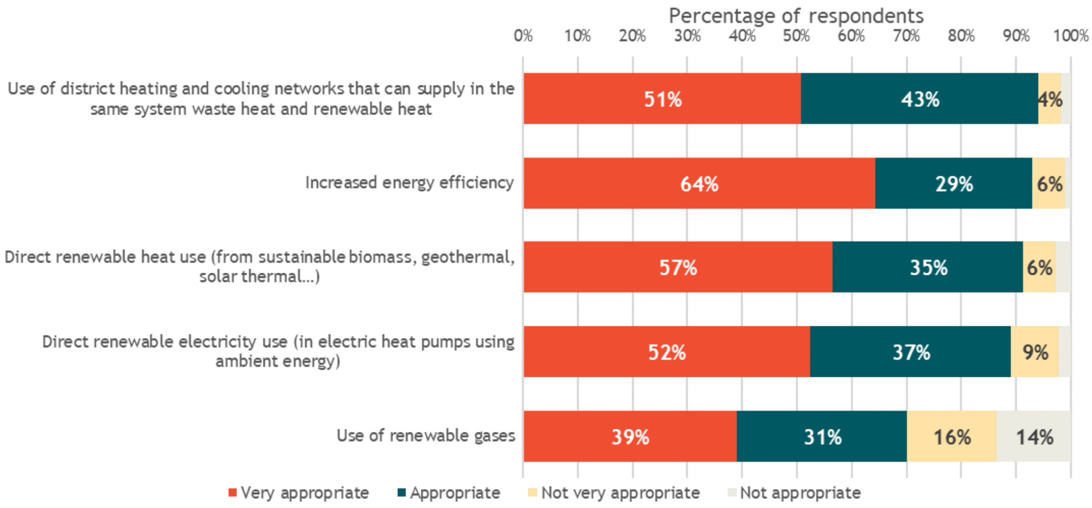


Table 3-31 Summary of results from Q4.1.1

Summary of results from Q4.1.1, open ended question concerning Q4.1, where participants were asked to explain other options that could be appropriate for increasing the uptake of renewable energy heating and cooling.
In total, Q4.4.1 received 234 responses, of which 15 are not unique. Responses were primarily from business organisations (238 responses), NGOs (52 responses) and EU citizens (19 responses). Other stakeholder groups responded in smaller frequencies ranging from 2 to 8 responses. The main messages from the analysis are summarised below. **System-wide integration and harmonisation across energy carriers (~30% of respondents)** Stakeholders want the EU to build system efficiency through greater harmonisation between the support systems offered to different energy carriers. **A broad portfolio of technological options should be promoted (~30% of respondents)** Infrastructure should support waste-to-energy plants, using existing facilities. Gas infrastructure should be "H2-ready", while hydrogen and synthetic fuels should be added as an option. Rooftop solar panels should also be supported. 17 NGOs via a coordinated response state that heat pumps, geothermal and solar heating should be scaled up and facilitated through heat storage and district heating. The same 17 stakeholders argue against renewable hydrogen used for low temperature heating in buildings, as other solutions are cheaper, more efficient and market ready. **Market-based solutions and consumer awareness to incentivise uptake (~20% of respondents)** Efficient system integration and renewable energy uptake will be fostered in the market and by consumers if they are incentivised through price signals (ETS, carbon-based taxes) and awareness.

Biomass has limited or non-existent climate benefits (~10% of respondents)
Stakeholders argue that the burning of biomass should not be increased because of the resulting air pollution, the minimal or non-existent climate benefits and potential biodiversity impacts from biomass sourcing, in particular regarding forest wood. 17 coordinated NGO stakeholders suggest biogas and bioenergy should be discouraged for heating in buildings, and any low-carbon sustainable bioenergy should fulfil stringent sustainability criteria and be restricted to critical applications.

Stop fossil fuel support (~10% of respondents)
Stakeholders, including 17 coordinated NGOs, argue subsidies for fossil fuels in the heating sector must come to an end so to have a level-playing field for renewable energy. The same 17 stakeholders argue indirect support provided by connecting new buildings to the existing gas infrastructure should also be stopped.

Limit to solar and geothermal, exclude wood burning and "sustainable biomass" (~5% of respondents)
NGO (6 coordinated responses) argue that an increase in the uptake of direct renewable heat use can be beneficial if it is limited to solar and geothermal while excluding additional wood and biomass burning. Another group of 9 NGO argue the structure of this question does not differentiate appropriately between energy sources, e.g., "sustainable biomass" and solar- and geothermal energy; 3 of them explicitly do not agree with the use of sustainable biomass but support solar and geothermal.

Prioritise biomass, solar heating, district heating and waste heat (~5% of respondents)
9 coordinated business stakeholders argue biomass, solar heating, district heating and waste heat should be favoured instead of electric heating, as increased use of electricity for heating will lead to more use of fossil-based marginal power production. Increased electric heating will also lead to increased capacity problems during the winter season.

Other suggestions (<5% of respondents)
5 coordinated business organisations suggest binding target for renewable heating and cooling. When including waste heat there should be a precautionary approach to avoid locking in fossil fuels and to promote the use of renewable heating and waste from renewable processes in district heating when possible (for this purpose the definitions of efficient district heating should include an increased renewable threshold).

Q4.2 Should the current indicative target of 1.3 ppt (or 1.1 ppt, if waste heat and cold is not used), annual average increase of renewable energy in heating and cooling set for the period of 2021-2030 in Article 23 become a binding target for Member States?

Q4.2 received 422 responses (Figure 3-22). A little over half of the participants (51%) think that the current indicative target of 1.3ppt annual average increase of renewable energy in heating and cooling set for the period 2021-2030 in Article 23 should *not* become a binding target for Member States. The rest of the respondents think that it should become a binding target for Member States (49%).

Figure 3-22 Should the current indicative target of 1.3 ppt (or 1.1 ppt, if waste heat and cold is not used), annual average increase of renewable energy in heating and cooling set for the period of 2021-2030 in Article 23 become a binding target for Member States? (n=422)

The results are split amongst stakeholders (Table 3-32). Citizens and representatives of academic institutions, consumer organisations, public authorities, trade unions and other organisations often think that the target should be binding. Those representing business organisations, environmental organisations and NGOs more often think that it should not be binding. Based on feedback provided to other questions, the main argument from NGOs and environmental organisations is that a biding target would incentivise bioenergy which they oppose on the ground of ensuring better protection of forests and risks related to air pollution.

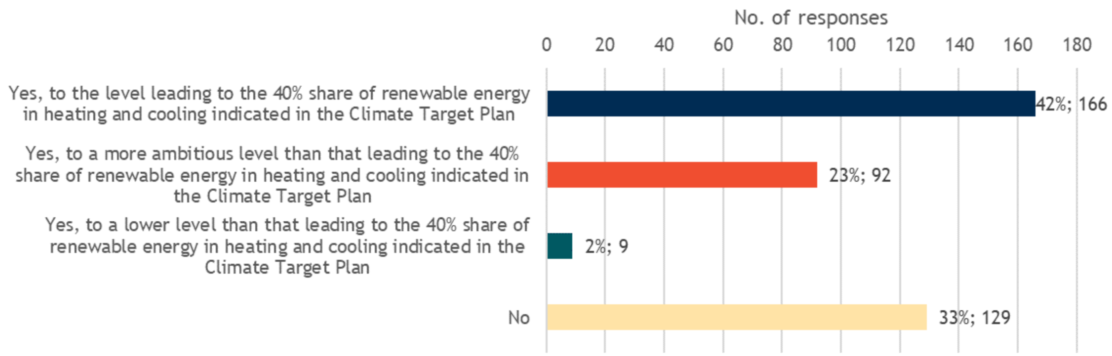
Table 3-32 Stakeholder correlation analysis for Q4.2

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	72% (48)	28% (19)
In a professional capacity or on behalf of an organisation	44% (157)	56% (198)
Of which:		
Academic/research institution	*82% (9)*	*18% (2)*
Business organisation	*44% (108)*	*56% (135)*
Consumer organisation	*80% (4)*	*20% (1)*
NGO/environmental organisation	*24% (15)*	*76% (47)*
Public authority	*50% (10)*	*50% (10)*
Trade union	*100% (1)*	*0% (0)*
Other	*77% (10)*	*23% (3)*

Q4.3 Should the annual average target of 1.3 ppt be increased?

Q4.3 received 396 responses (Figure 3-23). In total, 67% of the participants think that the annual average target of 1.3 ppt should increase in some way. 42% believe that it should increase to the level leading to the 40% share of renewable energy in heating and cooling indicated in the Climate Target Plan (166 responses). 23% think that it should be increased to a more ambitious level (92 responses). About a third of the participants think that the target should not increase (129 responses).

Figure 3-23 Should the annual average target of 1.3 ppt be increased? (n=396)



Those representing academic/research institutions, business organisations,/business organisations and *other* organisations most often think that the target should increase to match the Climate Target Plan ambitions (Table 3-33). Citizens and the one participant representing a trade union most often think that the target should be increased to a more ambitious target. NGOs/environmental organisations and public authorities most often think that the target should *not* increase. Of the three consumer organisations that responded to this question, their reply is split among these three responses.

Table 3-33 Stakeholder correlation analysis for Q4.3

	Yes, to the level leading to the 40% share of renewable energy in heating and cooling indicated in the Climate Target Plan	Yes, to a lower level than that leading to the 40% share of renewable energy in heating and cooling indicated in the Climate Target Plan	Yes, to a more ambitious level than that leading to the 40% share of renewable energy in heating and cooling indicated in the Climate Target Plan	No
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	33% (23)	3% (2)	39% (27)	25% (17)
In a professional capacity or on behalf of an organisation	44% (143)	2% (7)	20% (65)	34% (112)
Of which:				
Academic/research institution	*70% (7)*	*0% (0)*	*20% (2)*	*10% (1)*
Business organisation	*50% (114)*	*2% (5)*	*20% (46)*	*27% (61)*
Consumer organisation	*33% (1)*	*0% (0)*	*33% (1)*	*33% (1)*
NGO/environmental organisation	*16% (9)*	*2% (1)*	*14% (8)*	*69% (40)*
Public authority	*28% (5)*	*0% (0)*	*28% (5)*	*44% (8)*
Trade union	*0% (0)*	*0% (0)*	*100% (1)*	*0% (0)*
Other	*64% (7)*	*9% (1)*	*18% (2)*	*9% (1)*

Q4.4 Do you think renewable electricity used for heating and cooling should be counted towards the target for heating and cooling?

Q4.4 received 432 responses (Figure 3-24). Four of every five responses are in favour of counting renewable electricity used for heating and cooling towards the heating and cooling target (343 responses). 21% of the participants disagree. Preference for counting electricity towards the heating and cooling target is common among all the stakeholders groups, though at different margins (Table 3-34).

Figure 3-24 Do you think renewable electricity used for heating and cooling should be counted towards the target for heating and cooling? (n=432)

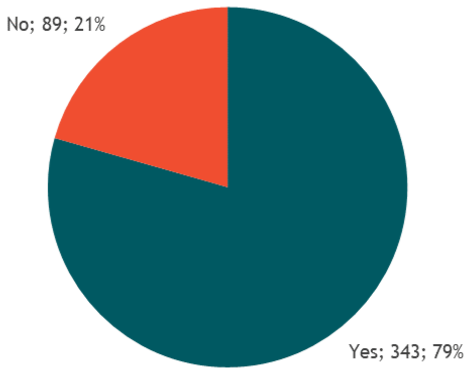


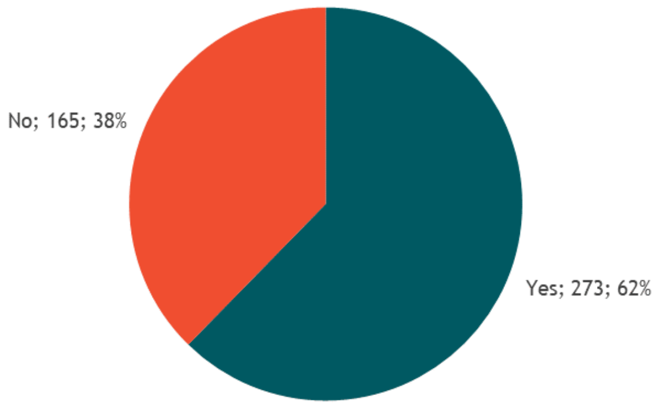
Table 3-34 Stakeholder correlation analysis for Q4.4

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	70% (49)	30% (21)
In a professional capacity or on behalf of an organisation	81% (294)	19% (68)
Of which:		
Academic/research institution	*67% (8)*	*33% (4)*
Business association	*82% (98)*	*18% (22)*
Company/business organisation	*74% (90)*	*26% (32)*
Consumer organisation	*83% (5)*	*17% (1)*
Environmental organisation	*100% (16)*	*0% (0)*
Non-governmental organisation (NGO)	*96% (44)*	*4% (2)*
Public authority	*79% (19)*	*21% (5)*
Trade union	*0% (0)*	*0% (0)*
Other	*88% (14)*	*13% (2)*

Q4.5 Do you think that renewable hydrogen and synthetic fuels produced using renewable electricity and used in heating and cooling should be counted towards the target for heating and cooling?

Q4.5 received 438 responses (Figure 3-25). 62% of the respondents think that hydrogen and synthetic fuels produced using renewable electricity and used in heating and cooling should be counted towards the target for heating and cooling (273 responses). 38% of the respondents disagree (165 responses).

Figure 3-25 Do you think that renewable hydrogen and synthetic fuels produced using renewable electricity and used in heating and cooling should be counted towards the target for heating and cooling? (n=438)



The opinions concerning whether to count renewable hydrogen and synthetic fuels towards the target for heating and cooling differ among stakeholders (Table 3-35). EU citizens and those representing environmental organisations and NGOs more often think that these energy sources should not count towards the heating and cooling target. The remaining stakeholders groups more often think that they should be counted.

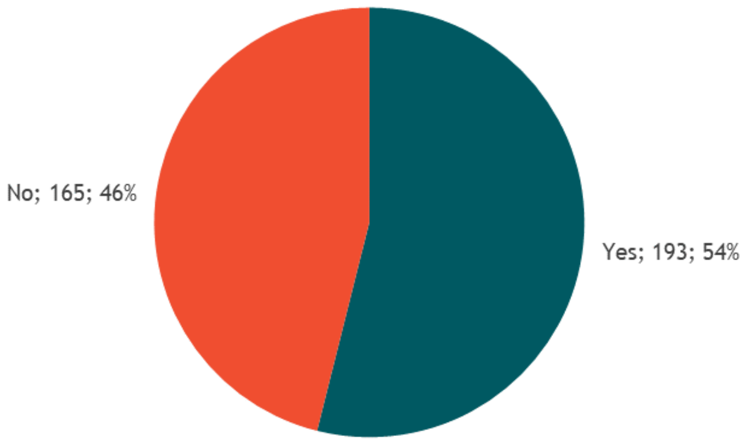
Table 3-35 Stakeholder correlation analysis for Q4.5

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	48% (34)	52% (37)
In a professional capacity or on behalf of an organisation	65% (239)	35% (128)
Of which:		
Academic/research institution	*73% (8)*	*27% (3)*
Business organisation	*74% (182)*	*26% (63)*
Consumer organisation	*75% (3)*	*25% (1)*
NGO/environmental organisation	*25% (17)*	*75% (50)*
Public authority	*68% (15)*	*32% (7)*
Trade union	*0% (0)*	*0% (0)*
Other	*78% (14)*	*22% (4)*

Q4.6 Do you think the list of measures provided in the Directive that Member States can use to increase the share of renewables in heating and cooling should be expanded or made more detailed?

Q4.6 received 358 responses (Figure 3-26). 54% of the respondents think that the list of measures provided in the Directive should be expanded or more detailed (193 responses). 46% of the respondents disagree (165 responses).

Figure 3-26 Do you think the list of measures provided in the Directive that Member States can use to increase the share of renewables in heating and cooling should be expanded or made more detailed? (n=358)



EU/Non-EU citizens and those representing business organisations, consumer organisations and public authorities more often think that this list of measures should not be expanded or more detailed (Table 3-36). The other types of stakeholders more often think that this list of measures should be expanded or more detailed.

Table 3-36 Stakeholder correlation analysis for Q4.6

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	41% (25)	59% (36)
In a professional capacity or on behalf of an organisation	57% (168)	43% (129)
Of which:		
Academic/research institution	*70% (7)*	*30% (3)*
Business organisation	*49% (97)*	*51% (101)*
Consumer organisation	*25% (1)*	*75% (3)*
NGO/environmental organisation	*87% (45)*	*13% (7)*
Public authority	*43% (9)*	*57% (12)*
Trade union	*0% (0)*	*0% (0)*
Other	*75% (9)*	*25% (3)*

Table 3-37 Summary of results from Q4.6.1

Summary of results from Q4.6.1, open ended question concerning Q4.6, where participants were asked to specify whether they think the list of measures provided in the Directive that Member States can use to increase the share of renewables in heating and cooling should be expanded or made more detailed.
In total, Q4.6.1 received 113 responses, of which 12 are not unique. Responses are primarily from business organisations (55 responses), NGOs (37 responses) and EU citizens (9 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-6 responses. The main messages from the analysis are summarised below.

Give priority to solar and geothermal energy (~25% of respondents)
The measures should more clearly favour solar and geothermal energy to foster their increased uptake. This is argued by a coordinated group of 4 NGO stakeholders who also claim that burning of biomass should not be increased because of the resulting air pollution, the minimal or non-existent climate benefits. Similarly, coordinated responses from 13 NGO stakeholders suggest only measures that support a binding sub-target for renewable heat should be strengthened, which should steer towards a higher uptake of renewable electricity, solar heating and geothermal.

Details on waste heat should be expanded (~10% of respondents)
The energy potential from waste heat is large and should refer to more diverse sources (e.g., from commercial data centres, transport metro systems, sanitary hot water in residencies and waste heat or cold in supermarkets). The definition on waste heat can also be modified to cover energy recovered from exhaust air in buildings. The concept of waste heat and cold should be enlarged to residential and commercial heat pump application.

All climate neutral technologies should be sought (~10% of respondents)
Stakeholders suggest the measures and their detailed formulations should not be exclusive, they should reflect the technology neutrality principle.

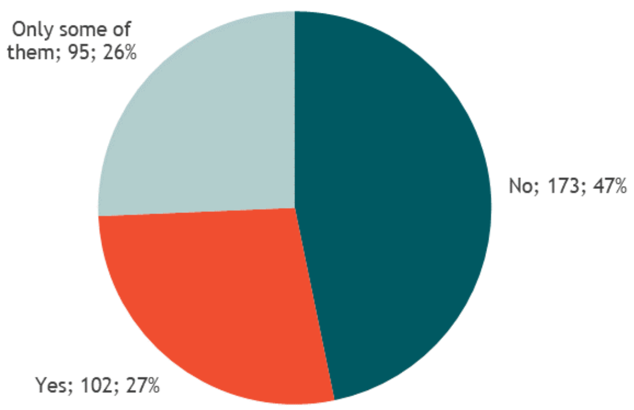
Measures should reflect decentralised solutions (~10% of respondents)
Microgrids, distributed energy resources and energy storage are vital for an integrated decentralised energy system. Measures could mandate that technologies (e.g., on-site solar) are made ready for micro-grids. Generally, measures should promote local/decentralised solutions.

Biomass measures should align with biodiversity protection (~5% of respondents)
Stakeholders argue measures promoting biomass should be protective of biodiversity and aligned with biodiversity regulations.

Q4.7 Do you think these measures should be made binding?

Q4.7 received 370 responses (Figure 3-27). 47% of the respondents think that the list of measures mentioned in Q4.6 should not be binding (173 responses). 28% of the respondents disagree and think that they should be binding (102 responses). 26% of the respondents think that only some of the measures should be binding (95 responses).

Figure 3-27 Do you think these measures should be made binding? (n=370)



EU/Non-EU citizens as well as those representing academia, consumer organisations and *other* organisations tend to think that the measures should be binding (Table 3-38). Whereas those who represent NGOs/environmental organisations tend to think that only some of the measures should be binding. Those representing business organisations and public authorities more often think that the measures should not be binding.

Table 3-38 Stakeholder correlation analysis for Q4.7

	Yes	Only some of them	No
	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	50% (31)	18% (11)	32% (20)
In a professional capacity or on behalf of an organisation	23% (71)	27% (84)	50% (153)
Of which:			
Academic/research institution	*50% (5)*	*30% (3)*	*20% (2)*
Business organisation	*18% (38)*	*19% (39)*	*63% (129)*
Consumer organisation	*80% (4)*	*0% (0)*	*20% (1)*
NGO/environmental organisation	*23% (13)*	*66% (37)*	*11% (6)*
Public authority	*24% (5)*	*14% (3)*	*62% (13)*
Trade union	*0% (0)*	*0% (0)*	*0% (0)*
Other	*60% (6)*	*20% (2)*	*20% (2)*

Table 3-39 Summary of results from Q4.7.1

Summary of results from Q4.7.1, an open ended question concerning Q4.7, where participants were asked to explain whether they think the measures referred to in Q4.6 should be made binding.

In total, Q4.7.1 received 57 responses, of which 10 are not unique. Responses are primarily from business organisations (28 responses) and NGOs (26 responses). Other stakeholder groups submitted generally 1 response each. The main messages from the analysis are summarised below.

Binding regulations for renewable electricity, solar- and geothermal energy (~40% of respondents)
According to a coordinated group of 16 NGO stakeholders, the list of measures in the Directive should (only) be binding for renewable electricity, solar- and geothermal energy.

Regulations should be binding for energy efficiency measures (~30% of respondents)
Several stakeholders, including a group of 4 coordinated business stakeholders suggest energy efficiency measures should be made binding for new buildings and in renovations, e.g., because of the direct mitigation and GHG reduction effect.

Member States should be left flexibility to reach the electrification target (~30% of respondents)
Measures should not be binding but good practice should be encouraged. Member States have different conditions, e.g., Southern European countries have less potential in district heating and cooling.

Regulations should not be binding for biomass (~15% of respondents)
Making biomass measures binding would collide with air pollution provisions and biodiversity protection. This is stated by several stakeholders including a group of 3 coordinated NGOs.

The electrification target of 40% should be made binding (~5% of respondents)

A few stakeholders, including a group of 3 coordinated business stakeholders suggest the indicative RES target of 40% should be binding rather than making the measures binding.

Q4.8 How would you rank the appropriateness of the following measures in increasing the share of renewable energy in heating and cooling?

Q4.8 asked respondents to rate the appropriateness of seven measures along a four point scale. In Figure 3-28, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. Participants find that *pricing instruments* and *EU guidance on support schemes* to be *(very) appropriate* measures.

Figure 3-28 How would you rank the appropriateness of the following measures in increasing the share of renewable energy in heating and cooling?

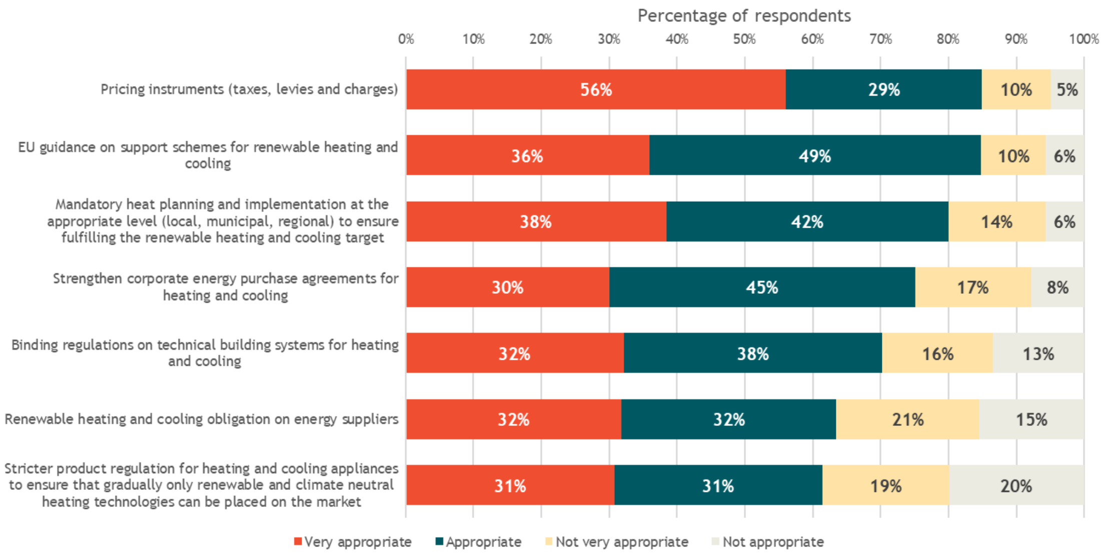


Table 3-40 Summary of results from Q4.8.1

Summary of results from Q4.8.1, an open ended question concerning Q4.8, where participants were asked to specify other appropriate measures for increasing the share of renewable energy in heating and cooling.
In total, Q4.8.1 received 177 responses, of which 20 were not unique. Responses were primarily from business organisations (105 responses), NGOs (44 responses) and EU citizens (10 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-7 responses. The main messages from the analysis are summarised below. **Carbon pricing (~25% of respondents)** Many stakeholders, including 4 coordinated business stakeholders emphasise the need for holistic carbon pricing to encourage the switch to RES solutions for economic actors and consumers. 2 other coordinated business stakeholders say energy and carbon taxation is the most powerful tool outside the EU ETS to drive the energy transition. In total, 16 stakeholders mention the ETS as a useful tool while 27 mention the potential effectiveness of energy and carbon taxation across the EU. **Opposition towards "climate neutral" heating technologies (~10% of respondents)**

Summary of results from Q4.8.1, an open ended question concerning Q4.8, where participants were asked to specify other appropriate measures for increasing the share of renewable energy in heating and cooling.
Many stakeholders, including two groups of altogether of 14 coordinated NGOs oppose “climate neutral” heating technologies, which they refer to as either fossil fuel based or bioenergy based on feedstocks that may increase emissions compared to fossil fuels. **Consumer awareness and mobilisation at local levels (~5% of respondents)** Stakeholders suggest a change in mindset is essential, pointing to raised awareness for local authorities and at the consumer level. 4 coordinated business stakeholders argue funding and technical assistance is needed on-site for the development of decentralised energy systems including district heating. **Stricter product regulations (~5% of respondents)** Stakeholders suggest stricter product regulations could be appropriate if they recognise the potential for substituting conventional fuels with renewable fuels. The Energy Related Product Directive could be revised to guarantee low carbon appliances with GHG reduction impact. **Guarantees of Origin (~5% of respondents)** A few stakeholders suggest GOs have clear advantages over other methods (e.g., PPAs). GOs may help avoid double counting (e.g., with regards to biomethane production statistics). Some argue GOs should be mandatory for the whole energy market.

Q4.9 Which of the following measures do you think could be appropriate to encourage public authorities to identify renewable heating and cooling potentials?

Q4.9 asked respondents to rate the appropriateness of three measures along a four point scale. In Figure 3-29, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. Notably, 52% of respondents think that *mandatory long-term strategies with binding milestones and measures taking into account synergies with other policy areas* are *very appropriate*.

Figure 3-29 Which of the following measures do you think could be appropriate to encourage public authorities to identify renewable heating and cooling potentials?

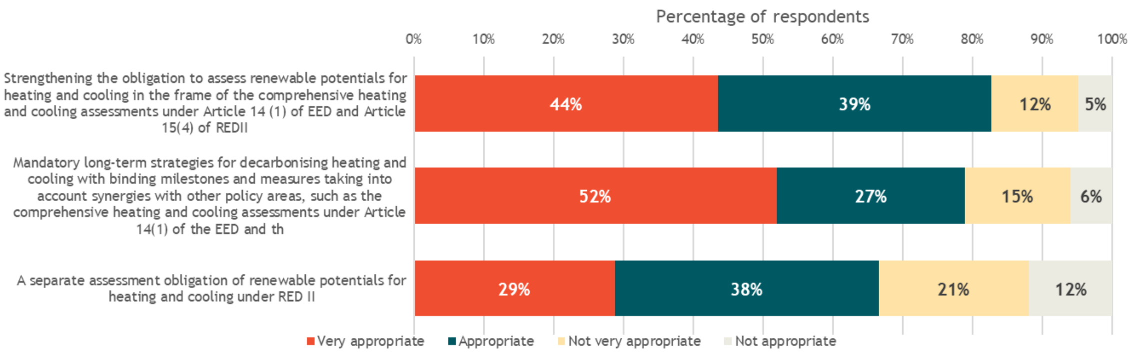


Table 3-41 Summary of results from Q4.9.1

Summary of results from Q4.9.1, an open ended question concerning Q4.9, where participants were asked to specify other measures they think could be appropriate to encourage public authorities to identify renewable heating and cooling potentials.
In total, Q4.9.1 received 115 responses, of which 14 are not unique. Responses were primarily from business organisations (61 responses), NGOs (27 responses) and EU citizens (12 responses). Other stakeholder groups responded in smaller frequencies ranging from 1-6 responses. The main messages from the analysis are summarised below. **Support for mandatory long-term strategies (~20% of respondents)** Many stakeholders, including 12 coordinated NGOs, are highly supportive of mandatory long-term strategies for decarbonising heating and cooling provided that this leads to a comprehensive and reinforced policy framework that addresses in a coherent way both demand and supply. **Local / municipal authorities should be encouraged (~10% of respondents)** Many stakeholders want encouragement at the local / municipal level. 4 coordinated responses from a mix of stakeholders suggest building capacity of local authorities is of vital importance to allow them to fulfil their potential. 3 coordinated business stakeholders argue for energy planning at local level. 9 more coordinated business stakeholders want municipalities to be encouraged to plan for district heating and cooling. **Measures must be consistent and avoid overlapping requirements (~10% of respondents)** According to 3 coordinated business stakeholders, there needs to be consistency between NECPs, long-term renovation strategies and the comprehensive assessment from Article 14 of the Energy Efficiency Directive. Other stakeholders argue against overlapping requirements between the Renewable Energy Directive, Energy Efficiency Directive and Energy Performance of Buildings Directive. **Discretion should be given to Member States (~10% of respondents)** 9 coordinated business stakeholders suggest measures should be up to Member States to handle. Similarly, another 2 coordinated business stakeholders argue requirements for technical building systems for heating and cooling should be at the discretion of Member States. **No preferential treatment to fossil cogeneration (~10% of respondents)** 12 coordinated NGOs suggest Article 14 of the EED should be revised to abolish the preferential treatment of fossil cogeneration and create a level playing field for renewable heat technologies. **Carbon taxation (~10% of respondents)** 9 coordinated business stakeholders suggest carbon taxation will make introduction of renewable heating and cooling profitable for market actors.

Renewables in District Heating and Cooling

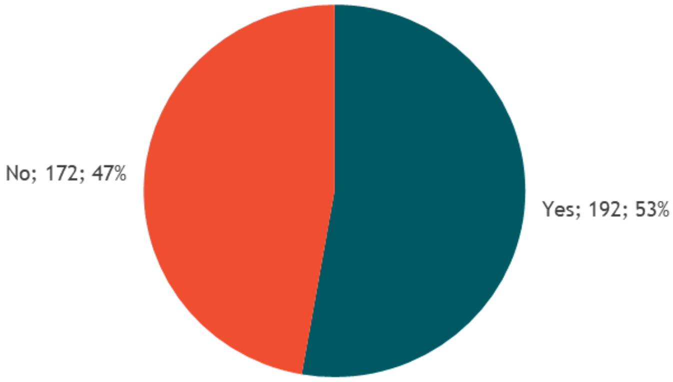
There are a total of 6 main questions in this section of the questionnaire. Results are presented below.

Q5.1 heating and cooling set for the period of 2021¬2030 become a binding target?

Q5.1 received 364 responses (

Figure 3-30). Over half of the participants think that the current target for renewable energy in district heating and cooling should become binding (192 responses; 53%). The rest of the respondents think it should not be a binding target (172 responses).

Figure 3-30 Should the current indicative target of 1 ppt annual average increase of renewable energy in district heating and cooling set for the period of 2021¬2030 become a binding target? (n=364)



Those representing environmental organisations, NGOs and public authorities more often think that the current indicative target for renewable energy in district heating and cooling should *not* become binding (Table 3-42). Based on feedback provided to other questions, the main argument from NGOs and environmental organisations is that a biding target would incentivise bioenergy which they oppose on the ground of ensuring better protection of forests and risks related to air pollution. The other stakeholder groups tend to think that it should be binding. Those representing companies/business organisations are split 51% yes to 49% no.

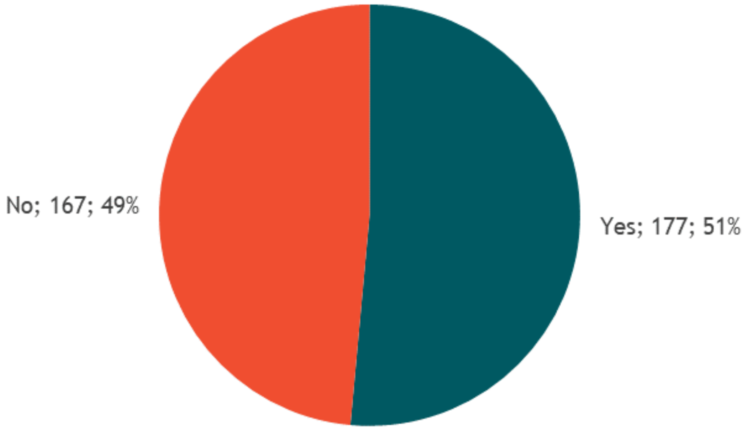
Table 3-42 Stakeholder correlation analysis for Q5.1

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	73% (44)	27% (16)
In a professional capacity or on behalf of an organisation	49% (148)	51% (156)
Of which:		
Academic/research institution	*70% (7)*	*30% (3)*
Business organisation	*51% (105)*	*49% (102)*
Consumer organisation	*75% (3)*	*25% (1)*
NGO/environmental organisation	*30% (14)*	*70% (32)*
Public authority	*33% (7)*	*67% (14)*
Trade union	*100% (1)*	*0% (0)*
Other	*73% (11)*	*27% (4)*

Q5.2 Should the level of the current indicative target of 1 ppt annual average increase of renewable energy in district heating and cooling be increased?

Q5.2 received 344 responses (Figure 3-31). More than half of the participants think that the current indicative target for renewable energy in district heating and cooling should increase (177 responses). The other 49% of respondents think that it should not increase.

Figure 3-31 Should the level of the current indicative target of 1 ppt annual average increase of renewable energy in district heating and cooling be increased? (n=344)



Stakeholders representing environmental organisations, NGOs and public authorities more often think that the target for district heating and cooling *should not* increase (Table 3-43). All other stakeholders tend to think that it should increase.

Table 3-43 Stakeholder correlation analysis for Q5.2

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	57% (34)	43% (26)
In a professional capacity or on behalf of an organisation	50% (143)	50% (141)
Of which:		
Academic/research institution	*67% (6)*	*33% (3)*
Business organisation	*56% (109)*	*44% (84)*
Consumer organisation	*67% (2)*	*33% (1)*
NGO/environmental organisation	*24% (11)*	*76% (34)*
Public authority	*25% (5)*	*75% (15)*
Trade union	*100% (1)*	*0% (0)*
Other	*69% (9)*	*31% (4)*

Table 3-44 Summary of results from Q5.2.1

Summary of results from Q5.2.1, an open ended question concerning Q5.2, where participants were asked to specify how much the level of the current indicative target of 1 ppt annual average increase of renewable energy in district heating and cooling should be increased.
In total, Q5.2.1 received 85 responses, of which 12 are not unique. Most of these participants responded for business organisations (56 participants), followed by EU citizens (15 participants), and NGOs (5 participants). Other stakeholders responded in smaller frequencies, ranging from 1 to 3 responses.

Stakeholders provided both quantitative and qualitative suggestions of how much the target for renewable energy in district heating and cooling should be increased.

Responses with a quantified target

In total, 18 respondents (21%) provided a numerical value of how much the target should increase (Figure 3-32). 10 respondents think that the target should increase to between 2 and 3 ppts, consisting mostly of business associations and EU citizens. 3 participants think that the target should increase by 50%.

Figure 3-32 Quantitative responses to Q5.2.1

Responses without a quantified target

69 participants (79%) provided an explanation without a specific value (Figure 3-33). 14 participants explicitly want to make sure that waste heat is included in the target. 11 business organisations (as a coordinated group) want to make sure that renewable fuels like biomass and biogenic waste are promoted but not with a binding target. 8 participants think that the target needs to be more ambitious in general. 8 participants think that the target should vary per Member State. 8 participants think that the target needs to match the targets set by the 2030 and/or 2050 emission goals. 6 participants, as a coordinated group, think that the targets should correspond with the increase of overall targets and other sectoral objectives. 2 participants think that there needs to be an assessment to find the optimal target. 12 participants provided other answers, including providing a general indication of support of an increase in the target as well as increasing the target so that it ensures investments are made to upgrade heating and cooling systems.

Summary of results from Q5.2.1, an open ended question concerning Q5.2, where participants were asked to specify how much the level of the current indicative target of 1 ppt annual average increase of renewable energy in district heating and cooling should be increased.

Figure 3-33 Qualitative responses to Q5.2.1

Q5.3 How would you rank the appropriateness of the following measures in encouraging the use of waste heat and cold by district heating and cooling networks?

Q5.3 asked respondents to rate the appropriateness of five measures along a four point scale. In Figure 3-34 the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. Participants find that requiring relevant authorities to prepare necessary plans, policies or regulations for enabling waste H&C into district heating to be an *appropriate or very appropriate* measure. Notably, the majority of respondents think that a specific target for waste heat and cold use would be *not very appropriate* (29%) and *not appropriate* (29%) to encourage the use of waste heat and cold by district heating and cooling networks.

Figure 3-34 How would you rank the appropriateness of the following measures in encouraging the use of waste heat and cold by district heating and cooling networks?

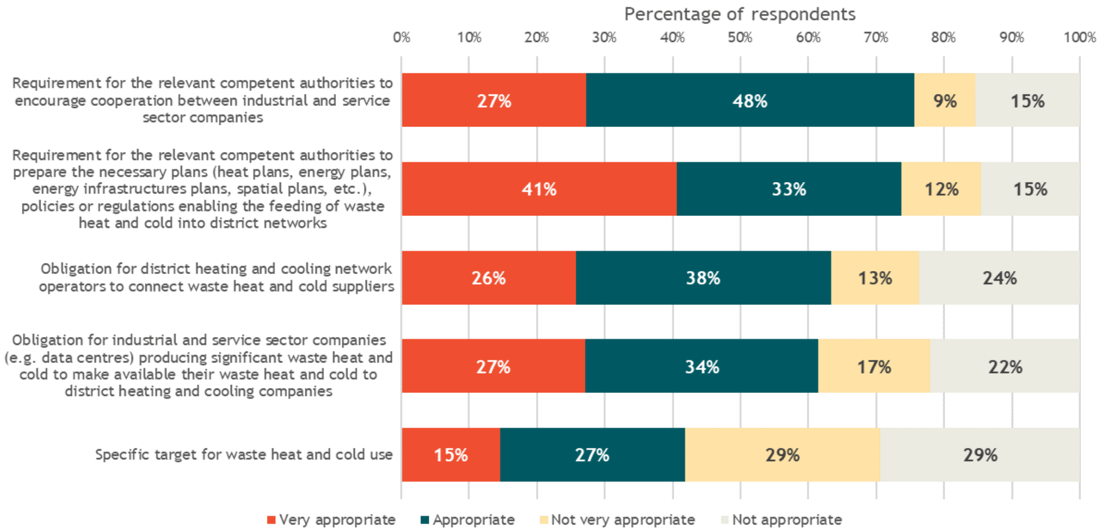


Table 3-45 Summary of results from Q5.3.1

Summary of results from Q5.3.1, an open ended question concerning Q5.3, where participants are asked to suggest additional measures to encourage the use of waste heat and cold by district heating and cooling networks.
In total, Q5.3.1 received 133 responses, of which 17 are not unique. Most of these participants responded for business organisations (87 participants), followed by NGOs (26 participants) and EU citizens (8 participants). Other stakeholders responded in smaller frequencies, ranging from 1-5 responses. The main messages from the analysis are summarised below. **Economic and technical feasibility (~20% of respondents)** More than 25 stakeholders (the majority being business organisations) think that waste heat should only be promoted where it is economically (maintain competition) and technically (temperature and pressure) feasible. This includes three coordinated groups of 7, 5 and 4 business organisations. **No obligations to use waste heat (~20% of respondents)** Many business organisations think that waste heat use should be promoted but not forced. **Energy system integration (~15% of respondents)** At least 18 stakeholders (mainly business-related) think that an integral approach should be adopted, including a coordinated group of 5. An integrated energy system would create a balance in order to avoid shortages and disruptions of energy production and industrial processes. **Other suggestions (≤10% of respondents)** • **Agreements made on commercial basis and use market-based tools** A coordinated group of 9 business organisations think that the use of waste heat should be agreed upon on a commercial basis and market-based tools, like carbon taxation should be implemented to promote waste-heat use. These opinions are also shared by other stakeholders. • **Current measures are sufficient, additional measures should go into EED** Several stakeholders, including a coordinated group of seven participants (NGOs and environmental organisations), think that the current measures on waste heat in RED are

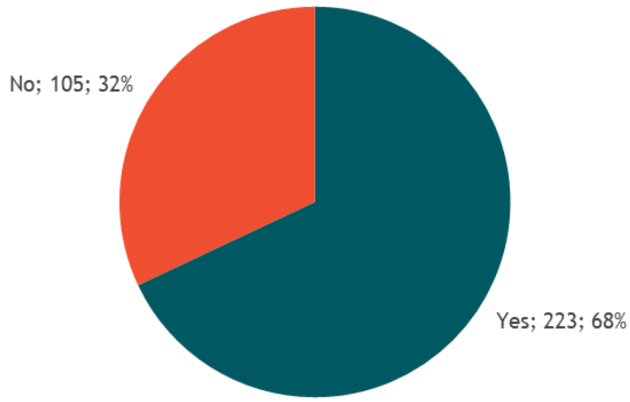
sufficient. Fourteen stakeholders, including this coordinated group, think that additional measures should be in the Energy Efficiency Directive instead.

- Waste heat use depends on local conditions
  A variety of stakeholders think that the use of waste heat is very dependent on local conditions and therefore should not be considered under general regulations. Alternatively, the use of waste heat should be dealt at the Member State or local level.
- Other stakeholders provided additional suggestions, including: promoting local cooperation; planning infrastructure investments; avoiding the use of biomass, fossil-fuels and imported waste; avoid burdening local authorities with costs; and promoting the use of waste heat on-site as well as waste heat as power.

Q5.4 Do you consider that third party access to district heating networks by renewable heat suppliers should be strengthened?

Q5.4 received 328 responses (Figure 3-35). A clear majority of participants think that third party access to district heating and cooling by renewable heat suppliers should be strengthened (223 responses). The other 32% of respondents disagree (105 responses).

Figure 3-35 Do you consider that third party access to district heating networks by renewable heat suppliers should be strengthened? (n=328)



Amongst all stakeholder groups, there seems to be a consensus that third party access should be strengthened, though the margin of agreement differs per stakeholder type (Table 3-46). For instance, 50% of those responding for public authorities agree while 94% of NGOs and environmental organisations agree.

Table 3-46 Stakeholder correlation analysis for Q5.4

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	75% (44)	25% (15)
In a professional capacity or on behalf of an organisation	67% (179)	33% (90)
Of which:		
Academic/research institution	*75% (6)*	*25% (2)*
Business organisation	*58% (102)*	*42% (75)*
Consumer organisation	*100% (4)*	*0% (0)*
NGO/environmental organisation	*94% (47)*	*6% (3)*
Public authority	*50% (8)*	*50% (8)*
Trade union	*100% (1)*	*0% (0)*
Other	*85% (11)*	*15% (2)*

Table 3-47 Summary of results from Q5.4.1

Summary of results from Q5.4.1, an open ended question concerning Q5.4, where participants are asked to explain why third party access to district heating networks by renewable heat suppliers should or should not be strengthened.

In total, Q5.4.1 received 119 responses, of which 2 are not unique. Most of these participants responded for business organisations (85 participants), followed by EU citizens (8 participants), and NGOs (8 participants). Other stakeholders responded in smaller frequencies, ranging from 1-5 responses.

Those that think that third party access should be strengthened gave the following reasons:

Remove monopolies, increase competition (~20% of respondents)

Around 13 stakeholders mention how district heating and cooling networks are (often) monopolies. To make the district heating and cooling sector more competitive and therefore reduce prices and incentivise innovation in renewable conversion, these stakeholders agree that third party access should be strengthened. These are mainly business organisations (8 participants) as well as a consumer organisation, NGO, environment organisation, *other* organisation and EU citizen. Though not mentioning *monopoly* specifically, 14 other stakeholders also reason that TPA would increase competition, reduce prices and stimulate innovation.

More efficient (~15% of respondents)

Six business organisations think that strengthening third party access will make the DHC system more efficient and thus reduce costs.

Other explanations (<10% of respondents)

- **Strengthen access with certain conditions**
  Some stakeholders think that third party access should be strengthen, but only under certain conditions. A few stakeholders think that TPA should be facilitated but not forced. Also, there should be exceptions if TPA would impact the business case of a vertically integrated entity. Further, the economic conditions should be checked to make sure TPA is possible.
- **All renewable options must be used**
  Three stakeholders (two individuals and an environmental organisation) think that all sources must be used to decarbonise DHC.

Those that think that third party access should *not* be strengthened gave the following reasons:

DHC is fundamentally different from other energy systems (~10% of respondents)

A coordinated group of three business organisations reason that DHC is fundamentally different than cross-border power and gas grids so it must be treated differently. These stakeholders think that opening all DHC grids to TPA would lead to economic inefficiency and compromise the development of DHC projects. Obligating TPA would thus be technically and economically unrealistic in the DHC sector. Further, as DHC is local in nature, other stakeholders are also concerned that strengthening TPA would put an additional burden on small, local district heating networks.

Other explanations (<10% of respondents)

- **RED sufficiently strengthens TPA**
  Several stakeholders think that RED already sufficiently strengthens TPA. Particularly, five business organisations mention the RED 2018 revision of Article 24, which provides the option of third-party energy taking into account the economic and technical conditions. One stakeholder specifically requesting that Art. 24 par. 3 remain.
- **Not relevant for Scandinavian countries**
  Eight stakeholders (7 business-related and 1 public authority) mention how these regulations are not needed in Scandinavian countries (Sweden and Finland). In Sweden, DHC is already decarbonised and in Finland the heating market is already sufficiently open.
- **Should not be regulated at the EU level**
  Several stakeholders think that TPA should not be regulated at the EU level. Instead, these agreements should be made at the market level.

Q5.5 Which of the following measures do you think would be appropriate in strengthening the rights of consumers in district heating and cooling networks?

Q5.5 asked respondents to rate the appropriateness of five measures along a four point scale. In Figure 3-36, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. Participants think that *improving consumer information* (82%) and *increasing price transparency* (79%) a *(very) appropriate* measure.

Figure 3-36 Which of the following measures do you think would be appropriate in strengthening the rights of consumers in district heating and cooling networks?

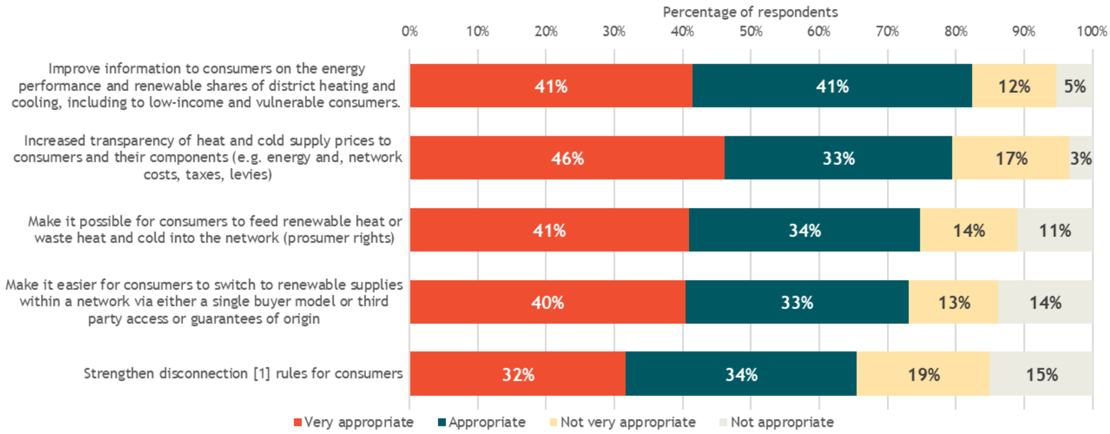


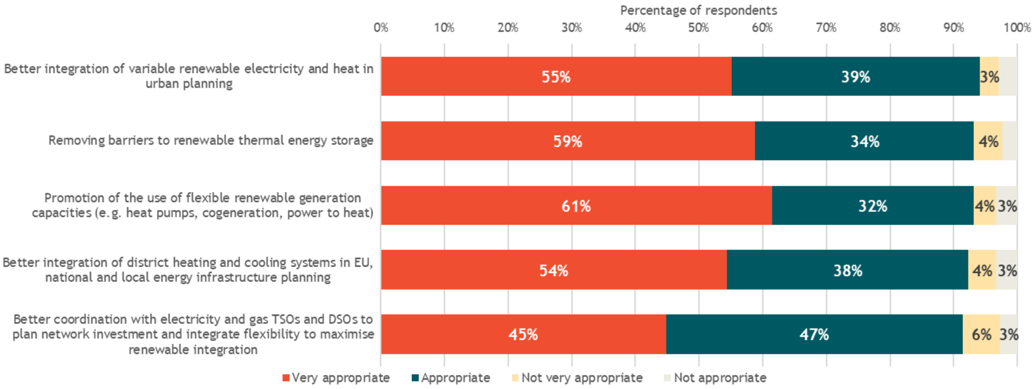
Table 3-48 Summary of results from Q5.5.1

Summary of results from Q5.5.1, open ended question concerning Q5.5, where participants are asked to suggest additional measures to strengthen the rights of consumers in district heating and cooling networks.
In total, Q5.5.1 received 86 responses, of which 9 are not unique. Most of these participants responded for business organisations (59 participants), followed by EU citizens (7 participants), and NGOs (7 participants). Other stakeholders responded in smaller frequencies, ranging from 2-6 responses. The main messages from the analysis are summarised below. **No additional information requirements (~15% of respondents)** Many business organisations, as well as one NGO and *other* organisation, think that no additional information requirements should be added. Some of these participants mention Article 24, par. 1, which they reason provides enough information rights to consumers and therefore additional requirements are unnecessary. As mentioned above, other stakeholders think there should be an impact assessment of the current RED and EED information requirements before any additional requirements are added. Further, five business organisations mention that the guarantees of origin system should in part support greater transparency and thus empower consumers. One company does not think that consumer rights should be regulated by RED. **Disconnection rights (~5% of respondents for; ~5% of respondents against)** Several stakeholders (business associations, NGO/environmental organisations) think that it is important that consumers have the right to disconnect from fossil-fuel district heating to renewable district heating. One of these stakeholder reasons that the right to disconnection prevents regulatory monopolies, which do not facilitate energy efficiency or the adoption of renewable energy. On the other hand, there are several business organisations and public authorities (about 5% of the respondents), which think that disconnection should be avoided. These stakeholders argue that disconnection makes DHC projects economically inefficient and reason that the current disconnection rules for consumers in RED II are already sufficient. **Other suggestions (≤10% of respondents)** • **Avoid policy overlap with EED** 9 stakeholders mention the Energy Efficiency Directive (EED). Three of these stakeholders are concerned that these regulations are already a part of EED and should not be included in RED to avoid policy overlap. The other six stakeholders think that since the information requirement from the current RED and EED has not be implemented and thus evaluated, no additional requirements should be added. • **Implement at Member State level, not at EU level** A coordinated group of nine business organisations, think that this should be regulated at the Member State level, not EU level. • **Prosumer rights** Several business organisations, as well as an NGO and *other* organisation, are concerned about strengthening prosumer rights and allowing prosumers to sell to the grid. • Other stakeholders mentioned the following comments/concerns: make sure new measures do not cause administrative burden on energy companies/grid operators; take international competitiveness into account; same rules should apply to all energy carriers.

Q5.6 How appropriate do you think the following measures are in making district heating and cooling systems be better integrated within the overall energy system?

Q5.6 asked respondents to rate the appropriateness of five measures along a four point scale. In Figure 3-37, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. For all five measures, more than 90% of the respondents think that the measure is appropriate or *very appropriate*.

Figure 3-37 How appropriate do you think the following measures are in making district heating and cooling systems be better integrated within the overall energy system?



- ### *Renewable energy in Buildings*

There are a total of 4 main questions in this section of the questionnaire. Results are presented below.

Q6.1 Do you think that Member States should require a minimum percentage of renewable energy in the energy use of new buildings or buildings subject to major renovation?

Q6.1 received 415 responses (Figure 3-38). In total, 78% of the participants think that *there should be a requirement* for a minimum percentage of renewable energy in the energy use of new buildings or building subject to major renovation. This is a common result across all stakeholders groups (Table 3-49). 16% of the participants indicate that this should only be for new buildings (65 responses) and 3% indicated that this *should only be for buildings subject to major renovation* (11 responses). 22% of the participants think that *there should not be a minimum percentage* (91 responses). *Yes* is the most common reply among all stakeholder groups (Table 3-49).

Figure 3-38 Do you think that Member States should require a minimum percentage of renewable energy in the energy use of new buildings or buildings subject to major renovation? (n=415)

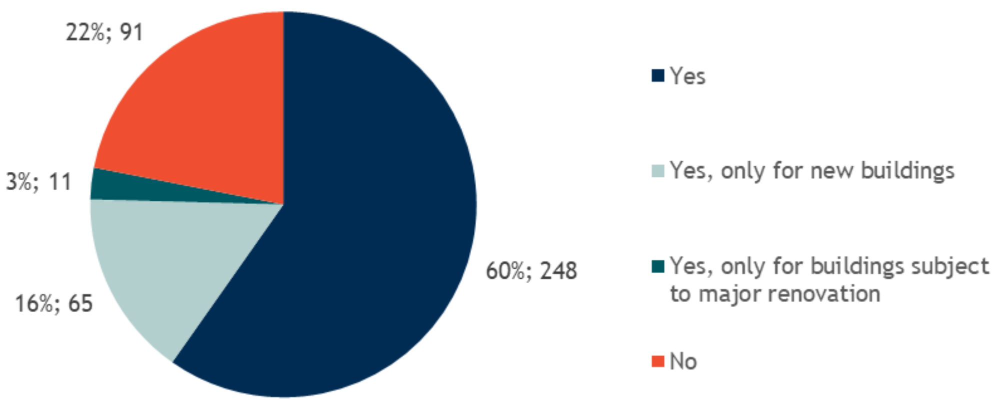


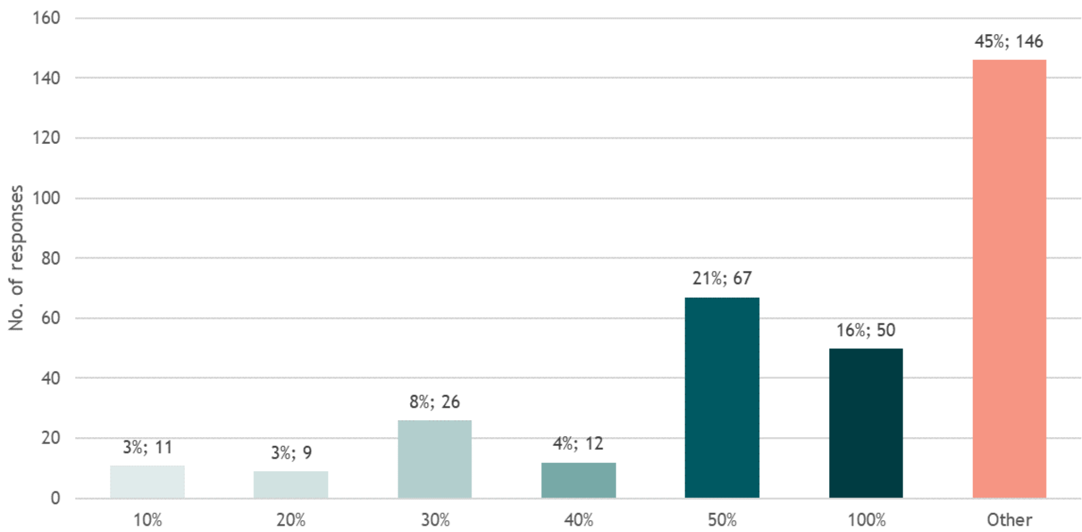
Table 3-49 Stakeholder correlation analysis for Q6.1

	Yes	Yes, only for new buildings	Yes, only for buildings subject to major renovation	No
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	62% (46)	16% (12)	5% (4)	16% (12)
In a professional capacity or on behalf of an organisation	59% (202)	16% (53)	2% (7)	23% (79)
Of which:				
Academic/research institution	*50% (5)*	*20% (2)*	*0% (0)*	*30% (3)*
Business organisation	*54% (124)*	*18% (40)*	*2% (5)*	*26% (59)*
Consumer organisation	*67% (4)*	*0% (0)*	*0% (0)*	*33% (2)*
NGO/environmental organisation	*83% (49)*	*5% (3)*	*2% (1)*	*10% (6)*
Public authority	*48% (10)*	*14% (3)*	*5% (1)*	*33% (7)*
Trade union	*100% (1)*	*0% (0)*	*0% (0)*	*0% (0)*
Other	*56% (9)*	*31% (5)*	*0% (0)*	*13% (2)*

Q6.2 If yes, what minimum percentage of energy consumed by a building do you think must come from renewable sources?

Q6.2 received 321 responses, almost 100% of the participants who replied *yes* to Q6.1 (Figure 3-39). 45% of the participants chose the *other* option. Amongst the provided percentages, *50%* is the most common response (21%; 67 responses); followed by *100%*, with 50 participants choosing this option. About 18% of the respondents chose a percentage of 40% or lower (58 responses).

Figure 3-39 If yes, what minimum percentage of energy consumed by a building do you think must come from renewable sources? (n=321)



Overall, for most stakeholder groups, the *other* option is the most common response (Table 3-50). For EU/Non-EU citizens and those representing academia, *50%* share of renewables is the most chosen option.

Table 3-50 Stakeholder correlation analysis for Q6.2

	Minimum share of RES in buildings						
	10%	20%	30%	40%	50%	100%	Other
	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)
As an individual in a personal capacity	5% (3)	3% (2)	12% (10)	5% (3)	34% (22)	26% (17)	15% (10)
In a professional capacity or on behalf of an organisation	3% (8)	3% (7)	7% (136)	4% (9)	18% (45)	13% (33)	53% (136)
Of which:							
Academic/research institution	0% (0)	11% (1)	0% (0)	0% (0)	56% (5)	11% (1)	22% (2)
Business organisation	4% (7)	2% (4)	8% (13)	5% (8)	18% (30)	11% (19)	51% (85)
Consumer organisation	0% (0)	0% (0)	0% (0)	0% (0)	33% (1)	0% (0)	67% (2)
NGO/environmental organisation	2% (1)	2% (1)	4% (2)	0% (0)	11% (5)	21% (10)	60% (28)
Public authority	0% (0)	6% (1)	13% (2)	0% (0)	13% (2)	19% (3)	50% (8)
Trade union	0% (0)	0% (0)	0% (0)	100% (1)	0% (0)	0% (0)	0% (0)
Other	0% (0)	0% (0)	7% (1)	0% (0)	14% (2)	0% (0)	79% (11)

Table 3-51 Summary of results from Q6.2.1

Summary of results from Q6.2.1, an open ended question concerning Q6.2, where participants were asked to specify the minimum percentage of energy consumed by a building must come from renewable sources.

In total, Q6.2.1 received 143 responses, of which 8 are not unique. Most of these participants responded for business organisations (83 participants), followed by NGOs (27 participants), other organisation (11 participants), EU citizens (10 participants) and public authorities (8 participants). Other stakeholders, such as those representing environmental organisations and academic institutions, responded as well but in smaller totals. The main messages from the analysis are summarised below.

Alternative minimums and timelines (~15% of respondents)

- A couple stakeholders (a company and academic/research institution) recommend a minimum between 20-50% which gradually increases over time. These include stakeholder from academia and companies;
- Some stakeholders (5%) recommend a minimum between 50-75%, which is not an option provided in Q6.2. These include stakeholders from business organisations, NGOs, other organisations and EU citizens;
- 3% of respondents (two companies and three EU citizens) recommend a minimum between 75% and 100%;
- Some stakeholders (6%) recommend a minimum of 100% by a certain time, such as 2030 or 2050. These include stakeholders from academia, business organisations, NGOs, other organisations and EU citizens.

Minimum dependent on type of building (~15% of respondents)

Summary of results from Q6.2.1, an open ended question concerning Q6.2, where participants were asked to specify the minimum percentage of energy consumed by a building must come from renewable sources.

Many stakeholders from business organisations, NGOs, and public authorities have indicated that minimums should differ depending on the type of building, whether it is residential/non-residential, publicly/privately-owned. Some reasons for this distinction include not imposing financial burdens on vulnerable consumers and different energy needs.

Minimum dependent on condition (new/renovated) (~10% of respondents)

Several participants from business organisations, consumer organisations, NGOs and environmental organisations have indicated that minimums should differ depending on the condition of the building in terms of being new or renovated.

Other suggestions (≤15% of respondents)

- **Independently decided by Member States**
  Many participants across many stakeholder groups (companies, business associations, public authority and EU citizens) believe that these minimums should be decided by Member States and depend on the national/local circumstances.
- **No use of biomass/bioenergy**
  There is a significant call from NGOs, as well as environment organisations and EU citizens to make sure that biomass/bioenergy is not incentivised to be consumed by buildings.
- **Alternative methods (carbon taxation, public support schemes)**
  Some participants from companies, business associations and EU citizen suggest alternative methods instead of minimum renewable energy consumption, including carbon taxation and public support schemes. Carbon taxation is argued to make heating and cooling with fossil fuels non-competitive.

Q6.3 How would you rank the following measures in terms of their appropriateness in ensuring that buildings’ heating and cooling systems are increasingly based on renewable energy while fossil fuels are gradually phased out?

Q6.3 asked respondents to rate the appropriateness of six measures along a four point scale. In Figure 3-40, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of very appropriate and appropriate responses. Simplifying permitting and administrative procedures and strengthening consumer information and accessibility are considered appropriate measures to ensure buildings’ heating and cooling systems are increasingly based on renewable energy while fossil fuels are gradually phased out.

Figure 3-40 How would you rank the following measures in terms of their appropriateness in ensuring that buildings' heating and cooling systems are increasingly based on renewable energy while fossil fuels are gradually phased out?

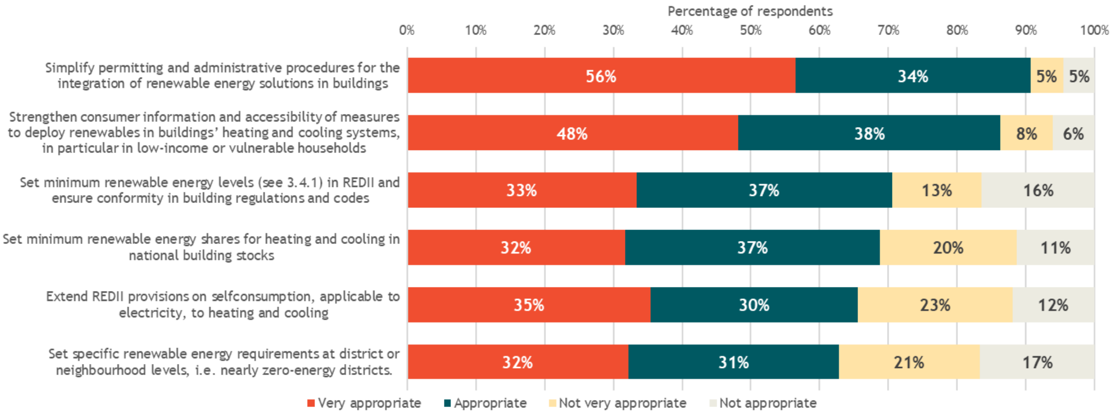


Table 3-52 Summary of results from Q6.3.1

Summary of results from Q6.3.1, open ended question concerning Q6.3 where participants were asked to suggest additional measures to ensure that buildings' heating and cooling systems are increasingly based on renewable energy while fossil fuels are gradually phased out
In total, Q6.3.1 received 163 responses, of which 23 are not unique. Most participants responded for business associations (89 participants), followed by NGOs (43 participants) and EU citizens (15 participants). Other stakeholders, such as those representing public authorities and academic institutions, responded as well but in smaller numbers. The main messages from the analysis are summarised below. **No measures that increase the use of (forest) biomass/bioenergy/non-fossil gases (~15% of respondents)** Many stakeholders, including 3 coordinated groups of 4, 12 and 15 participants, call for the exclusion of (forest) biomass or bioenergy/non-fossil gases in the measures. These participants were mainly from NGOs and environmental organisations as well as a few EU citizens. The coordinated participants do not provide a specific reason, but other participants reason that these energy sources are unsustainable, not climate neutral and lead to loss of biodiversity. **Use carbon taxation/proper CO2 pricing instead (~10% of respondents)** Many stakeholders, including a coordinated group of 8 business organisations, think that carbon taxation would make these measures unnecessary. The coordinated group finds general incentives to be a better approach than detailed regulation, although one participant thinks that carbon taxation could make the measures listed *profitable*. Additionally, one NGO suggests a sort of climate tax: a fee for *climate-disrupting* fuels which should be levied close to the source (e.g. mines, wells, importing ports). **Build upon Renovation Wave Strategy (~10% of respondents)** Many business organisations think that district energy concepts should be pursued based on the Renovation Wave Strategy, which stipulates that *synergies for renovation become evident when scaled up to district and community approaches*. Stakeholders from other groups (business association, company and other organisation) think that there should be a district level approach (without mentioning the Renovation Wave Strategy). **Other suggestions (≤5% of respondents)**

- **Avoid policy overlapping with EPBD** Seven business organisations mention the Energy Performance of Buildings Directive (EPBD). Stakeholders think that these measures create an overlap between RED and EPBD which should be avoided.
- **Address energy poverty** Several stakeholders are concerned about access to renewable energy for low-income and rural consumers. Three business organisations suggest facilitating access to renewable energy to those off the grid through prioritising actions on buildings in these areas and developing specific support programmes. Other stakeholders from academia, private sector as well as an EU citizen are concerned about low-income and vulnerable households. These stakeholders suggest a focus on these household through public funding such as subsidies.
- **Implement at Member State level, not at EU level** Several business organisations think that these measures can be implemented at the Member State level and not be included in RED. Since the situation in each Member State differs significantly, it would not be cost effective to implement EU level targets.
- Other stakeholders provide suggestions such as: focus on harmonising standards/setting minimums at EU level; no tax on self-generated solar/wind energy; focus on reducing consumption; focus on energy efficiency; introduce scheduled replacements; adopt technology neutral or technology open approach.

Q6.4 How would you rank the appropriateness of the following measures in improving the replacement of heating systems, in particular to encourage the replacement of fossil fuel appliances by renewable heating systems?

Q6.4 asked respondents to rate the appropriateness of seven measures along a four point scale. In Figure 3-41, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of very appropriate and appropriate responses. *Information campaigns* and *building renovation programmes* are highest ranked measures in terms of appropriateness (95% and 90%, respectively, of participants ranked as *appropriate* or *very appropriate*). Notably, all seven measures are considered *appropriate or very appropriate* by more than 80% of the participants.

Figure 3-41 How would you rank the appropriateness of the following measures in improving the replacement of heating systems, in particular to encourage the replacement of fossil fuel appliances by renewable heating systems?

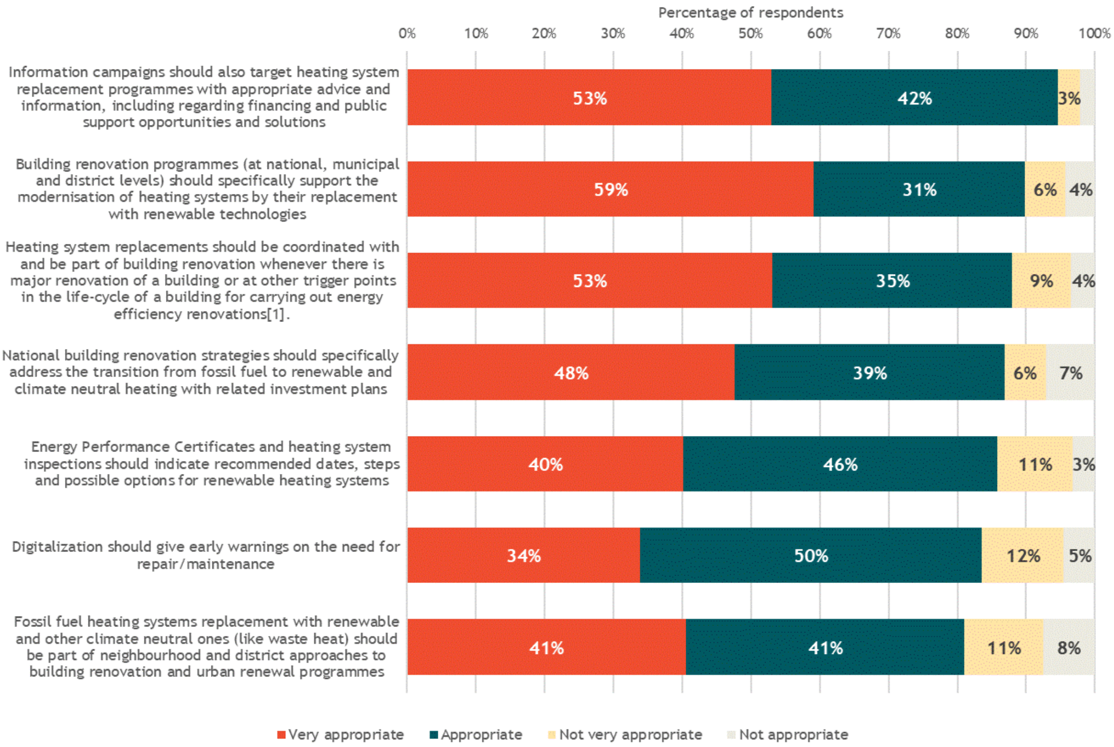


Table 3-53 Summary of results from Q6.4.1

Summary of results from Q6.4.1, an open ended question concerning Q6.4, where participants are asked to suggest additional measures to improve the replacement of heating systems, in particular to encourage the replacement of fossil fuel appliances by renewable heating systems.
In total, Q6.4.1 received 159 responses, of which 18 are not unique. Most participants responded for business organisations (101 participants), followed by NGOs (24 participants), EU citizens (12 participants) and public authorities (7 participants). Other stakeholders, such as those representing environmental organisations and academic institutions, responded as well but in smaller numbers. Rather than suggest additional measures, most stakeholders raised concerns they have about the measures listed, as indicated below. **Renewable energy only (~10% of respondents)** A coordinated group of 14 stakeholders (NGOs and environmental organisations) do not support measures concerning *climate neutral* heating technologies, but rather should focus on renewable energy sources only. Other smaller coordinated groups have similar opinions. Further, some companies and NGOs are against the use of biomass, which is said to cause a loss of biodiversity. One EU citizens is against the use of nuclear energy. On the other hand, there are several business organisations who think that low-carbon fuels, such as biomethane, are the most cost effective solution to decarbonise the building sector since there is not technology change. **Focus on local/urban planning (~10% of respondents)** A group of five business associations think that it is the responsibility of public authorities to promote renewable energy in heating and cooling, as it heating needs/sources are a part of urban planning. Some stakeholders mention that the focus neighbourhood/district level and not building level. On the other

hand, some consumer organisations (and one NGO) (~3%) think there should be a focus on providing independent advice to consumers.

Avoid policy overlapping with EPBD (~10% of respondents)

In total, 12 business organisations mention the Energy Performance of Buildings Direction (EPBD). Stakeholders are concerned that RED regulation would overlap with EPBD regulation, which should be avoided. Therefore, these measures, while considered appropriate, should be within EPBD and not RED.

Other suggestions/comments (<10% of respondents)

- **Heating infrastructure/technology is neutral, no technology bans**
  Several business organisations disagree that there are 'fossil fuel appliances', as heating technology and infrastructure can also be used for low carbon and renewables energies. Instead, the focus should not be on changing the type of infrastructure/equipment but rather energy efficiency (e.g. more efficient boilers, better insulation) and the type of fuels/energy used.
- **Implement at Member State level, not EU level**
  A coordinated group of nine business organisations think that all of the measures are appropriate, however, these measures can be implemented at the Member State level and not be included in RED. Further, they think that these measures accompanied with a carbon tax would make these measures profitable. Additionally, a few business related-stakeholders and a public authority think that these measures are not very relevant to Scandinavian countries which have already made the fossil-free transition.

Namely, a couple of business associations think that Energy Performance Certificates (EPCs) should be complimented with Building Renovation Passports (BRPs) (~1%). Some stakeholders think an impact assessment is needed to make sure that there are no obligations where it is not cost-efficient or technically/functionally/economically feasible (~2%).

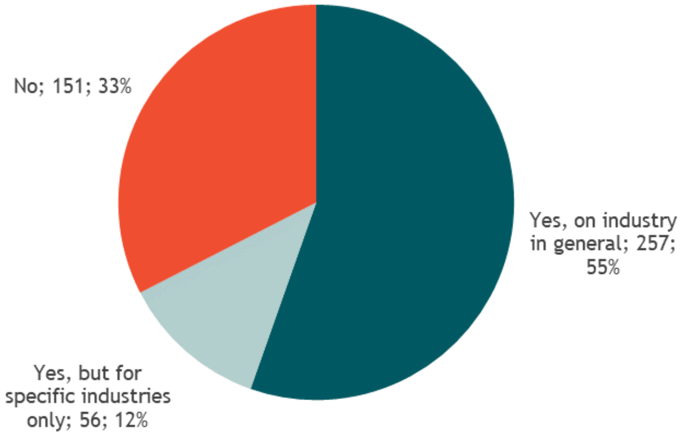
- *Renewable energy use in Industry*

There are a total of 2 main questions in this section of the questionnaire. Results are presented below.

Q7.1 Do you think there should be an obligation on industry or certain industrial sectors to use a minimum amount of renewable energy?

Q7.1 received 464 responses (Figure 3-42) . In total, 67% of the participants think that there should be an obligation on *industry in general* or *certain industries* to use a minimum amount of renewable energy (313 responses). 55% of the participants think that this obligation should be on *industry in general* while 12% think that this obligation should be on *specific industries only*. A third of respondents think there should not be this obligation on industry (151 responses).

Figure 3-42 Do you think there should be an obligation on industry or certain industrial sectors to use a minimum amount of renewable energy? (n=464)



Overall, amongst all stakeholder groups, stakeholders tend to agree than there should be obligations on industry to use a minimum amount of renewable energy (Table 3-54). Notably, a relatively higher amount of stakeholders representing public authorities as well as business organisations think that there should not be an obligation (41% and 42% of these stakeholder groups, respectively, replied *no*).

Table 3-54 Stakeholder correlation analysis for Q7.1

	Yes, on industry in general	Yes, but for specific industries only	No
	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	80% (59)	5% (4)	15% (11)
In a professional capacity or on behalf of an organisation	51% (198)	13% (52)	36% (140)
Of which:			
Academic/research institution	*64% (7)*	*18% (2)*	*18% (2)*
Business organisation	*45% (127)*	*13% (37)*	*42% (120)*
Consumer organisation	*67% (2)*	*0% (0)*	*33% (1)*
NGO/environmental organisation	*80% (45)*	*9% (5)*	*11% (6)*
Public authority	*36% (8)*	*23% (5)*	*41% (9)*
Trade union	*100% (1)*	*0% (0)*	*0% (0)*
Other	*62% (8)*	*23% (3)*	*15% (2)*

Table 3-55 Summary of results from Q7.1.1

Summary of results from Q7.1.1, an open ended question concerning Q7.1, where participants were asked to specify which industry should have obligations to use a minimum amount of renewable energy.
In total, Q7.1.1 received 39 responses, of which all are unique. Most participants responded for business organisations (27 participants), followed by public authorities (4 participants) and NGOs (3 participants). Other stakeholders, such as those representing other organisations and academic institutions, responded as well but in smaller numbers. The main messages from the analysis are summarised below. **Exclude sectors already subject to the EU-ETS (~30% of respondents)** Many business organisations are concerned that some sectors will be overburdened if they are subject to the EU-ETS as well as additional obligations. Two different stakeholders think that renewable energy should be encouraged with incentives like the EU-ETS and carbon pricing instead. Several stakeholders think that only sectors which are not currently subject to the EU-ETS should have obligations. This will ensure that all industries are being encouraged to decarbonise. **Hard to abate sectors (~15% of respondents)** Six stakeholders (four companies, one academic and one public authority) think that obligations should be focused on hard-to-abate/energy-intensive sectors to stimulate decarbonisation. This includes four companies, one academic/research institution and one public authority. One stakeholder says that it would contribute more to decarbonisation if these sectors are focused on. Another stakeholder mentions that obligations on these sectors need to take the risk of international competition into account. **Obligations accompanied with financial support (~15% of respondents)** Seven stakeholders (six business-related, one public authority) mention that obligations should be accompanied with financial support. Specifically, four of these stakeholders mention that OPEX and CAPEX investments are necessary to support the transition to renewable energy. **Other suggestions** Other stakeholders provided specific suggestions. Five business organisations (including one other organisation) (~12%) suggest obligations for (low-carbon) hydrogen use. A group of 3 coordinated business organisations (~7%) think that industries that produce biogenic waste streams should be encouraged towards a circular economy approach and further think that industries already subject to the EU-ETS. Two NGOs (~5%) think that all sectors should have obligations. One NGO (~2%) is concerned that agriculture and forestry will become a 'dustbin' for emission reduction if other sectors are not also focused on. Additionally, one public authority (~2%) think that a quota for energy suppliers would be more efficient than setting minima for industry sectors.

Q7.2 Would you rank the appropriateness of certain additional measures to encourage the use of renewable energy in industry.

Q7.2 asked respondents to rate the appropriateness of six measures along a four point scale. In Figure 3-43, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. 95% of the participants think that *simplifying permitting and administrative procedures* is an *(very) appropriate* measure to encourage the use of renewable energy in industry. Notably, *setting minimum renewable energy shares in national building stocks* and *extending RED II provisions on self-consumption* are considered very appropriate by more than half of the participants.

Figure 3-43 How would you rank the appropriateness of the following additional measures to encourage the use of renewable energy in industry?

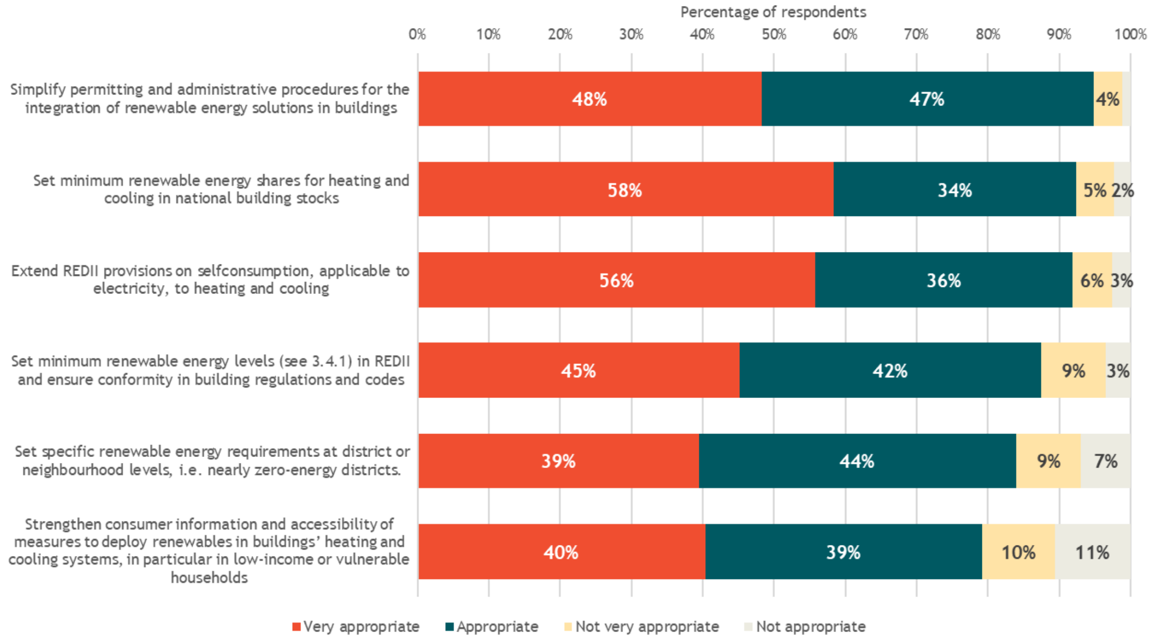


Table 3-56 Summary of results from Q7.2.1

Summary of results from Q7.2.1, open ended question concerning Q7.2, where participants were asked to suggest additional measures to encourage the use of renewable energy in industry.
In total, Q7.2.1 received 145 responses, of which 11 are not unique. Most participants responded for business organisations (100 participants), followed by NGOs (22 participants) and EU citizens (11 participants). Other stakeholders, such as those representing public authorities and academic institutions, responded as well but in smaller numbers. The main messages from the analysis are summarised below. **Measures concerning particular energy sources (~30% of respondents)** Many stakeholders comment on which energy sources should be focused or excluded from measures. Renewable electricity (~5%), hydrogen (~20%), solar/wind energy (~3%) and sustainable biomass (~4%) are discussed. Additionally, measures concerning on-site renewables are proposed by a NGO, companies/business organisations and academia/research institutions (~4%). Also, the explicit exclusion of biomass is also proposed by NGOs and companies (~6%), mainly because of concerns about biodiversity. **Innovation programmes, R&D and industrial parks/clusters (~15% of respondents)** Support for innovation programmes, R&D and the creation/support of industrial parks/clusters is a common suggestion across most stakeholder types, including academia, companies, environmental organisations, public authorities and EU citizens. Innovation is said to be necessary to expand the potential of renewables and electricity in industry, and further, it will increase the competitiveness of renewables. Those wanting measures specific to industrial parks/clusters ask for a focus on reducing regulatory barriers and investment incentives. Additionally, some stakeholders mention that measures for industrial parks/clusters are appropriate where there are synergies in the use of energy. However, one stakeholder (~1%) representing a business association warns not to provide additional support measures to industrial parks/clusters since these already get enough support under existing EU and national legislation. Additionally, one stakeholder (~1%) argues that innovation R&D is not important, as 'there are enough results already', and focus instead on supporting project development.

Summary of results from Q7.2.1, open ended question concerning Q7.2, where participants were asked to suggest additional measures to encourage the use of renewable energy in industry.

Other suggestions (≤10% of respondents)

- **Regulation under RED is unnecessary**
  Many stakeholders, including a coordinated group of 9 business organisations, believe that measures outside of RED II should be used instead to promote renewable energy in industry. These stakeholders mention that this should be handled by the following mechanisms: EU emissions trading system (ETS), carbon taxation, (carbon) contracts for difference (CfDs), PPAs. Particularly, CfDs are popular amongst business associations, while EU ETS and carbon taxation are more popular within the company/business organisation stakeholder group.
- **Financial support**
  Many stakeholders mention financial support mechanisms as crucial for a transition in industry, including stakeholder representing businesses, business associations and public authorities. Many of these stakeholders suggest support to capital expenditure (CAPEX) and some to operational expenditure (OPEX). In particular, these support tools are recommended for the phasing out of coal to sustainable biomass
- **Guarantees of Origin (GOs)**
  Business organisations suggest real-time Guarantees of Origin (GOs) since these would help renewable electricity effectively enter the industry sector. Some of them also suggest a revision of GOs provisions such that there is a better way to track renewable electricity, which would lead to a more efficient entry of renewable electricity in industry.
- **Energy efficiency principle**
  Many public authority stakeholders highlight the importance of applying the energy efficiency principle to current processes so that industries can 'explore means to reduce energy demand and resource use'.
- **No additional obligations**
  Stakeholders representing companies/business organisations, business associations and public authorities think that there should be no additional obligations on EU industry. Many specify that no obligations should be made until there is a 'level playing field' between EU and non-EU competitors.
- **Administrative support**
  Business organisations voice concerns about regulatory burdens and the need for administrative support. Other stakeholders, mostly NGOs and companies, warn that simplified permitting and administrative support should not weaken protections of biodiversity.

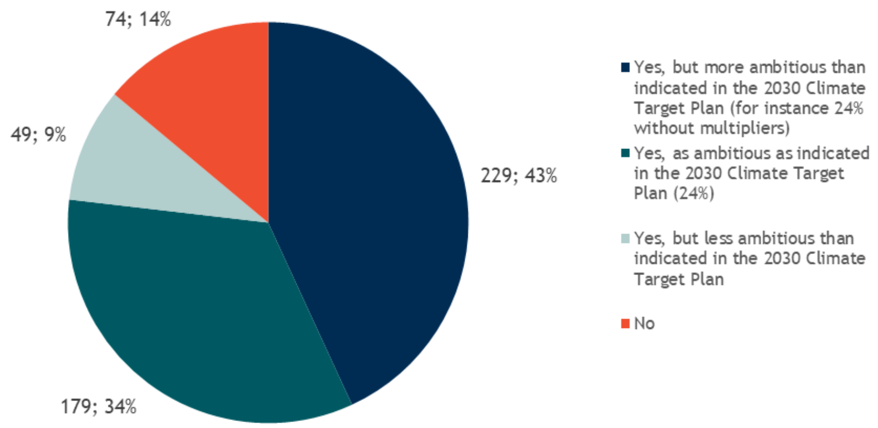
Renewable energy in Transport

There are a total of 8 main questions in this section of the questionnaire. Results are presented below.

Q8.1 Do you think that the level of the renewable target in transport should be increased?

Q8.1 received 531 responses (Figure 3-44). In total, the majority of respondents (86%) think that the level of the renewable target in transport should be increased. 229 respondents (43%) think that it should be *more ambitious* than indicated in the 2030 Climate Target Plan (CTP). 179 respondents (34%) think that it should be *as ambitious as* indicated in the 2030 CTP. 48 respondents (9%) think that it should be *less ambitious* than the 2030 CTP. 14% of the respondents think that the level of the renewable target in transport should not be increased (74 responses).

Figure 3-44 Do you think that the level of the renewable target in transport should be increased? (n=531)



For both respondents who participated in a personal or a professional capacity, most respondents think that renewables targets in transport should be increased in some way (Table 3-57). Stakeholders from NGOs/environmental organisations tend to disagree more (33% of this stakeholder group think that the level of the renewable target in transport should not increase).

Table 3-57 Stakeholder correlation analysis for Q8.1

	Yes, but less ambitious than the 2030 CTP	Yes, as ambitious as the 2030 CTP (24%)	Yes, but more ambitious than the 2030 CTP	No
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	8% (6)	27% (21)	50% (39)	15% (12)
In a professional capacity or on behalf of an organisation	9% (43)	35% (158)	42% (190)	14% (62)
Of which:				
Academic/research institution	*15% (2)*	*31% (4)*	*31% (4)*	*23% (3)*
Business organisation	*6% (21)*	*37% (122)*	*47% (153)*	*9% (30)*
Consumer organisation	*0% (0)*	*50% (3)*	*50% (3)*	*0% (0)*
NGO/environmental organisation	*26% (17)*	*17% (11)*	*24% (16)*	*33% (22)*
Public authority	*9% (2)*	*35% (8)*	*30% (7)*	*26% (6)*
Trade union	*33% (1)*	*33% (1)*	*33% (1)*	*0% (0)*
Other	*0% (0)*	*56% (9)*	*38% (6)*	*6% (1)*

Table 3-58 Summary of results from Q8.1.1

Summary of results from Q8.1.1, open ended question concerning Q8.1 where participants were asked to explain why the level of the renewable energy target in transport should or should not be increased.

In total, Q8.1.1 received 280 responses, of which 14 are not unique. Most of these participants responded for business organisations (187 participants), followed by NGOs (42 participants), EU citizens (21 participants) and public authorities (12 participants). Other stakeholders, such as those representing environmental organisations and academic institutions, responded as well but in smaller totals.

Those who think that renewable energy targets in transport should be more ambitious than those in the 2030 CTP (48% of respondents) justified their answer with the following reasons/specifications:

No multipliers (~20% of respondents)

The removal of multipliers is a very common proposal by stakeholders who chose this option. Stakeholders bring many different reasons for this. Some stakeholders think that multipliers make targets inefficient and weak as well as that it is confusing and misleading. Some stakeholders think that a life-cycle analysis or well-to-wheel approach should be used instead. In particular, there is a coordinated response from a group of 9 business organisations who think that double counting should be eliminated, as it makes the 14% target misleading and ineffective. On the other hand, a few business organisations think that double counting should be eliminated but multipliers should remain, to account for higher efficiency of certain powertrain systems.

Focusing on certain modes of transport (~25% of respondents)

Summary of results from Q8.1.1, open ended question concerning Q8.1 where participants were asked to explain why the level of the renewable energy target in transport should or should not be increased.

Several stakeholders mention the need to focus on certain modes of transport (e.g. aviation (6%), maritime (4%), road (10%), rail (2%)). Also, 1 NGO emphasizes the need to promote public transportation in order to curb emissions.

Transport sector is lagging on meeting targets (<10% of respondents)

Several stakeholders stress the urgency for a quicker transition in the transport sector, as it is lagging behind. Particularly, stakeholders from businesses, public authorities and NGOs (~3%) mention how more ambitious targets are necessary to achieve the Paris Climate Agreement. Also, three business organisations mention that the national projections from the EEA suggest that 2030 emissions from transport will remain above 1990 levels with the current measures. Therefore, further action is necessary.

Those who think that renewable energy targets in transport should be just as ambitious as those in the 2030 CTP (25% of respondents) justified their answer with the following reasons/specifications:

Keep multipliers (<10% of respondents)

Several stakeholders in this category think that multiplier should be kept. Some stakeholders argue that multipliers are good tools to promote the right feedstocks and technologies. A few stakeholders suggest multipliers only for certain energies (e.g. renewable hydrogen, biofuels).

2030 CTP targets are feasible (<10% of respondents)

Several stakeholders who chose this option think that the 2030 CTP targets are reasonable. Further, a more ambitious level would be unachievable.

Sustainable fuels only (~5% of respondents)

A few organisations are concerned that very ambitious targets will lead to dependence on crop-based fuels and emphasize the need to focus on sustainable renewable fuels only. On the other hand, some business organisations think that all renewable/low carbon energies must be considered.

Those who think that renewable energy targets in transport should be increased but remain less ambitious than those in the 2030 CTPs (9% of respondents), justified their answer with the following reasons/specifications:

Focus on quality of renewable fuels and avoid import dependence (~5% of respondents)

A coordinated group of 9 NGOs and environmental organisations urge the need to focus on the quality of fuels eligible to meet targets, instead of aim for high targets, which will lead to the promotion of unsustainable fuels which negatively impact the climate and environment (e.g. biofuels). These stakeholders also think that high targets will create import dependence for biofuels. These views are shared also by other stakeholders, including a company which emphasizes the need for renewable electricity and hydrogen. Further there are several stakeholders who want biofuels to be removed or phased out.

Current target is already challenging (~5% of respondents)

Several stakeholders comment that the current targets are already challenging. One company comments that It takes time to build infrastructure and adapt to new technology. Further a business association think that focus should be rather on public support schemes and market mechanisms

Summary of results from Q8.1.1, open ended question concerning Q8.1 where participants were asked to explain why the level of the renewable energy target in transport should or should not be increased.

Those who think that renewable energy targets in transport should not be increased (13% of respondents) justified their answer with the following reasons/specifications:

Against biofuels (~5% of respondents)
Several stakeholders (NGOs/environmental organisations and business organisations) are concerned that high targets, like that of the 2030 CTP, will increase the share of (crop-based) biofuels. Particularly, a group of three NGOs think that any target must exclude crop-based biofuels and focus on advanced fuels.

mpact assessment before setting new targets (<5% of respondents)
Some stakeholders (mainly NGOs) think that the current targets and eligible fuels must be assessed before targets are increased. Further four stakeholders are concerned that some fuels included are damaging to biodiversity.

Alternative mechanisms (<5% of respondents)
A few business organisations think that market mechanisms such as CO2 pricing and ETS should be used instead of specific targets.

Member States should have flexibility (<5% of respondents)
A few stakeholders think that member states should have flexibility to decide on targets and which sectors to focus on to achieve their renewable energy objectives. This opinion is held by business organisations and a public authority.

Q8.2 Member States can count renewable electricity, sustainable biofuel and biogas, hydrogen produced from renewable electricity (except if such electricity comes from biomass) and recycled carbon fuels towards the 14% target in transport. Do you think Member States should also be able to count other low carbon fuels which have fewer emissions than fossil fuels, such as low carbon hydrogen?

Q8.2 received 537 responses (Figure 3-45). More than half of the participants (55%) think that MS should not count other low carbon fuels which have fewer emissions than fossil fuels towards the 14% target in transport (291 responses). The remaining 244 participants think that other low carbon fuels should count (46%).

Figure 3-45 Member States can count renewable electricity, sustainable biofuel and biogas, hydrogen produced from renewable electricity (except if such electricity comes from biomass) and recycled carbon fuels towards the 14% target in transport. Do you think Member States should also be able to count other low carbon fuels which have fewer emissions than fossil fuels, such as low carbon hydrogen? (n=537)

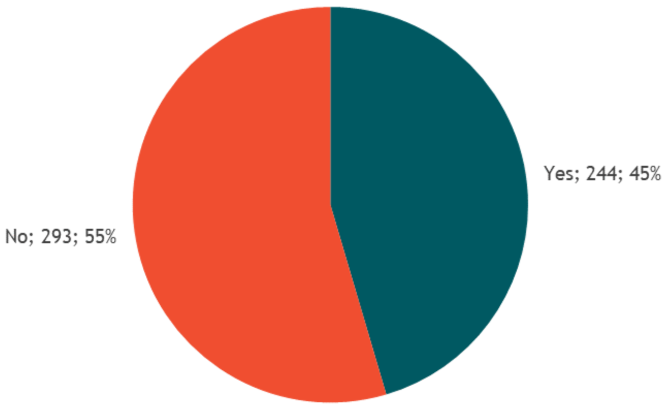


Table 3-59 presents the results by stakeholder type. Stakeholders from academia, business organisations and consumer organisations tend to think that low carbon fuels should count towards the 14% target in transport. Those representing public authority are split 50%-50%. The rest of the stakeholder groups tend to disagree.

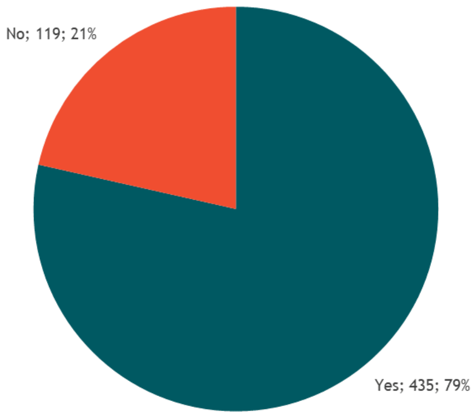
Table 3-59 Stakeholder correlation analysis for Q8.2

	Yes	No
	% (frequency)	**% (frequency)**
As an individual in a personal capacity	36% (26)	64% (46)
In a professional capacity or on behalf of an organisation	47% (218)	53% (247)
Of which:		
Academic/research institution	*55% (6)*	*45% (5)*
Business organisation	*53% (177)*	*47% (156)*
Consumer organisation	*67% (4)*	*33% (2)*
NGO/environmental organisation	*14% (10)*	*86% (61)*
Public authority	*50% (13)*	*50% (13)*
Trade union	*33% (1)*	*67% (2)*
Other	*47% (7)*	*53% (8)*

Q8.3 Do you think that some renewable and low carbon fuels should be specifically promoted in transport, beyond being part of the obligation on fuel suppliers?

Q8.3 received 554 responses (Figure 3-46). 79% of the participants think that some renewable and low carbon fuels should be specifically promoted in transport, beyond being part of the obligation on fuel suppliers (435 responses). The remaining 119 participants disagree (21%).

Figure 3-46 Do you think that some renewable and low carbon fuels should be specifically promoted in transport, beyond being part of the obligation on fuel suppliers? (n=554)



Amongst all stakeholder groups, stakeholders tend to agree that certain renewable and low carbon fuels should be specifically promoted in transport, though the margin of agreement differs per stakeholder group (Table 3-60).

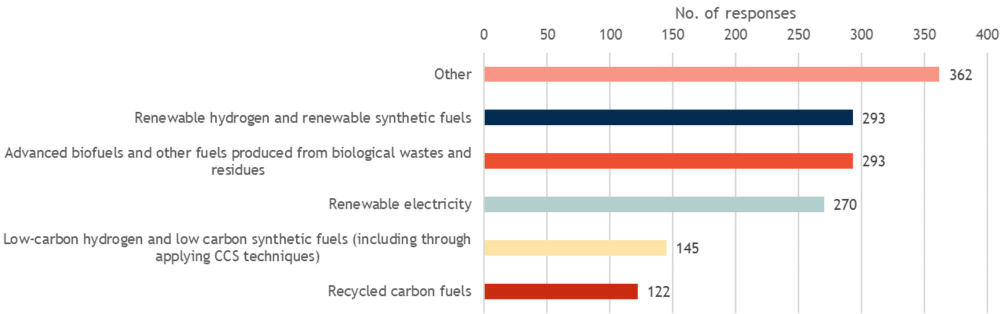
Table 3-60 Stakeholder correlation analysis for Q8.3

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	73% (54)	27% (20)
In a professional capacity or on behalf of an organisation	79% (381)	21% (99)
Of which:		
Academic/research institution	*64% (9)*	*36% (5)*
Business organisation	*80% (279)*	*20% (69)*
Consumer organisation	*67% (4)*	*33% (2)*
NGO/environmental organisation	*87% (59)*	*13% (9)*
Public authority	*63% (15)*	*38% (9)*
Trade union	*75% (3)*	*25% (1)*
Other	*75% (12)*	*25% (4)*

Q8.4 If you answered *yes* to the previous question, which of the following types of renewable and low carbon fuels do you think should be specifically promoted? (Multiple answers possible)

Q8.4 received 1,485 responses from 445 participants (multiple answers possible). Participants could choose from six options and provided 3.2 responses on average. Figure 3-47 presents the participants' responses. The *other* option is the most commonly chosen response. Amongst the specific types of renewable and low carbon fuels to specifically promote, *advanced biofuels and other fuels produced from biological waste and residues* (293 responses) and *renewable hydrogen and renewable synthetic fuels* (293 responses) are the most chosen. These two are followed by *renewable electricity* (270 responses), *low-carbon hydrogen and low carbon synthetic fuels* (145 responses) and *recycled carbon fuels* (122 responses).

Figure 3-47 If you answered *yes* to the previous question, which of the following types of renewable and low carbon fuels do you think should be specifically promoted? (Multiple answers possible) (n=465; 1485 responses)



Overall, participants from a variety of stakeholder groups tend to choose the *other* option (Table 3-61; percentages are in terms of total responses, *not* participants). Particularly, participants from NGOs and environmental organisations as well as citizens often think that renewable electricity should be promoted. *Advanced biofuels* is more often chosen by those from academia, trade unions and *other* organisations, compared to other stakeholder groups in terms of stakeholder group share.

Table 3-61 Stakeholder correlation analysis for Q8.4

	Advanced biofuels and other fuels from biological waste	Renewable hydrogen and renewable synthetic fuels	Low-carbon hydrogen and low carbon synthetic fuels[969]	Renewable electricity	Recycled carbon fuels	Other
	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)
As an individual in a personal capacity	17% (29)	22% (36)	8% (13)	23% (38)	7% (12)	23% (39)
In a professional capacity or on behalf of an organisation	20% (264)	19% (257)	10% (132)	18% (232)	8% (110)	25% (323)
Of which:						
Academic/research institution	27% (8)	13% (4)	13% (4)	13% (4)	7% (2)	27% (8)
Business organisation	21% (206)	20% (198)	11% (111)	15% (147)	9% (89)	24% (242)
Consumer organisation	15% (3)	15% (3)	15% (3)	20% (4)	15% (3)	20% (4)
NGO/environmental organisation	15% (23)	18% (28)	1% (2)	35% (55)	4% (7)	27% (43)
Public authority	19% (12)	21% (13)	10% (6)	19% (12)	8% (5)	23% (14)
Trade union	22% (2)	11% (1)	11% (1)	11% (1)	22% (2)	22% (2)
Other	22% (10)	22% (10)	11% (5)	20% (9)	4% (2)	22% (10)

[969] including through applying CCS techniques

Table 3-62 Summary of results from Q8.4.1

Summary of results from Q8.4.1, open ended question concerning Q8.4, where participants are asked to specify which types of renewables and low carbon fuels should be specifically promoted in transport

In total, Q8.4.1 received 147 responses, of which 10 are not unique. Most of these participants responded for business organisations (110 participants), followed by NGOs (17 participants), EU citizens (7 participants) and public authorities (6 participants). Other stakeholders responded in smaller frequencies ranging from 1 to 6 responses. The main messages from the analysis are summarised below.

Renewable hydrogen and synthetic fuels (~25% of respondents)

Among business organisations, the promotion of particular hydrogen/synthetic fuel options is popular. These includes bio-based hydrogen (~1%), low-carbon hydrogen (~11%), bio-compressed natural gas (bioCNG) (~7%), bio-liquified natural gas (bioLNG) (~4%) and bio-liquified petroleum gas (bioLPG) (~3%). In light of the EUs ambitious decarbonisation targets, these types of fuels are stated to be fast, affordable and available solutions. However, many stakeholders state that hydrogen/synthetic fuels are only sustainable in hard-to-abate sectors such as maritime and aviation.

All renewable and/or low-carbon fuels (~20% of respondents)

Many business organisations call for the promotion of renewable and/or low-carbon fuels. A coordinated group of 9 business organisations suggest the promotion of all renewables, including biofuels, but do not want low-carbon fuels to be promoted. For these stakeholders, using fossil-fuel sources is said to *compromise* RED. Particularly, biofuels are considered necessary for hard-to-abate sectors where electrification is not available. For some participants (~3%), they view that all options are needed to achieve EU climate goals. About 6% of the respondents think that all low-carbon fuels should be promotes; these are all companies/business organisations or business associations.

Electrification/batteries (~20% of respondents)

Many stakeholders focus on the need for the promotion of electric mobility and battery development. It is argued that electric mobility is the most efficient and fastest way to decarbonise the transport sector, especially towards road transport. Though, one coordinated group of eight NGOs and business associations (~5%) reason that Member States are already obliged to report renewable electricity supplied to road/rail transport and further the credit mechanisms will need to examine to determine their use.

Sustainability criteria (~15% of respondents)

Many participants find the application and compliance of sustainability criteria important. This view is seen across almost all stakeholder groups.

Technology-neutral vs. Technology-open (~5% of respondents)

The suggestion for technology-neutral or technology-open approaches are both found in the responses to this question. Technology-neutral approaches are suggested from business associations and *other* organisations (~4%), while technology-open approaches are suggested from business organisations only (~1%).

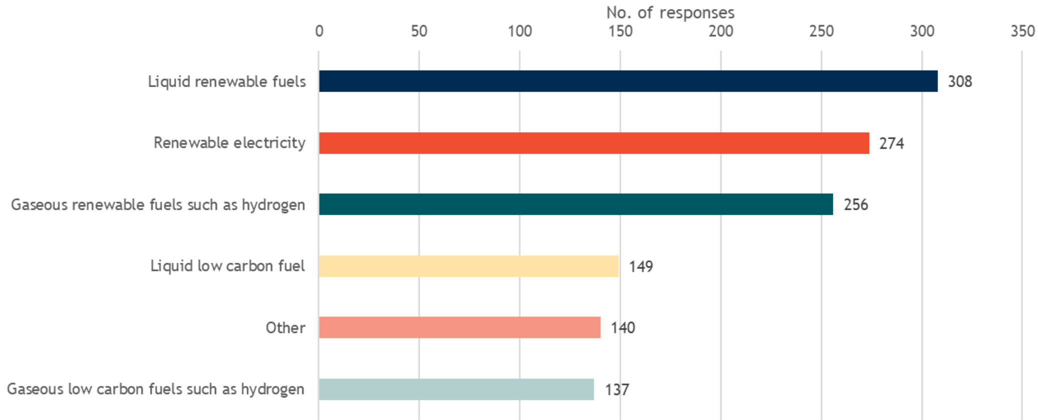
Other renewables (solar, tidal and wind) and nuclear (<5% of respondents)

Some participants (business organisations and NGOs) also mention other renewable energy sources that should be promoted, including solar, tidal and wind energy. A couple participants (~1%) mentioned the promotion of nuclear energy. While it is said not to be a renewable, it is an affordable option to decarbonise the transport sector. This option is mentioned by environmental organisations and EU citizens.

Q8.5 Which types of renewable and low carbon fuels can be best promoted by an obligation on fuel suppliers, based either on energy content or GHG emissions, compared to other instruments?

Q8.5 received 1264 responses from 490 participants (multiple answers possible. Participants could choose from six options and responded with 2.6 answers on average. Figure 3-48 presents the participants' responses. *Liquid renewable fuels* is the most chosen to be promoted (308 responses). This is followed by *renewable electricity* (274 responses), *gaseous renewable fuels* (256 responses) and *liquid low carbon fuel* (149 responses). 140 participants chose the *other* option. *Gaseous low carbon fuel* was the least chosen fuel to be promoted (137 responses).

Figure 3-48 Which types of renewable and low carbon fuels can be best promoted by an obligation on fuel suppliers, based either on energy content or GHG emissions, compared to other instruments? (n=490; 1,264 responses)



Amongst citizens and those representing academia, consumer organisations, environmental organisations and NGOs, *renewable electricity* is the most commonly chosen renewable energy to be promoted (Table 3-63; percentages are in terms of total responses, *not* participants). For those representing business organisations, *liquid renewable fuels* is the most commonly chosen fuel to be promoted.

Table 3-63 Stakeholder correlation analysis for Q8.5

	Liquid renewable fuels	Liquid low carbon fuel	Gaseous renewable fuels	Gaseous low carbon fuels	Renewable electricity	Other
	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)	% (freq.)
As an individual in a personal capacity	24% (35)	8% (12)	22% (32)	8% (11)	29% (42)	9% (13)
In a professional capacity or on behalf of an organisation	24% (273)	12% (137)	20% (224)	11% (126)	21% (232)	11% (127)
Of which:						
Academic/research institution	21% (7)	15% (5)	18% (6)	9% (3)	24% (8)	12% (4)
Business organisation	26% (226)	13% (111)	21% (181)	12% (102)	18% (154)	10% (89)
Consumer organisation	24% (4)	24% (4)	12% (2)	12% (2)	24% (4)	6% (1)

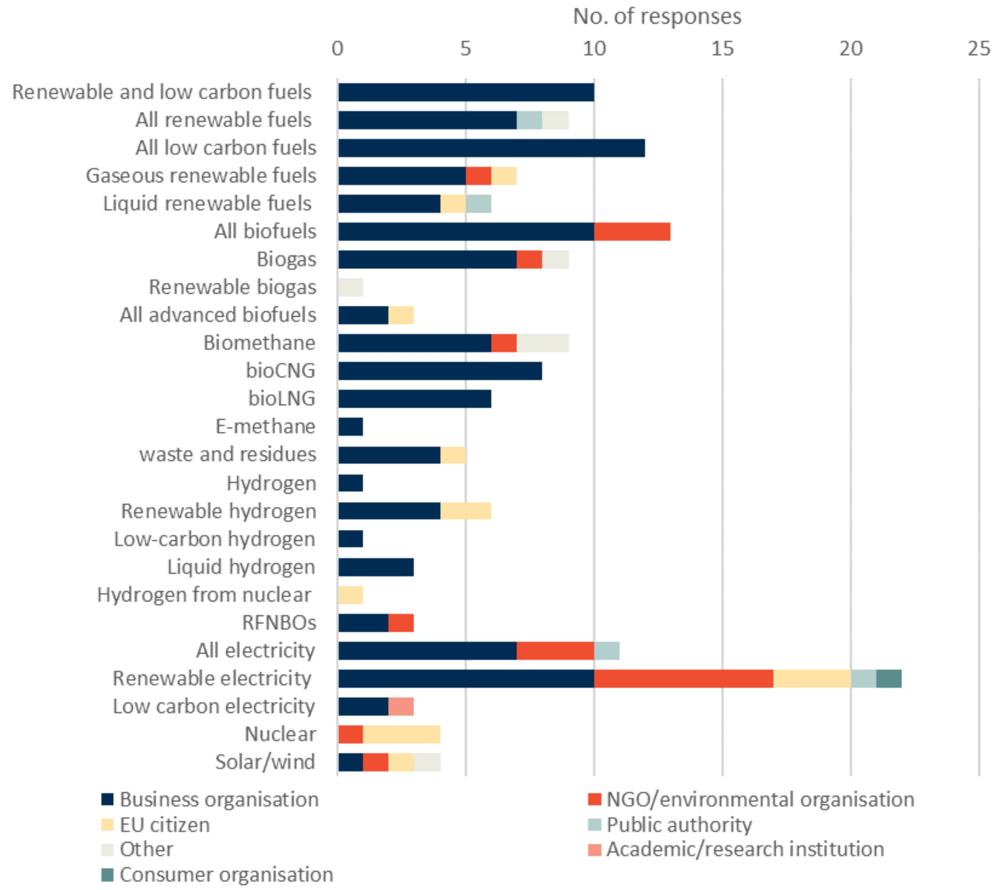
	Liquid renewable fuels	Liquid low carbon fuel	Gaseous renewable fuels	Gaseous low carbon fuels	Renewable electricity	Other
NGO/environmental organisation	11% (11)	9% (9)	9% (9)	6% (6)	43% (42)	21% (21)
Public authority	24% (15)	8% (5)	24% (15)	11% (7)	24% (15)	10% (6)
Trade union	20% (1)	20% (1)	20% (1)	20% (1)	20% (1)	0% (0)
Other	23% (9)	5% (2)	25% (10)	13% (5)	20% (8)	15% (6)

Table 3-64 Summary of results from Q8.5.1

Summary of results from Q8.5.1, open ended question concerning Q8.5, where participants are asked which types of renewable and low carbon fuels can be best promoted by an obligation on fuel suppliers, based either on energy content or GHG emissions, compared to other instruments.
In total, Q8.5.1 received 126 responses, of which 12 are not unique. Most of these participants responded for business organisations (87 participants), followed by NGOs (13 participants), and EU citizens (10 participants). Other stakeholders responded in smaller frequencies, ranging from 1-6 responses. Some of the responses have come from small coordinated groups of participants (providing identical responses). These groups were mainly either supporting renewable electricity or against low-carbon fuels. Stakeholders provided several suggestions for specific renewable/low-carbon fuels to promote in transport (Figure 3-49). Renewable electricity is the most commonly suggested fuel to promote (~15%), followed by biofuels (~10%). Many participants suggest that all renewable and/or low carbon fuels should be promoted (31 respondents in total).

Summary of results from Q8.5.1, open ended question concerning Q8.5, where participants are asked which types of renewable and low carbon fuels can be best promoted by an obligation on fuel suppliers, based either on energy content or GHG emissions, compared to other instruments.

Figure 3-49 Renewable/low carbon fuels to promote in transport suggest by participants in Q8.5.1, by stakeholder type



Additionally, some stakeholders provided suggestions not necessarily specific to a certain type of fuel. Around 13 business organisations are against the promotion of low-carbon fuels and one company stakeholder is against the promotion of biomethane specifically. A few stakeholders commented that obligations on suppliers is not a good measure. One stakeholder thinks that alternatively, focus should be put on the development, production and distribution of fuels in general. Also, a few stakeholders emphasise the importance of maintaining a technologically neutral approach.

Q8.6 How would you rate the appropriateness of the following measures regarding the use of renewable and low carbon fuels in transport?

Q8.6 asked respondents to rate the appropriateness of seven measures along a four point scale. In Figure 3-50, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. *Basing fuel supply obligation on GHG emissions targets* ranks the highest amongst all of the measures. Particularly, almost half of the participants (48%) think that the measure which gives *Member States flexibility to design the supply obligation* is *not very appropriate* or *not appropriate* in regard to use of renewables and low carbon fuel in transport.

Figure 3-50 How would you rate the appropriateness of the following measures regarding the use of renewable and low carbon fuels in transport?

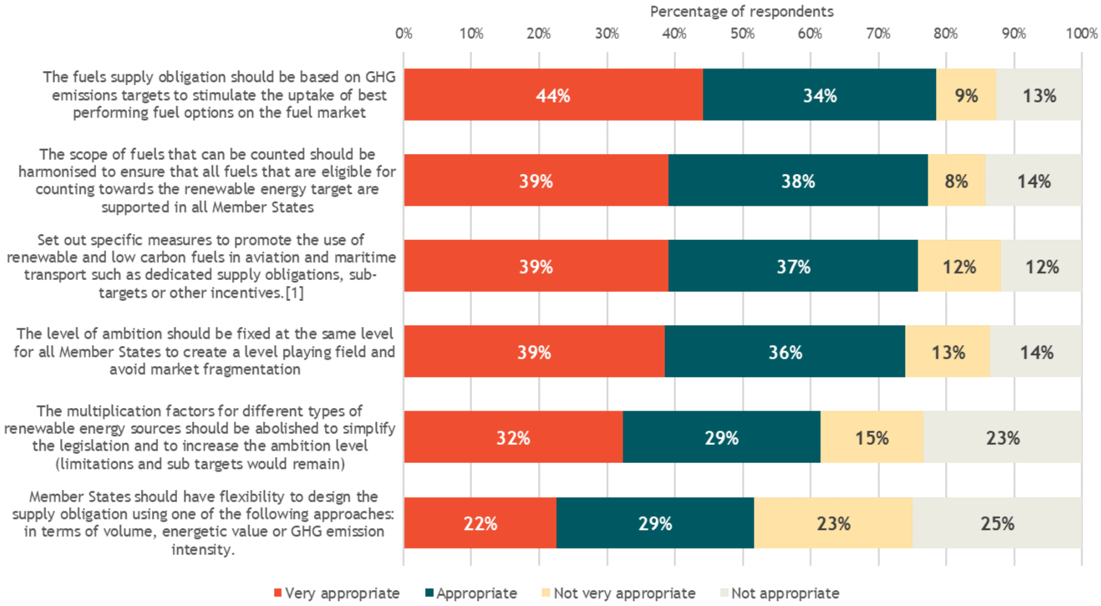


Table 3-65 Summary of results from Q8.6.1

Summary of results from Q8.6.1, open ended question concerning Q8.6, where participants were asked to suggest additional measures regarding the use of renewable and low carbon fuels in transport.
In total, Q8.6.1 received 206 responses, of which 14 are not unique. Most of these participants responded as business organisations (145 participants), followed by NGOs (29 participants), EU citizen (13 participants) and public authorities (8 participants). Other stakeholders responded in smaller frequencies, ranging from 1-6 responses. The main messages from the analysis are summarised below. **Harmonisation (<10% of respondents)** Several business organisations emphasize the importance of harmonisations to avoid creating market distortions. Namely, many stakeholders (<5%) call for there to be a *minimum* level of ambition for all Member States, which provides an even playing field but also allows MS's to be more ambitious. There are multiple groups of business organisations, which provide coordinated responses with these views. Additionally, some stakeholders (<10%) think that the supply obligation design should be harmonised across all Member States and that it should be derived from energy values and GHG emission intensity. **Flexibility for Member States (~10% of respondents)** Many stakeholders suggest flexibility for Member States. Multiple NGOs replied, in a coordinated fashion, that MS's should have the flexibility to restrict the eligibility of certain fuels based on their environmental and climate impact. Also, some stakeholders stress that flexibility is needed because fuel stocks vary between Member States. **Multipliers/double counting (~25-30% of respondents for; ~5% against)** Many stakeholders think multipliers/double counting are important, while some stakeholders (~5%) are against multipliers/double counting Some arguments to not use multipliers are that it creates an uneven playing field, they are no longer needed because renewable electricity is already well developed, go against technology neutrality and accelerate sustained use of fossil fuels. Further, GHG-emission intensity is proposed as an alternative.

Summary of results from Q8.6.1, open ended question concerning Q8.6, where participants were asked to suggest additional measures regarding the use of renewable and low carbon fuels in transport.
On the other hand, multipliers are argued to maintain market stability for biofuels produced from feedstocks in part A) and part B) of Annex IX. This argument is provided by an organised group of 10 business organisations. Additionally, another coordinated group of NGOs warns that if multipliers are removed for advanced biofuels, then their targets will need to be revised as well. Additionally, many stakeholders provide specific suggestions for multiplier values for certain renewable energies (e.g. renewable hydrogen, renewable electricity) as well as prioritisation of certain sectors (e.g. maritime and aviation). Another suggestion (from a company) is that the multiplier methodology should be scalable. **Other suggestions (<5% of respondents)** • **Carbon taxation** An organised group of 9 business organisations think that carbon taxation should be used to promote biofuels. This group also think that restrictions on crop-based biofuels as well as double counting should be removed. • **RED alignment with Fuel Quality Directive** Several stakeholders think that RED needs to be aligned with the Fuel Quality Directive (FQD). This includes some business related stakeholders as well as a public authority and EU citizen. • **Remove cap on biofuels** A few business organisations propose that the 1.7% cap of feedstocks listed in part B of Annex IX to the transport obligation should be removed. • **Technology neutrality** Three stakeholders mention that the transport sector should adopt a technology neutral approach.

Q8.7 How appropriate do you think the following measures would be in encouraging the use of hydrogen and hydrogen-derived synthetic fuels in transport modes that are difficult to decarbonise?

Q8.7 asked respondents to rate the appropriateness of three measures along a four point scale. In Figure 3-51, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. For all three measures, the rate of approval is lower than 50% (in terms of participants who chose *appropriate* or *very appropriate*). Particularly, 49% of participants think that *double counting of hydrogen and hydrogen-derived synthetic fuels* is *not appropriate*.

Figure 3-51 How appropriate do you think the following measures would be in encouraging the use of hydrogen and hydrogen-derived synthetic fuels in transport modes that are difficult to decarbonise?

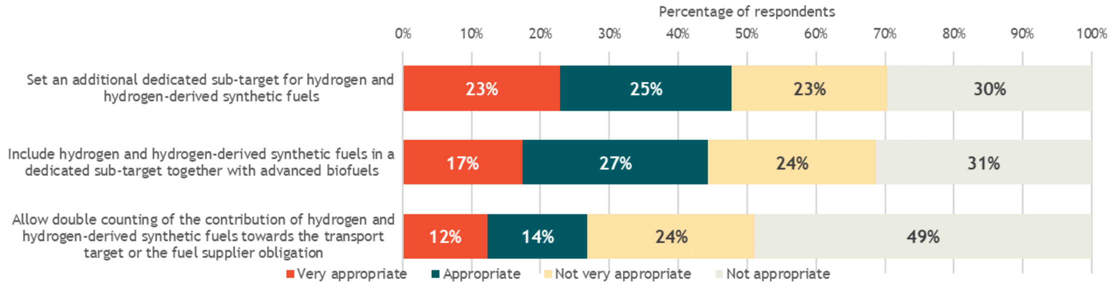


Table 3-66 Summary of results from Q8.7.1

Summary of results from Q8.7.1, open ended question concerning Q8.7, where participants were asked to specify other appropriate measures to encourage the use of hydrogen and hydrogen-derived synthetic fuels in transport modes that are difficult to decarbonise.
In total, Q8.7.1 received 191 responses, of which 20 are not unique. Most of these participants responded as business organisations (125 participants), followed by NGOs (28 participants), EU citizen (17 participants) and public authorities (10 participants). Other stakeholders responded in smaller frequencies, ranging from 1-4 responses. The main messages from the analysis are summarised below. **Encouraging green hydrogen exclusively (~20% of respondents)** A variety of stakeholders specified that only green hydrogen and renewable energy in general should be encouraged. More specifically, some stakeholders think that green hydrogen should have its own sub-targets. **No multipliers/double counting (~10% of respondents)** There are a few groups of business organisations as well as groups of NGOs which are against doubling counting and/or multipliers in general. A few of these NGOs say that multipliers accelerate the sustained use of fossil fuels. On the other hand, two business associations are against double counting, but are in favour of multipliers to account for higher efficiency of certain systems compared to others. One stakeholder states that double counting and multipliers are ambiguous and lower public confidence in the targets and public funding for renewables. **Strictly hard-to-abate sectors (~10% of respondents)** Many stakeholders stress that hydrogen should be strictly encouraged only in hard-to-bate sectors. These definitions of hard-to-abate vary and are provided by individual stakeholders as well as several coordinated stakeholder groups. Some stakeholders only identify (long-distance) shipping and aviation as hard-to-abate, while others include trucks. A group of NGOs and environmental organisations say the use of hydrogen in these sectors will be in line with the energy efficiency first principle. Further, some NGOs and a business association also include steel and chemical. However, there are a few different business organisations that think that hydrogen and e-fuels should be promoted in all sectors. **Other suggestions (<10% of respondents)** • **Technological neutrality** Several business organisations, including some organised groups of companies, state that regulation should be technologically neutral. • **CO2-standard based on well-to-wheel approach or life cycle analysis**

Summary of results from Q8.7.1, open ended question concerning Q8.7, where participants were asked to specify other appropriate measures to encourage the use of hydrogen and hydrogen-derived synthetic fuels in transport modes that are difficult to decarbonise.
A few business associations mention that GHG emissions from fuels should be based on the well-to-wheel approach or life-cycle analysis to ensure that all emissions are effectively counted. • **Critique of additionality** A few stakeholders critique/question the additionality criterion. Specifically, one public authority think that additionality should be removed.

Q8.8 How would you rank the effectiveness of the following measures in encouraging the use of renewable electricity in the transport sector?

Q8.8 asked respondents to rate the appropriateness of six measures along a four point scale. In Figure 3-52, the measures are ranked from most appropriate to least appropriate, based on the combined percentage of *very appropriate* and *appropriate* responses. Participants find that *ensuring the availability and interoperability of public recharging infrastructure* is a *(very) appropriate* measure to encourage renewable electricity in transport.

Figure 3-52 How would you rank the effectiveness of the following measures in encouraging the use of renewable electricity in the transport sector?

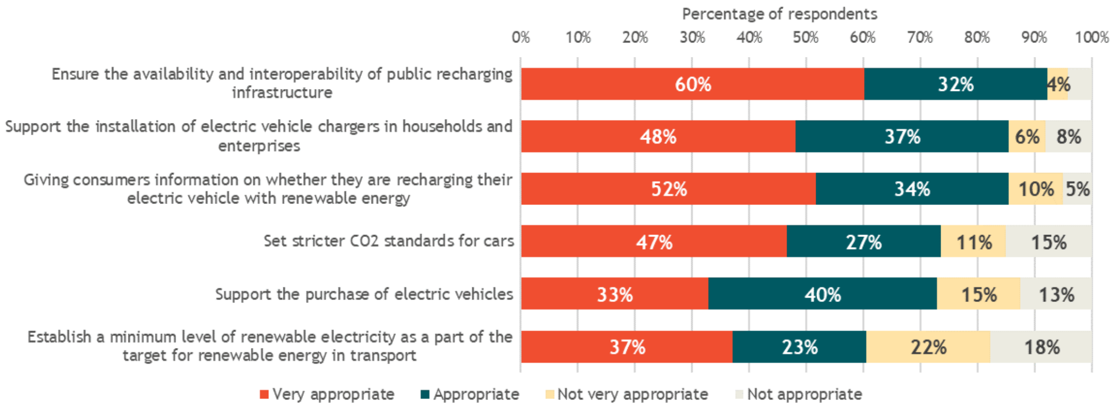


Table 3-67 Summary of results from Q8.8.1

Summary of results from Q8.8.1, open ended question concerning Q8.8 where participants are asked to rate the appropriateness of certain measures regarding encouraging the use of renewable energy in transport.
In total, Q8.8.1 received 188 responses, of which 14 are not unique. Most of these participants responded as business organisations (129 participants), followed by NGOs (27 participants) and EU citizen (16 participants). Other stakeholders responded in smaller frequencies, ranging from 3-6 responses. The main messages from the analysis are summarised below. **CO2-standard based on well-to-wheel approach/life cycle analysis (~20% of respondents)** a variety of stakeholders (~15%) prefer that emissions be based on a life cycle analysis (LCA), therefore the battery production and recycling are taken into account. Additionally, many business organisations (~5%) think that the use of renewable electricity should not be encouraged transport unless well-to-wheel emission standards are used instead of the tailpipe approach. These stakeholders often mention that this

Summary of results from Q8.8.1, open ended question concerning Q8.8 where participants are asked to rate the appropriateness of certain measures regarding encouraging the use of renewable energy in transport.
approach will create a fairer comparison between renewable electricity and other energy (specifically hydrogen and biofuels). **Technology-open vs technology-neutral (~20% of respondents)** Many business organisations (~15%) highlight the importance of staying tech-neutral. On the other hand, stakeholders from environmental organisations, NGOs and public authorities (~5%) stress the importance of staying tech-open. **Charging infrastructure (~15% of respondents)** Many stakeholders focus on the importance of the development of recharging infrastructure (at households, workplaces and public spaces) to encourage the adoption of e-mobility. Particularly, several stakeholders (<5%) think that the development of smart charging is important to create a reliable electricity network. **Other suggestions (≤5% of respondents)** • **Promote only e-mobility powered by renewable energy** In general, several stakeholders stress that e-mobility should only be encouraged if it is powered by renewable energy since electric vehicles can also be powered by fossil-fuel energy. Some stakeholders suggest a fuel-neutral credit trading mechanism. • **Credit trading system** A coordinated group of 9 NGO/environmental organisations recommend a credit trading system for renewable fuels, renewable electricity in particular, to promote renewable electricity in transport. • **Local/rural support** Several stakeholders think that providing local support is important for encouraging the use of renewable energy in transport. Namely, these stakeholders ask for targeted measures towards supporting local energy supply/sources and charging infrastructure in rural areas. • **Principle of additionality** Business organisations as well as EU citizens emphasized the importance of additionality for green accounting of renewable electricity. • **Against electricity produced by biomass** A few NGOs and an environmental organisation are against the use of biomass in electricity production. • **Information measures** A couple of stakeholders representing public authorities and *other* organisations think that information measures are needed to promote the image of e-mobility and stimulate the adoption of e-mobility. • **No measures** A couple of stakeholders think that none of these specific measures mentioned in Q8.8 should be included in RED II. One stakeholder says that the uptake of e-mobility will grow steadily on its own while the other think that alternatively the measures should apply to all renewable energy or none.

- ***Bioenergy Sustainability***

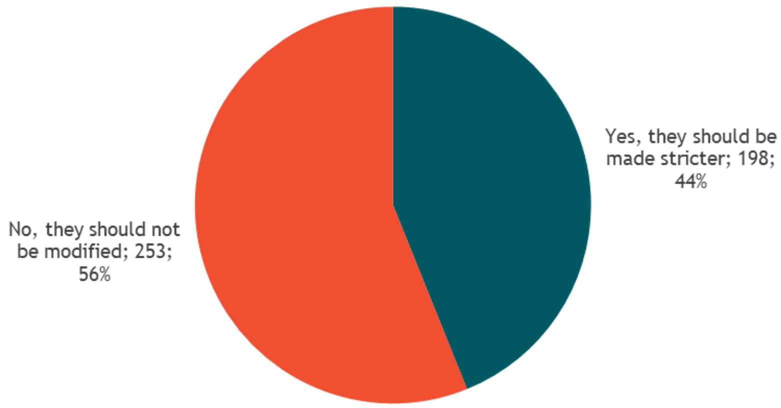
There are a total of 5 main questions in this section of the questionnaire. Results are presented below.

Question 9.3 and 9.3.1 (Do you think that there should be limits on the type of feedstock to be used for bioenergy production under REDII?) received the highest number of responses (38,786) due to a coordinated campaign which expressed views against the use of biomass, in particular forest biomass, excluding biomass from the list of renewable resources and limiting the use for bioenergy to locally-available waste and residues (38,313). While the campaign chose to focus on that specific question, it is relatively straightforward to interpret their sentiment in regard to the other questions.

Q9.1 Do you think the sustainability criteria for the production of bioenergy from forest biomass in RED II should be modified?

Q9.1 received 451 responses (Figure 3-53). More than half (56%, 253 responses) indicated that sustainability criteria for the production of bioenergy from forest biomass in RED II should not be modified, while 44% of the respondents (198 responses) think that the sustainability criteria should be made stricter. Besides the 38,313 participants from the coordinated campaign, 291 participants choose not to answer this question.

Figure 3-53 Do you think the sustainability criteria for the production of bioenergy from forest biomass in RED II should be modified? (only one reply possible) (n=451)



There is also a marked difference in opinion between respondents who have responded in their personal capacities and those who have done so in a professional capacity or on behalf of an organisation (Table 3-68). The majority of individuals, including EU and non-EU citizens, think that the sustainability criteria should be made stricter (55 answers, 73%). Only 38% (143 answers) of those responding on behalf of an organisation agree. Other than those representing consumer organisations, environmental organisations and NGOs, other professional stakeholders tend to be adverse towards modifications.

Table 3-68 Stakeholder correlation analysis for Q9.1

	Yes, they should be made stricter	No, they should not be modified
	% (frequency)	% (frequency)
As an individual in a personal capacity	73% (55)	27% (20)
In a professional capacity or on behalf of an organisation	38% (143)	62% (233)
Of which:		
Academic/research institution	*45% (5)*	*55% (6)*
Business organisation	*23% (54)*	*77% (183)*
Consumer organisation	*100% (2)*	*0% (0)*
NGO/environmental organisation	*81% (67)*	*19% (16)*
Public authority	*36% (8)*	*64% (14)*
Trade union	*0% (0)*	*100% (2)*
Other	*37% (7)*	*63% (12)*

Table 3-69 Summary of results from Q9.1.1

Summary of results from Q9.1.1, open ended question concerning Q9.1, where participants are asked whether the sustainability criteria for the production of bioenergy from forest biomass should become stricter.

In total, Q9.1.1 received 270 responses, of which 27 are not unique. Most of these participants responded as business organisations (270 participants), followed by NGOs (71 participants) and EU citizens (33 participants). Other stakeholders responded in smaller frequencies, ranging from 1 to 12 responses.

Those who said that the sustainability criteria for forest biomass should be stricter, provided reasons why it should be stricter as well as suggestions for restrictions. These views are mainly given by NGOs/environmental organisations as well as EU citizens and academia.

Negative impacts of biomass (~15% of respondents)

Many stakeholders brought up their concerns with the impact of biomass on air quality, biodiversity and the questionable sustainability of biomass in general. Particularly, these stakeholders mention how biomass production contributes to atmospheric concentrations of particulate matter (PM2.5). Further, stakeholders mention how harvesting forest biomass put pressure on biodiversity and the current sustainability criteria do not protect ongoing forest loss. Furthermore, stakeholders explain that forest biomass is likely to increase emissions.

Exclusion of forest biomass (~15% of respondents)

There is a call by many stakeholders (including a coordinated group of 15 NGOs and EU citizens) to complete exclude forest biomass as a renewable energy source. Many of these stakeholders mention the negative impacts above as reasons to exclude it. Particularly, the exclusion of primary forest biomass specifically is suggested, as it is likely to increase emissions.

Specific restrictions (~15% of respondents)

Some stakeholders (<5%) are concerned about how importing biomass makes biomass an unsustainable energy source. Further stakeholders suggest limiting biomass to locally-available wastes and residues only. Many stakeholders want to make sure that biomass is used optimally and sustainably, such as complying to the waste hierarchy, avoid stimulating the use of solid biomass and introducing a cap on biomass. A few

Summary of results from Q9.1.1, open ended question concerning Q9.1, where participants are asked whether the sustainability criteria for the production of bioenergy from forest biomass should become stricter.
stakeholders (<2%) also desire the prohibition of using natural forest for biomass production. Also, there is a call for a ban on high indirect land use change (ILUC) risk crop-based biofuels (<5%). A coordinated group of 6 NGOs think that RED should stop supporting both forest biomass and crop-based biofuels. Another coordinated group of NGOs/environmental organisations think that there needs to be a cap on the use of biomass for energy production. **Those who think that the sustainability criteria for forest biomass should not be modified also provided reasons why. These stakeholders are primarily business organisations.** **Too early to make changes (~20% of respondents)** Many of these stakeholders think that revising these criteria at this point it too premature, as these sustainability criteria are in the implementation phase. Many call for an assessment of the effectiveness of the current criteria before any changes are made. This includes a few coordinated groups of business organisations, including 7, 9, and 13 participants. **Regulatory consistency/stability (~10% of respondents)** Many stakeholders think that new modifications are unfair to investors who made investing decisions based on current criteria and could delay future investments. These stakeholders call for stability in legislation. Additionally, stakeholders worry quick changes to criteria will cause a great administrative burden, especially on smaller market actors.

Q9.2 The obligation to fulfil sustainability criteria for biomass and biogas in heat and power applies to bioenergy installations of at least 20 MW for solid biomass and 2 MW for biogas. Should these thresholds be lowered to include smaller installations?

Q9.2 received 414 responses (Figure 3-54) almost perfectly split between the yes and no (a difference of 4 votes, less than 1%). Just over half of the participants are in favour of lowering the thresholds for biomass and biogas to include smaller installations (50%, 208 responses). The remaining are against lowering the threshold (50% 206 responses). Besides the 38,313 participants from the coordinated campaign, 328 participants choose not to answer this question.

Figure 3-54 The obligation to fulfil sustainability criteria for biomass and biogas in heat and power applies to bioenergy installations of at least 20 MW for solid biomass and 2 MW for biogas. Should these thresholds be lowered to include smaller installations? (n=414)

Respondents who participated in a personal capacity more often replied that the threshold should be lowered (76%. 52 responses) than those who replied in a professional capacity (45%, 156 responses) (Table 3-70). Notably, individuals responding on behalf of a business organisations (67%, 148 responses) replied that the threshold should not be lowered. While those responding on behalf of environmental organisations and NGOs 77% (59 responses) replied that the threshold should be lowered.

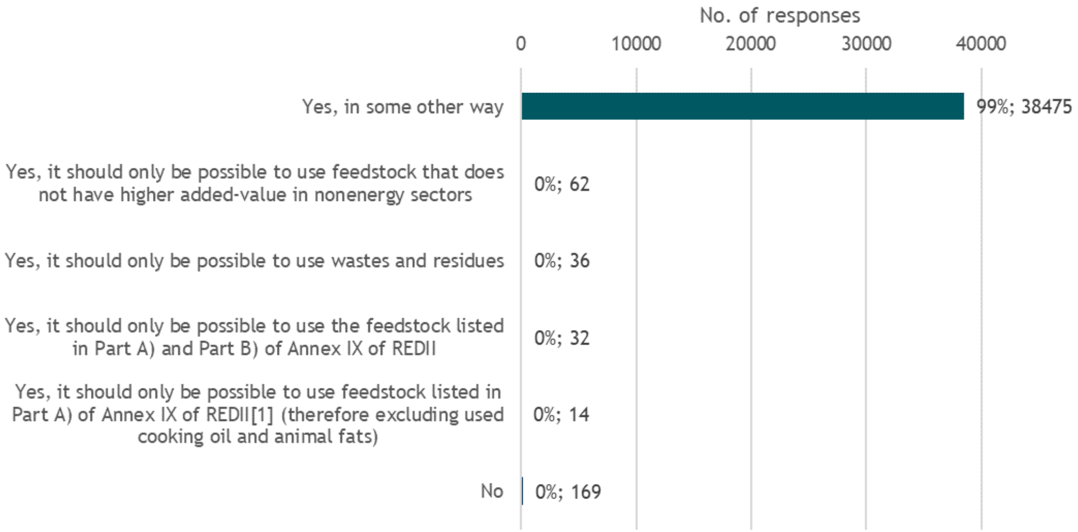
Table 3-70 Stakeholder correlation analysis for Q9.2

	Yes	No
	% (frequency)	% (frequency)
As an individual in a personal capacity	76% (52)	24% (16)
In a professional capacity or on behalf of an organisation	45% (156)	55% (190)
Of which:		
Academic/research institution	*60% (6)*	*40% (4)*
Business organisation	*33% (72)*	*67% (148)*
Consumer organisation	*67% (2)*	*33% (1)*
NGO/environmental organisation	*77% (59)*	*23% (18)*
Public authority	*40% (8)*	*60% (12)*
Trade union	*67% (2)*	*33% (1)*
Other	*54% (7)*	*46% (6)*

Q9.3 Do you think that there should be limits on the type of feedstock to be used for bioenergy production under REDII?

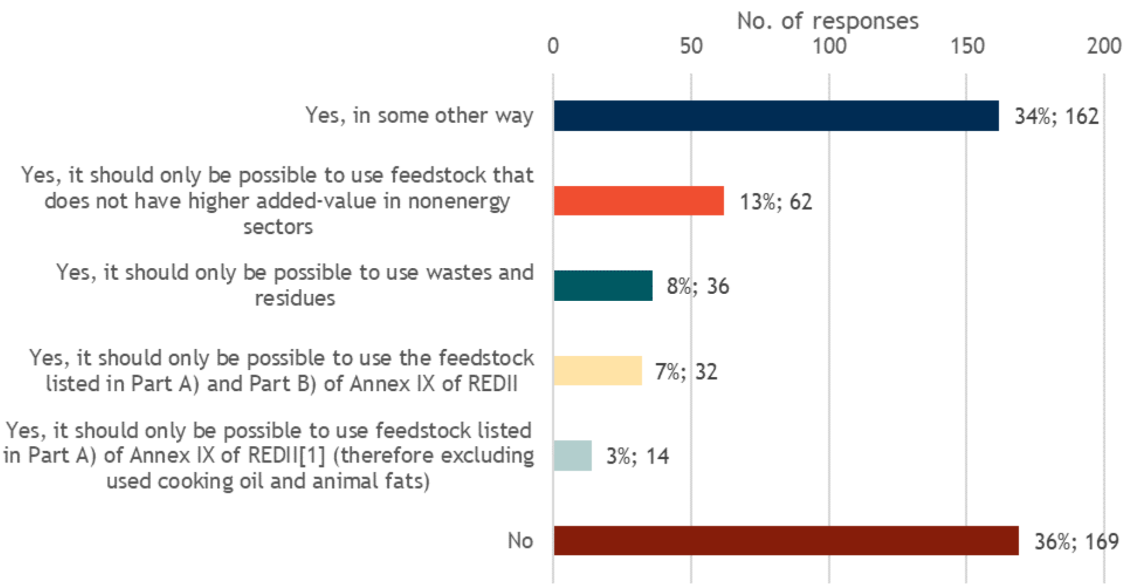
Q9.3 received 38,788 responses (Figure 3-55). In total, 99% of respondents replied that there should be some type of limit (38,473 responses), due to the exceptional citizens' participation. The high volume of responses to this question is the result of a coordinated initiative.

Figure 3-55 Do you think that there should be limits on the type of feedstock to be used for bioenergy production under REDII? (n=38,788)



If the responses from the coordinated initiative are removed, the distribution changes as presented in Figure 3-56. The most popular response is *No* (there should not be limits to the type of feedstock) with 36% of responses (136). However, the remaining 64% of participants believe that there should be some limitations to the type of feedstock, and the most popular answer (34%, 162 votes) is that limits should be different than those indicated by the other available options. Among the less popular responses: 62 participants (13%) think that *only feedstock which does not have higher added-value in nonenergy sectors should be used*; 36 participants (8%) responded that *only the use of waste and residues should be allowed*; 32 participants (7%) responded that *only feedstock listed in Part A) and Part B) of Annex IX of RED II should be allowed*; 14 participants (3%) responded that *only feedstock listed in Part A) of RED II should be allowed to be used*.

Figure 3-56 Do you think that there should be limits on the type of feedstock to be used for bioenergy production under REDII (excluding coordinated campaign)? (n=475)



Almost all individuals, including EU and non-EU citizens, think that there should be some other type of limit on feedstock used for bioenergy production under REDII (100%). While this is because of a coordinated campaign discussed above, even excluding these responses sees a predominant preference for limitation to the type of feedstock (only 12 citizens oppose it).

Of those responding in a professional capacity, the most popular response is that there should not be additional limits (39%, 157 responses), but the majority (61%, 244 responses) selected one of the Yes options. Of those that responded in a professional capacity, no stakeholder group showed a clear preference for no additional feedstock limits (50% of trade unions said yes, but a total of only 2 replies was received from this group). Most votes for No arrived from business organisations (a total of 122 votes, 47%) but even the majority business organisations (53%, 139 votes) recognised that some sort of additional limitations should be included.

Concerning the 38,313 participants in the coordinated response, they all declared to be EU citizens, even though 20% selected a non-EU country to the question "country of origin". It is possible that the EU citizen box was ticked automatically by the script that run the automated process, or that the country of origin was randomly selected. Participants in the campaign provided an ad-hoc email address registered under the domain "stopfakegreen". The names provided appear genuine.

Table 3-71 Stakeholder correlation analysis for Q9.3

	Yes, only feedstock listed in Part A) of Annex IX of REDII	Yes, only feedstock listed in Part A) and Part B) of Annex IX of REDII	Yes, only wastes and residues	Yes, only feedstock that does not have higher added-value in nonenergy sectors	Yes, in some other way	No
	% (freq.)	**% (freq.)**	**% (freq.)**	**% (freq.)**	**% (freq.)**	**% (freq.)**
As an individual in a personal capacity	0% (5)	0% (4)	0% (14)	0% (15)	100% (38337)	0% (12)
In a professional capacity or on behalf of an organisation	2% (9)	7% (28)	5% (22)	12% (47)	34% (138)	39% (157)
Of which:						
Academic/research institution	0% (0)	36% (4)	9% (1)	18% (2)	9% (1)	27% (3)
Business organisation	2% (5)	8% (21)	4% (10)	11% (30)	28% (73)	47% (122)
Consumer organisation	0% (0)	0% (0)	0% (0)	50% (1)	50% (1)	0% (0)
NGO/environmental organisation	1% (1)	1% (1)	6% (5)	8% (7)	64% (55)	20% (17)
Public authority	5% (1)	5% (1)	5% (1)	32% (7)	27% (6)	27% (6)
Trade union	0% (0)	0% (0)	50% (1)	0% (0)	0% (0)	50% (1)
Other	12% (2)	6% (1)	24% (4)	0% (0)	12% (2)	47% (8)

Figure 3-57 Country of origin of respondents participating in the coordinated campaign

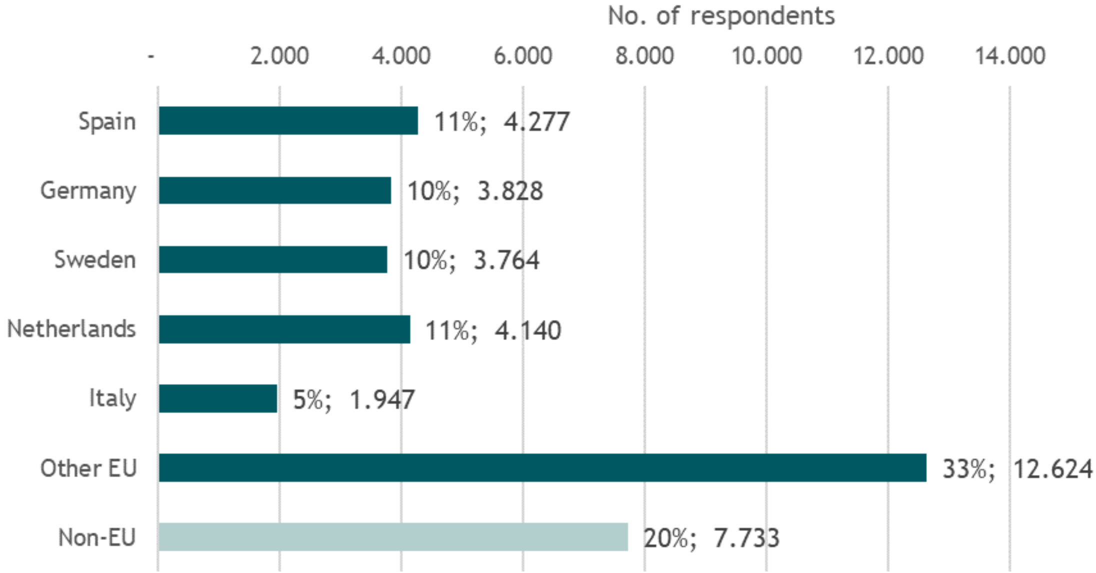


Table 3-72 Summary of results from Q9.3.1

Summary of results from Q9.3.1, open ended question concerning Q9.3 on what limits they suggest on type of feedstock used for bioenergy production under RED II
In total, Q9.3.1 received 38,462 responses, with most of these (38,313) providing the same answer, as they were part of a coordinated campaign. The majority of participants responded as EU citizens (38,314 participants, of which 21 outside the coordinated campaign), followed by business organisations (66 participants) and NGOs (52 participants). Other stakeholders responded in smaller frequencies, ranging from 1-5 responses. **Coordinated responses (99% of respondents)** The coordinated response requested to remove biomass from the list of renewable resources and limiting the use for bioenergy to locally-available waste and residues. This should be accompanied by a moratorium or a cap on the total amount of solid biomass in electricity and heating, by an accelerated phase-out of high ILUC risk fuels, and by the removal of incentives for bioenergy. NGOs and Environmental organisations expressed a similar message. This coordinated response comprises of more than 38,000 participants (see Text box 3-1). The emerging themes from responses other than the coordinated campaign are: **Exclusion of forest biomass (~30% of respondents, excluding the campaign)** A very common stance taken by NGOs/environmental organisations and EU citizens (including another coordinated group of 16 participants) is the prohibition of the use of forest biomass specifically. These responses mainly touch upon the negative impact of forest biomass, including increasing GHG emissions, loss of biodiversity. Among these respondents, forest biomass is largely considered a ‘harmful industry’ and many concerns are brought up about the subsidisation of this industry by Member States. **Phase out biofuels (~20% of respondents, excluding the campaign)** Many participants, mainly those representing NGOs and environmental organisations, suggest the phase-out of biofuels. Particularly, there is a call for a distinct phase out where palm/soy biodiesel are phased out by 2021, all crop-based biodiesel is phased out by 2025 and all remaining crop-based biofuels are phased out by 2030.

Common concerns shared amongst those that suggest a phase out are the increase of GHG emissions, biodiversity loss, effect on food security, promotion of monocultures and use of pesticides.

Other suggestions (<10% of respondents, excluding the campaign)

- **Only feedstock that does not have high added value in nonenergy sectors**
  Business organisations and a public authority suggest eliminating support for feedstock that does not have a high-added value in nonenergy sectors for example power only, heating and transport. This is also because using feedstock with high-added value for energy conversion would create market distortions and supply shortages in nonenergy sectors.
- **Sustainable feedstocks only**
  A group of seven business organisations propose that only sustainable feedstocks should be allowed.
- **(True) waste or residue only**
  Another common suggestion is the use of (true) waste or residues only. This is most common with NGOs and EU citizens, including a coordinated group of six NGOs. Many of these participants suggest that RED II should have stricter criteria for waste/residues, where residues have no alternative use and do not hinder biodiversity or intensify livestock farming (in regard to the use of manure).
- **No additional limits**
  Some business organisations suggest that the existing sustainability criteria in RED II already provide limits for the use of bioenergy and these 'strict' criteria are already followed by the bioenergy industry today.

Text box 3-1 Text of the coordinated response (38,313 responses)

"For many years, EU policies have encouraged types of bioenergy that increase emissions compared to fossil fuels and exacerbate pressure on forest biodiversity. Member States are subsidising this harmful industry to the tune of billions of euros every year.

The hugely negative unintended consequences of using crops to produce biofuels for cars have already been recognised for years now, but the impacts of the EU's incentives for burning forest biomass are no less alarming or counterproductive.

Harvesting forests for energy will typically increase GHG emissions compared to fossil fuels for decades or even centuries regardless of how sustainably the forests in question were managed. The requirements regarding Sustainable Forest Management and land use accounting are in no way a proxy for the climate impacts of burning specific feedstocks.

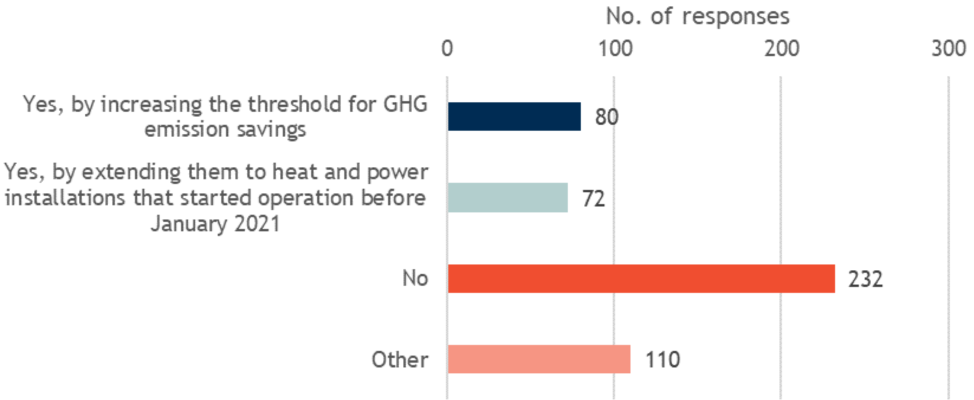
Unless and until the EU seriously reforms its bioenergy policies they will continue to undermine climate, air quality, and biodiversity objectives and our commitment to the Sustainable Development Goals, and cause serious harm to the EU's international reputation.

As a concerned EU citizen, I ask you when reviewing the Renewable Energy Directive to make the European Green Deal a reality by ending EU support for burning trees and crops for energy."

Q9.4 Do you think that the minimum GHG emission saving thresholds for biomass in heat and power, currently at 70% for installations starting operation from 2021 and at 80% for installations starting operation from 2026, should be extended and/or made stricter? (multiple answers possible)

Q9.4 received 494 responses from 405 participants (multiple answers possible). Participants could choose from four options and responded with 1.2 answers on average. Figure 3-58 presents an overview of the participants' responses. The most popular response, selected by 232 participants, was that the minimum GHG emission saving threshold for biomass in heat and power should *not* be made stricter or extended. A total of 152 participants instead believes that the GHG savings thresholds should be modified (80 participants indicated that the minimum GHG emission saving threshold for biomass in heat and power should be extended and 72 participants indicated that there should be an extension to heat and power installations that started operation before January 2021). Further 110 responses went to *other*.

Figure 3-58 Do you think that the minimum GHG emission saving thresholds for biomass in heat and power, currently at 70% for installations starting operation from 2021 and at 80% for installations starting operation from 2026, should be extended and/or made stricter? (multiple answers possible) (n=405; 494 responses)



There is a clear difference in opinion between participants who have responded in their personal capacity and those who have done so in a professional capacity or on behalf of an organisation (Table 3-73; percentages are in terms of total responses, *not* participants). A total of 60 citizens (62%) think that the thresholds should be either extended (30 responses) and/or made stricter (30 responses). Those responding in a professional capacity more often think that these thresholds should *not* be extended or made stricter (212 responses, 53% of total answers); these votes arrive mainly from those responding on behalf of business organisations (171 responses. 66% of business organisations). Among the responses provided on behalf of organisations, only NGOs and environmental organisations and consumer organisations did not have No as the most popular answer.

Table 3-73 Stakeholder correlation analysis for Q9.4

	Yes, by extending them to heat and power installations that started operation before January 2021	Yes, by increasing the threshold for GHG emission savings	No	Other
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	32% (30)	32% (30)	21% (20)	15% (14)
In a professional capacity or on behalf of an organisation	11% (42)	13% (50)	53% (212)	24% (96)
Of which:				

Academic/research institution	*31% (4)*	*23% (3)*	*46% (6)*	*0% (0)*
Business organisation	*6% (15)*	*10% (25)*	*66% (171)*	*19% (50)*
Consumer organisation	*100% (2)*	*0% (0)*	*0% (0)*	*0% (0)*
NGO/environmental organisation	*20% (17)*	*17% (15)*	*15% (13)*	*48% (41)*
Public authority	*9% (2)*	*18% (4)*	*59% (13)*	*14% (3)*
Trade union	*0% (0)*	*0% (0)*	*100% (1)*	*0% (0)*
Other	*13% (2)*	*20% (3)*	*53% (8)*	*13% (2)*

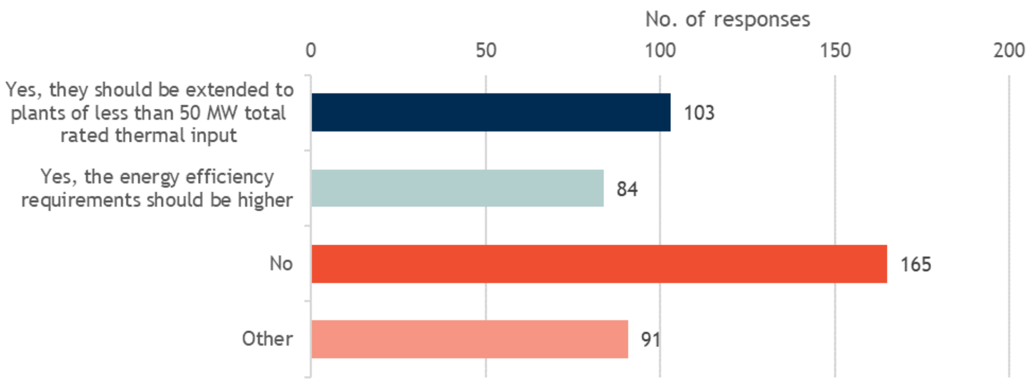
Table 3-74 Summary of results from Q9.4.1

Summary of results from Q9.4.1, open ended question concerning Q9.4 where participants are asked to explain why the minimum GHG emission saving thresholds for biomass in heat and power should or should not be extended and/or made stricter.
In total, Q9.4.1 received 109 responses, of which 21 are not unique. Most of these participants responded as business organisations (50 participants), followed by NGOs (40 participants) and EU citizens (12 participants). Other stakeholders responded in smaller frequencies, ranging from 2-3 responses. The main messages from the analysis are summarised below. **Revise GHG accounting method for biomass (~30% of respondents)** Many participants think that the GHG accounting method needs to be revised to take into account the full carbon and climate impact of biomass. Some of these stakeholders think that the threshold is meaningless without this change and currently provides a 'skewed image' of the real impact of biomass. Impacts, which are prescribed to be included in the GHG accounting method, are: carbon debt, land use change, combustion, pre-combustion processing. These views are primarily given by those from NGOs/environmental organisations and EU citizens. This includes a few coordinated groups of 5 NGO, 9 NGOs and 19 NGOs/EU citizens. **No further changes (~25% of respondents)** Business organisations, including a coordinated group of 9 participants, warn that there should not be any further changes to the sustainability criteria, including the GHG emissions threshold. Since these criteria are currently in the implementation phase, these stakeholders think that it is too early to make such changes and it is 'unfair' to market operators who made investment choices based on RED II. Further, some of these stakeholders think that the current criteria are already very ambitious. **Other suggestions (<5% of respondents)** • **Extend to all energies** Some business organisations think that the thresholds applying to biomass should also be applied to all energies. Further some of these stakeholders think that the thresholds should not be made stricter until they are applied to all renewable energies. • **Other commentary** Additionally, some stakeholders provided specific views. For instance, a couple of respondents are completely against biomass (NGOs). One stakeholder from a business organisation thinks that animal-based products should be excluded.

Q9.5 Do you think that the energy efficiency requirements applying to bio electricity-only installations (article 29, paragraph 11) should be made more stringent? (multiple answers possible)

Q9.5 received 443 responses from 362 participants (multiple answers possible). Participants could choose from four options and chose 1.2 answers on average. Figure 3-59 presents an overview of the participants' responses. The most popular answer (167 participants) was that the energy efficiency requirements should not be made more stringent. A total of 187 respondent however stated that they should be made more stringent, either by making the extending to plants of less than 50 MW total rated thermal input (103 participants) and/or by imposing a higher energy efficiency requirement (84 participants). Considering participants (rather than responses) a total of 140 indicated a positive answer (extending the limit to installations rated at less than 50 MW and/or higher requirements). 91 respondents responded with *other*.

Figure 3-59 Do you think that the energy efficiency requirements applying to bio electricity-only installations (article 29, paragraph 11) should be made more stringent? (multiple answers possible) (n=362; 443 responses)



Many individuals, including EU and non-EU citizens, indicated that the energy efficiency requirements should be either extended (29 responses) and/or made stricter (31 responses). Those responding in a professional capacity more often think that these requirements should *not* be extended or made stricter (145 responses) (Table 3-75; percentages are in terms of total responses, *not* participants). Many of these stakeholders against an extension of/stricter requirements are from business organisations (115 responses) and business organisations are also the only group with a marginal preference for no extension (52% or responses). Those responding for environmental organisations and NGOs chose more the *other* option 42 responses).

Table 3-75 Stakeholder correlation analysis for Q9.5

	Yes, they should be extended to plants of less than 50 MW total rated thermal input	Yes, the energy efficiency requirements should be higher	No	Other
	% (frequency)	% (frequency)	% (frequency)	% (frequency)
As an individual in a personal capacity	33% (29)	35% (31)	22% (20)	10% (9)

	Yes, they should be extended to plants of less than 50 MW total rated thermal input	Yes, the energy efficiency requirements should be higher	No	Other
In a professional capacity or on behalf of an organisation	21% (74)	15% (53)	41% (145)	23% (82)
Of which:				
Academic/research institution	*38% (5)*	*31% (4)*	*23% (3)*	*8% (1)*
Business organisation	*20% (43)*	*13% (29)*	*52% (115)*	*15% (33)*
Consumer organisation	*25% (1)*	*50% (2)*	*0% (0)*	*25% (1)*
NGO/environmental organisation	*16% (12)*	*12% (9)*	*17% (13)*	*55% (42)*
Public authority	*27% (7)*	*19% (5)*	*38% (10)*	*15% (4)*
Trade union	*0% (0)*	*50% (1)*	*50% (1)*	*0% (0)*
Other	*46% (6)*	*23% (3)*	*23% (3)*	*8% (1)*

Table 3-76 Summary of results from Q9.5.1

Summary of results from Q9.5.1, open ended question concerning Q9.5 where participants were asked if they think that the energy efficiency requirements applying to bio electricity-only installations (article 29, paragraph 11) should be made more stringent.

In total, Q9.5.1 received 90 responses, of which 20 are not unique. Most of these participants responded as NGOs (41 participants), business organisations (33 participants), and EU citizens (7 participants). Other stakeholders responded in smaller frequencies, ranging from 1-4 responses. The main messages from the analysis are summarised below.

Extend to all bioenergy facilities (~25% of respondents)

Many NGOs/environmental organisations and EU citizens indicate that the energy efficiency requirements should be applied to all bioenergy facilities and excluding biomass and bioliquid since they are inefficient energy sources by definition. Instead, some of these stakeholders suggest priority should be given to renewable energy such as wind and solar. Stakeholder representing environmental organisations, public authorities, business organisations, as well as EU citizens also expressed similar views.

Do not promote (forest) biomass use (30-35% of respondents)

The exclusion of (forest) biomass is a common view among different types of stakeholders (NGOs, companies, business associations, consumer organisations, environmental organisations, public authorities, and citizens). Particularly, there are several coordinated responses with similar messages to exclude forest biomass. A few of these stakeholders point out that RED II allows the expansion of forest biomass use in electricity-only installations, even though cleaner technologies are available. These stakeholders call for more action to ensure secondary wood resources are being used for more sustainable purposes. A group of 16 NGOs/EU citizens (coordinated response) think that electricity generated from biomass/bioliquids should be excluded and the

Summary of results from Q9.5.1, open ended question concerning Q9.5 where participants were asked if they think that the energy efficiency requirements applying to bio electricity-only installations (article 29, paragraph 11) should be made more stringent.
efficiency criteria should apply to all industrial bioenergy installations. 5 NGOs provided a coordinated response that existing electricity only installations that use biomass need to be phased out. Another coordinated group of 8 NGOs suggest that RED II should make sure that biomass resources are used optimally and sustainably only where other alternatives are not available. **Keep current requirements (~15% of respondents)** Business organisations, NGOs/environmental organisations as well as citizens suggested that there should not be any more changes the energy efficiency requirements. A group of companies say that the current requirements in RED II are already based on the best available technologies in the EU Industrial Emissions Directive, which represents the current best practice. Many of these stakeholders mention the importance of legal consistency as well as a disapproval of frequent adjustments to requirements. Further, a group of 8 business organisations mention that bio-electricity only installations may be needed to offer capacity/balance in the grid when renewable energy sources are not available. **Removal of Article 29, paragraph 11 (<5% of respondents)** Two stakeholders (a representative of an environmental organisation and an EU citizen) propose that Article 29, paragraph 11 be removed. These stakeholders believe it is a redundant regulation.

Additional contributions

A number of stakeholders submitted further responses and evidence via email. These are summarised below.

Organisations that submitted additional feedback

34 organisations submitted additional feedback, of which 9[970] also responded to the questionnaire. Of these participants, 16 were identified as NGOs, 14 as business organisations, while the remaining 4 other stakeholders comprise both public authorities and research institutions. Among the 17 NGOs were 13 coordinated stakeholders related to the NGO: International Council on Monuments and Sites (ICOMOS). Some of these coordinated stakeholders are local public authorities on cultural preservation but are treated as an NGO group. The remaining organisations with additional feedback provided unique responses. In the subsections below we synthesise their main messages, categorised by type of stakeholders and structured according to the sectors and themes in the questionnaire.

Business organisations

Responses by business-related stakeholders on renewable energy in specific sectors were most often related to heating and cooling and district heating and cooling (7 stakeholders), followed by transport (6 stakeholders), bioenergy (5 stakeholders) and electricity production (4 stakeholders). There were few submissions related to industry, while those concerned with the building sector mention linking the RED with the EED and EPBD.

On a general note, all business-related stakeholders except for one[971] are supportive of raising the renewable energy target beyond 32%, several claiming that this would reflect the increased GHG emission reduction target for 2030. One stakeholder proposes raising the target to 40% by 2030. At least 3 business stakeholders[972] mention carbon pricing as a key policy instrument to drive the increased uptake of renewable energy.

A handful of stakeholders[973] suggest modifications to the Guarantees of Origin system, whilst 1 is not supportive of the Guarantees of Origin arguing it leads to green washing and inadequate incentives[974]. Of those proposing modifications to the system, stakeholders say: that GOs should foster cross-border trade of CO2 neutral hydrogen; that the obligation to certify to consumers the share of energy from renewable sources should be extended to renewable fuels and low carbon fuels including biomethane and hydrogen; that there should be an EU-wide system for renewable and low-carbon fuel certification accounting for life cycle GHG performance; that there is a need for a more transparent framework with additional information captured to evidence the consumption of renewable electricity; and that it must contain clear rules to guarantee the traceability for renewable power purchase agreements in Europe.

[970] WindEurope, Vattenfall, CEE Bankwatch Network, Institutional Investors Group on Climate Change, Neste, Energy Community, European Federation of Energy Efficiency Services, RE-Source, Siemens Gamesa Renewable Energy
[971] Federation of Belgian Enterprises
[972] Hydro, Association of German Chambers of Industry and Commerce, German Association on District Heating and Cooling
[973] Association of German Chambers of Industry and Commerce, European Committee for Standardization, International Association of Oil and Gas Producers, RE-Source, Siemens Gamesa Renewable Energy
[974] Hydro

Power purchase agreements are of further interest to at least 2 business stakeholders[975]. Stakeholders see a need to remove administrative and regulatory barriers to power purchase agreements which still exists in many Member States, despite Art. 15.8 of the RED asking governments to remove these barriers. Furthermore, corporate buyers and sellers of renewable energy need committed policies for the implementation of enabling frameworks for power purchase agreements.

2 business stakeholders[976] are especially interested in how to incorporate CCS into the RED. One recommendation is that BECCS and DAC should be prioritised in any CCS context, where another proposes expanding the scope of the RED to incorporate CCS by encouraging low carbon hydrogen facilities as well as retrofitting existing hydrogen facilities with CCS.

On heating and cooling, 1 stakeholder[977] recommends measures to go hand in hand with district heating and cooling linking integrated energy planning at local level with efficient heating and cooling under annex 8 of the EED Art. 14 as well as the EPBD. Similarly, another stakeholder suggests measures must create a level playing field between individual heating solutions and district heating and cooling[978]. 2 stakeholders[979] see improved measures comprising waste heat useful for long-term energy efficiency, while another argues strengthening the access rights to district heating networks for third parties can contribute to make use of waste heat potential in industry[980]. A final key message for heating and cooling is on that targets and the role of Member States, where 1[981] argues for binding targets, while another[982] believes in flexibility for Member States to design the level and form of support under the existing overarching principles.

For transport, stakeholders mention several recommendations crossing the modes road, maritime and aviation. There is support for increasing the share of renewable energy in transport to at least 24% in 2030, where the Commission is proposed to work further on the reFuelEU and FuelEU Maritime initiatives for the development of advanced biofuels and fuels derived from green hydrogen to meet the needs of aviation and maritime transport[983]. 1 stakeholder suggests supporting aviation biofuels with a dedicated and ambitious mandate in a separate legislative proposal[984]. Another stakeholder argues for measures to support power-to-x technologies (e.g., renewable hydrogen/ammonia) to deliver substantial improvement to the GHG footprint of shipping while improving air quality in ports and shipping corridors[985].

Also specific to transport, 1 stakeholder[986] suggests the use of multipliers in renewable fuels are no longer fit for purpose. The supply of renewable fuels to shipping should be at a minimum incentivised to the same degree as road and rail. Furthermore, they believe in ramping up the technology readiness of e.g., advanced biofuels, ammonia, renewable hydrogen, renewable synthetic fuels, and recycled

[975] Siemens Gamesa Renewable Energy, RE-Source
[976] International Association of Oil and Gas Producers, Landwärme
[977] European Federation of Intelligent Energy Efficiency Services
[978] German Association on District Heating and Cooling
[979] European Federation of Intelligent Energy Efficiency Services, Vattenfall
[980] DIHK
[981] European Federation of Intelligent Energy Efficiency Services
[982] Vattenfall
[983] Institutional Investors Group on Climate Change
[984] Neste
[985] Siemens Gamesa Renewable Energy
[986] World Shipping Council

carbon fuels, which should all be considered to evaluate how practical their use, production, and distribution may be.
On renewable electricity production, 1 stakeholder[987] argues that a major overhaul of RED is not required, except for e.g., legal definitions on offshore hybrid projects and multi-purpose interconnectors. Another stakeholder argues for simplification of permitting rules, complementing Art. 16 with an annex setting out benchmarks for good practices, potentially derived from the Commission funded "RES-simplify" project[988]. Finally, 1 stakeholder highlights the need for direct electrification based on further support to technology-specific auctions, as technology-neutral auctions may not serve adequately the different generation profiles across technologies[989].

A common view for business organisations concerning bioenergy is that it is necessary and sustainable, as long as sustainability and GHG saving criteria are respected. Where 1 stakeholder[990] is satisfied with the current criteria under Art. 29, another leaves the door open for modifications,[991] suggesting an evaluation of the criteria before potentially modifying them. 1 stakeholder sees a need to lay down criteria for biofuels and liquid biomass and above all provide certainty for the users of biomass[992], while another highlights that implementation of the criteria adopted in 2018 still needs to happen at local level[993]. A final recommendation is restriction on the approval of palm oil as well as palm oil effluent and empty palm fruit bunches as feedstock qualifying for advanced biofuel[994].

NGOs and environmental organisations

As mentioned in the introduction to this chapter, 13 NGO stakeholders connected to ICOMOS provided coordinated responses via e-mail. These stakeholders have a clear message, namely that a raised target and the revision must incorporate cultural heritage and monument protection. They claim that consideration of cultural heritage cannot be left to Member States alone and urge the Commission to show responsibility through its legislative competence, in view of the repeated commitments made by the EU to the common European cultural heritage. A key point they mention is that financial incentives must not lead to simple solutions (e.g., standard solar panels) being given preference over alternative and other listed measures, simply because standard solutions receive higher funding.

4 other NGOs also submitted additional responses, containing diverse recommendations across specific topics and sectors. No NGOs oppose raising the target, and as indicated by at least 1 stakeholder[995] amending the RED by raising the ambition and targets are natural to align it with the European Green Deal.

2 NGOs[996] are highly sceptic of hydropower for renewable electricity production. 1 stakeholder claims that Articles akin to the existing Art. 29/30 (but simpler) need to be added for hydropower, to prevent EU targets further stimulating projects that contravene the EU environmental acquis. This would increase public acceptance of renewables, increase policy coherence, and boost the implementation of

[987] Vattenfall
[988] WindEurope
[989] Siemens Gamesa Renewable Energy
[990] Neste
[991] European Federation of Intelligent Energy Efficiency Services
[992] Federation of Belgian Enterprises
[993] Vattenfall
[994] Landwärme
[995] CEE Bankwatch Network
[996] CEE Bankwatch Network, World Fish Migration Foundation

the EU nature directives. More clearly an opponent of hydropower is another stakeholder which wants an end to the expansion of hydropower in Europe suggesting it could wipe out entire ecosystems and the services they provide to people and nature.

Specific to bioenergy, 1 stakeholder suggests the sustainability criteria for the production of bioenergy from forest biomass in RED II should be made stricter e.g., to protect the biodiversity of major wood pellet sourcing regions[997]. More robust monitoring and verification of sources are needed, and restrictions on eligibility for end-use of woody biomass should be developed to prohibit electricity-only large-scale biomass and to instead use biomass in high-efficiency heating and cooling applications.

Other stakeholders

The remaining 4 stakeholders were identified as public authorities, research institutions or simply other stakeholders. General remarks include support for renewable energy in those end use sectors where they have the greatest decarbonisation impact, support for green hydrogen, support for minimum shares or quotas for renewable and low carbon fuels (with certification extended to biomethane and hydrogen), definition of claim rules for Guarantees of Origin or allocate this responsibility to Member States (national regulatory bodies), and the importance of linking the Directive with ESG provisions, the Taxonomy on Sustainable Finance, Circular Economy as well as standards and materiality assessments[998].

Another stakeholder claim we can only achieve our climate targets if we build efficient storage facilities and massively strengthen our networks, and if a European Energy Grid (trans-European HVDC network) is built at European level, enabling electricity exchange in Europe[999].

Other stakeholders recommend the revision to be aligned with the Energy System Integration- and Hydrogen Strategies, putting electrification based on renewables as the most energy and cost-efficient alternative to achieve decarbonisation. The energy efficiency principle, and direct electrification through electric vehicles and electric heat pumps are also supported. Finally, other stakeholders suggest adding to Art 19.11 on guarantees of origin that: "Contracting Parties of the Energy Community shall not be considered third countries within the meaning of this paragraph".

[997] National Wildlife Federation
[998] European Committee for Standardization
[999] WiseEuropa

Annex J - Scenario Modelling

Annex J to the

Final Report

Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration

In association with:

LIST OF ACRONYMS

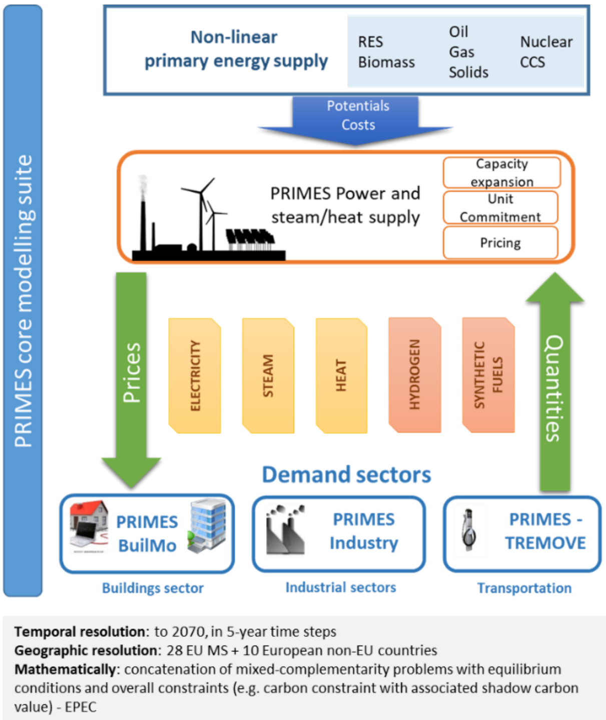
Acronym	Full name
ACSG	Artelys Crystal Super Grid
AGB	Above ground biomass
BAT	Best available technology
BAT-AEEL	Best available technology associated energy efficiency levels
BREF BAT	Best Available Techniques Reference Document
CHP	Combined heat and power
CO_2	Carbon dioxide
CoC	Chain of Custody
DG ENV	European Commission's Directorate General for Environment
DH	District heating
EC	European Commission
EEA	European Environment Agency
EU	European Union
FW	Fuelwood
GDP	Gross domestic product
GHG	Greenhouse gases
GW	Gigawatt
GWh	Gigawatt-hour
HCVF	High Conservation Value Forests
JRC	Joint Research Centre
JRC-PPDB-OPEN	JRC Open Power Plants Database
KBA	IUCN Key Biodiversity Areas
ktoe	Kilo ton oil equivalent
FSC	Forest Stewardship Council
ha	hectares
IFCC	Integrated gasification combined cycle
ILUC	Indirect land use change
IRW	Industrial round wood
IUCN	International Union for Conservation of Nature
LOL	Loss of load
LOLE	Loss of load expectation
LULUCF	Land Use, Land-Use Change and Forestry
Mm^3	Million cubic meters
MS	Member State
Mt	Mega ton
Mtoe	Mega ton oil equivalent
MW	Megawatt
MWh	Megawatt-hour
NAI	Net annual increment
NDC	Nationally determined contribution
NECP	National Energy and Climate Plans
NGO	Non-governmental organization
ODT	Oven-dried ton
OPC	Open public consultation
PEFC	Programme for the Endorsement of Forest Certification
PJ	Peta joule
PM	Particulate matter
RE	Renewable energy
RED (RED I)	Renewable Energy Directive (Directive 2009/28/EC)
RED II	Recast Renewable Energy Directive (2018/2001/EU)
RES	Renewable energy sources
RES-E	Electricity from renewable energy sources
RoW	Rest of the world
SBP	Sustainable Biomass Program
SITC	Standard international trade classification
SME	Small and medium enterprises
TWh	Terawatt-hour
VOC	Volatile organic compound

Modelling of scenarios and quantification

This document presents a technical summary of the modelling work carried out in support of the revision of the Renewable Energy Directive as part of the project: *Technical support for RES policy development and implementation: delivering on an increased ambition through energy system integration*.

Modelling tools

PRIMES model

Time horizon	The PRIMES model runs in 5-year time steps from 2020 to 2070; the years 1990 to 2015 are calibrated to statistics. Yearly resolution can be made available upon request.
Geographic coverage	The PRIMES model covers all 28 EU Member States individually with country specific models; the model is further available for 10 other European countries: Albania, Bosnia-Herzegovina, Iceland, Kosovo, Montenegro, North Macedonia, Norway, Serbia, Switzerland, Turkey. The expansion of the model to other countries (e.g. Moldova, Ukraine) is possible. For these countries, it is suggested to use the compact-PRIMES model which requires slightly less data resolution for its application.
Sectoral coverage	The PRIMES model covers all energy demand and supply sectors.
Short model description	The PRIMES (Price-Induced Market Equilibrium System) is a large-scale applied energy system model that provides detailed projections of energy demand, supply, prices and investment to the future, covering the entire energy system including emissions. The distinctive feature of PRIMES is the combination of behavioural modelling (following a micro-economic foundation) with engineering aspects, covering all energy sectors and markets. The model has a detailed representation of policy instruments  related to energy markets and climate, including market drivers, standards, and targets by sector or overall (over the entire system). It handles multiple policy objectives, such as GHG emission reductions, energy efficiency and renewable energy targets, and also provides a pan-European simulation of internal markets for electricity and gas. PRIMES offers the possibility of handling market distortions, barriers to rational decisions, behaviours, as well as and market coordination issues and includes a complete accounting of costs (CAPEX and OPEX) and investment expenditure on

	infrastructure needs. PRIMES is designed to analyse complex interactions within the energy system in a multiple agent – multiple markets framework. Decisions by agents are formulated based on a microeconomic foundation (utility maximization, cost minimization and market equilibrium) embedding engineering constraints, behavioural elements and an explicit representation of technologies and vintages and optionally perfect or imperfect foresight for the modelling of investments in all sectors. PRIMES is well-placed to simulate medium and long-term transformations of the energy system (rather than short-term ones) and includes non-linear formulation of potentials by type (resources, sites, acceptability etc.) and technology learning The full suite comprises the following models: • **PRIMES-TREMOVE transport model**: Transport model of PRIMES; enhanced to include linkage to synthetic fuels and hydrogen, as well as including higher split of fuel choices (1st and advanced generation biofuels); • **PRIMES BuiMo residential and services model**: new model with high resolution representation of the housing and office building stock, embedded in an economic-engineering model of multi-agent choice of building renovation, heating system and equipment/appliances by energy use; • **PRIMES-Industry model**: recently enhanced version of the very detailed industrial model that includes a high-resolution split of industrial consumption by sector and type of industrial process and now includes the possibility of using hydrogen and synthetic fuels directly, as well as extended possibilities of electrification and the possible emergence of non-fossil hydrocarbon feedstock in the chemicals; • **PRIMES Biomass supply model**: detailed biomass supply model that includes land use constraints, many types of biomass and waste feedstock, sustainability regulation, and endogenous learning and industrial maturity of a large number of potential biomass to biofuels conversion technologies; recently enhanced in the linkage with the IIASA models that handle LULUCF and forestry, as well as linkage with the agricultural model CAPRI; • **PRIMES Electricity and Heat/Steam supply and market model**: fully new model version which includes the hourly unit commitment model - with a pan-European market simulation over the grid constraints and detailed technical operation restrictions - the long-term power system expansion model, the costing and pricing electricity and grid model, the integration of heat supply and industrial steam supply with synchronised hourly operation; • **PRIMES Gas Supply and Market model**: a stand-alone model representing in detail the gas supply and infrastructure in the Eurasian and Middle-East area and the internal European market of gas within an oligopoly model embedding engineering gas flow modelling; • **PRIMES new Fuels and storage model** covering Hydrogen, Synthetic fuels, Power-to-X, CO_2 capture from the air and biogenic, CCS/CCU and process-emissions modelling to enhance and perform sectoral integration aiming at simulating a zero-CO_2 system; • **PRIMES IEM model**: a simulation tool for the internal energy market; it aims to simulate in detail the sequence of operation of the European electricity

	markets, namely the day-ahead market, the intraday and balancing markets and finally the reserve and ancillary ser-vices market or procurement.
Mathematical model approach	Mathematically PRIMES is described as an Equilibrium Problem with Equilibrium Constraints (EPEC), which allows prices to be explicitly determined. Prices influence demand and demand influences in turn supply. The demand and supply modules are subject to system-wide constraints, which when binding convey non-zero shadow prices (dual values) to the demand and supply modules. Therefore, the PRIMES model has overall a mixed-complementarity mathematical structure.

The model version used for the purpose of the modelling partly included the new modelling feature of hydrogen trading of the PRIMES model.

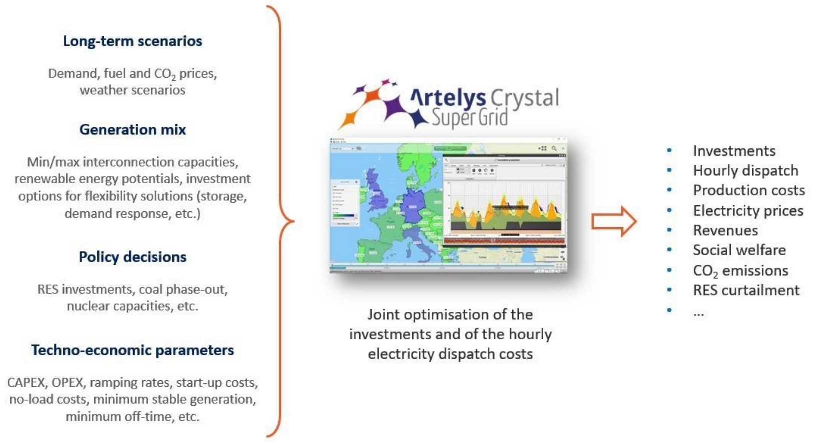
Further the model version with the enhanced fuel choice module, distinguishing fully between Part A, Part B and 1st generation biofuels, was used.

METIS model

Time horizon	METIS is designed to perform medium to long-term assessments (2030/2050) of the European energy system. The tool typically focusses on a single year, which is then simulated at hourly granularity. A new feature for pathway modelling is currently under development.
Geographic coverage	Bu default, METIS covers all 27 EU Member States plus Switzerland, Norway, UK, Bosnia Hercegovina, North Macedonia, Montenegro and Serbia individually as single nodes. In addition, METIS allows to model European transmission and distribution grids (the latter via archetypes). The modelling of the EU at an intermediate geographical granularity (NUTS1 level) is currently under development
Sectoral coverage	METIS focusses on the electricity, gas, heat and hydrogen sectors. It considers the energy demand of all economic sectors as exogenous inputs and allows for an endogenous optimisation of the hourly demand of specific end uses (such as electric vehicles, heat pumps). The technology mix for electricity and heat supply (in particular for industrial heat demand featuring different temperature levels) may be subject to a capacity optimisation. Similarly, the dimensioning and operation of cross-sectoral energy conversion facilities (e.g., power plants, electrolysers) is endogenously modelled. METIS further disposes of a dedicated district heating module.
Short model description	METIS was developed on behalf of the European Commission since 2015. Since then, development activities are ongoing, adding additional functionalities to the tool. The objective is to provide the European Commission and the JRC with a holistic, fully-fledged and user-friendly EU energy system model. METIS contains tailor-made functionalities that were explicitly developed upon request of the European Commission. METIS integrates major scenarios published by the European Commission (such as the EUCO scenarios, or scenarios from the LTS) and allows for an enhanced analysis of these scenarios at hourly granularity to better understand the infra-annual

dynamics. METIS follows the open-book approach. This means, the entire mathematical description as well as all input data are publicly available on the METIS website.[1000] The website gives also access to all major studies recently prepared with METIS, plus a number of technical notes describing the functionality of certain modules.

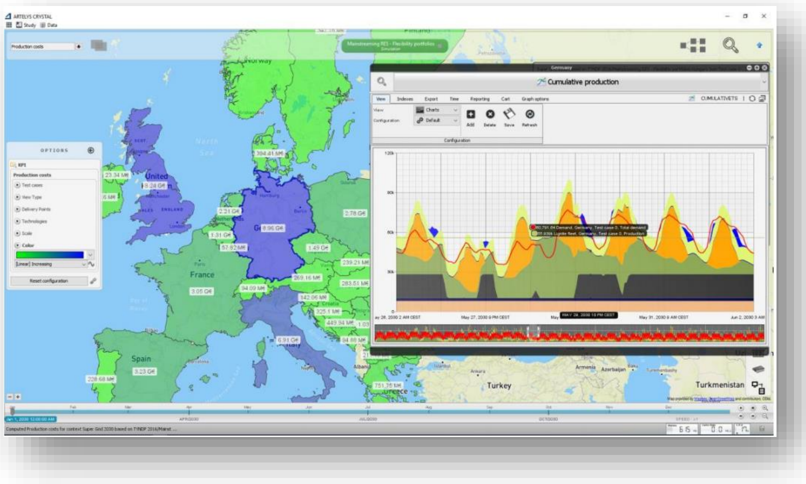
METIS builds upon Artelys Crystal Super Grid, a software that is designed to simulate the operations of a power system, taking into account techno-economic and environmental constraints. It is particularly well suited to analyse the role played by the flexibility solutions in power systems and to quantify their benefits.
Artelys Crystal Super Grid, based on a fundamentals model, can jointly optimize the dispatch of generation to meet the energy and reserves demands, and investments to ensure that a given security of supply criterion is met. The software has the ability to simulate several energy vectors and their interactions: electricity, gas, heat, etc. Other resources (e.g. water, hydrogen, etc.) can be included in the modelling so as to identify synergies between sectors.



High-level description of Artelys Crystal Super Grid

Artelys Crystal Super Grid is regularly used, including by researchers and academics, to evaluate the impacts of infrastructure projects (e.g. interconnectors, smart grid technologies, etc.) in terms of social welfare, to analyse the impacts of policy measures, to conduct cost-benefit analyses, or to find the optimal set of investments to ensure that a given security of supply constraint is met and/or that a given decarbonization target is reached. This software has been adopted by, amongst others, the French Regulatory Commission of Energy (CRE), the Belgian Energy Ministry (FPS Economy), the Belgian Federal Planning Bureau (FPB), power producers, academics and researchers, DG ENER (as part of the METIS project), and the Joint Research Centre of the European Commission.

[1000] https://ec.europa.eu/energy/data-analysis/energy-modelling/metis



Artelys Crystal Super Grid Interface: Result View – Hourly dispatch optimization

Artelys Crystal Super Grid optimizes the hourly operations of the EU power system using cost minimization as an objective. By comparing simulation results with and without the Project for a range of scenarios, one can assess the value brought by the project, in terms of social welfare, producer surplus, consumer surplus, marginal cost of electricity, carbon savings, etc.

In the following paragraphs we briefly present some of the most important features of Artelys Crystal Super Grid so as to demonstrate the appropriateness of the tool to conduct the required cost-benefit analyses:

Bottom-up model – all power generation fleets are represented at the country level along with the demand-response capacities, and storage technologies. Interconnection capacities between countries are explicitly represented.

Time resolution – An hourly time resolution is required when studying topics such as the integration of renewable energy sources, the procurement of reserves, or resource adequacy. Moreover, a growing number of publicly available datasets – some of which will be used during this project - adopt an hourly time resolution.

Climatic years and stress cases – Artelys Crystal Super Grid is able to perform a stress-case of the energy system by considering several climatic years. The resulting power system is therefore guaranteed to be robust, and to perform adequately during stress episodes.

Joint dispatch of electricity and reserves – Artelys Crystal Super Grid is able to jointly optimize the dispatch of electricity generation and the portfolio of technologies that provide reserves.

Multi-energy modelling - Artelys Crystal Super Grid is able to run joint simulations on power, gas, heat and new fuels (such as hydrogen) encompassing demand across different sectors in order to determine the least-cost hourly operation of supply, storage, network and demand assets, fully capturing the dynamics of the system.

	Easy Manipulation of Data – All scenarios can easily be modified and re-run, allowing us to perform sensitivity analyses (e.g. penetration of wind power, nuclear capacity in central Europe and GB, fuel and CO2 prices, etc.). Comparison mode - Artelys Crystal Super Grid includes an automatic comparison mode allowing us to assess the impact of the Project or of a change of parameter without having to handle large quantities of data, thereby reducing the risks of error. Resource adequacy assessment – When performing capacity expansion planning, one should make sure that the investments are sufficient to satisfy a given security of supply criterion (e.g. less than 3 hours of scarcity pricing). This assessment can be performed either at the national level (interconnections are assumed not to improve security of supply) or at the regional level (interconnections are taken into account, with a de-rating factor). Artelys Crystal Super Grid can be used in either way, which makes it a very well-adapted tool to assess the capacity value brought by interconnectors. All the indicators mentioned above (total system cost, LOLE, LOL, socio-economic welfare, consumer surplus, producer surplus, congestion rent, electricity prices, CO2 emissions, RES curtailment) are automatically computed by Artelys Crystal Super Grid, via Key Performance Indicators (KPIs). These KPIs have been extensively tested and have been demonstrated to be robust. By minimizing the number of operations having to be executed by hand, this tool significantly reduces the risks of error.
Mathematical model approach	Artelys Crystal Super Grid allows to perform a joint capacity and dispatch optimisation, relying on a linear optimisation approach. The Artelys Crystal Optimization Engine translates the high-level model into linear programs using optimized formulations. These linear programs are then optimized using FICO Xpress optimization solver.

Scenarios modelled

For the preparation of the Impact Assessment a number of scenarios were quantified with the PRIMES energy system modelling suite. The modelling included runs with the entire PRIMES energy system model as well as with selected modules (PRIMES-TREMOVE and PRIMES Biomass). The scenarios quantified have been based on the core scenarios for the FIT for 55% package, and more specific on the basis of the MIX 55 scenario. All model runs carried out with the METIS model relied on the framework data from the MIX 55 scenario.

Variant on reaching 40 GW on RE electrolysers "MIX-40"

Scenario basis	MIX 55
Model	Full PRIMES modelling suite
Model specifications/additions to model required	This PRIMES model version was the first practical application in scenarios for the European Commission of the newly developed Hydrogen Trading module of PRIMES, a model expansion which include intra-EU trading of hydrogen. The model version allows for a more optimal use of resources particularly renewable sources allowing for trade of hydrogen on top of the existing trading flows between countries.
Scenario aim	The aim is to have a scenario compliant with the EU hydrogen strategy (July 2020)[1001] in terms of electrolyser capacity -40GW in the EU. The scenario aims at a smooth transition with the quantities of hydrogen and new fuels required for climate neutrality in 2050.
Scenario specifications	Production of hydrogen and e-fuels • Assumption that all e-fuels are produced in the EU; • Up to 2035 (inclusive) additional "e-fuels" (e-liquids, e-gas, hydrogen) should be produced from electricity applying the additionality principle for renewables. RES-E share applied to e-fuels to identify amount of RFNBOs; • From 2040 onwards "e-fuels" are to be produced from "low carbon" electricity (i.e. nuclear and renewable origin). No need for additionality principle; • Source of CO2 biogenic or air capture. Demand for hydrogen and e-fuels • The maritime/aviation mandates of MIX are conserved; • Additional demand expected in all transport through expansion of infrastructure compared to MIX; • Stationary demand: o Industry: substitution of hydrogen currently produced from SMR to "green hydrogen"; o Refineries use electrolytic hydrogen.
2030 targets	The 2030 targets for EE, RES, and GHG can be overshot (PEC target may be undershot)
Number of runs (until May 13th 2021)[1002]	3

Ex-ante and ex-post work for the scenario

For the purpose of this scenario a number of steps and analysis were required:

- An analysis of the projections of electricity demand from the national MS hydrogen strategies and from the work of the FCH-JU country fiches which have been prepared. Through interaction with the European Commission the levels of demand required by scenario and the underlying drivers were determined;
- Final integration of the hydrogen trade module in the full PRIMES modelling runs;
- Preparation of additional scenario output: hydrogen trade between EU Member States.

[1001] https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

[1002] The number of variants run are the number of reruns required to address comments and changed specifications of the EC

Variant of MIX-40 that rather than taking RFNBOs only to fulfil the aviation/maritime quotas (or to build 40 GW) takes all low carbon fuels "MIX-LF"

Scenario basis	MIX -40
Model	Full PRIMES modelling suite
Scenario aim	Not only RFNBOs are counted towards aviation/maritime mandates but all e-fuels produced with decarbonised electricity (i.e. nuclear electricity is OK too)
Scenario specifications	Additionality principle for RES is no longer required; all types of low carbon electricity can be used for hydrogen and e-fuel production
2030 targets	The 2030 targets for EE, RES, and GHG can be overshot (PEC target may be undershot)
Number of runs (until May 13th 2021)[1003]	1

Ex-ante and ex-post work for the scenario

For the purpose of this scenario a number of steps and analysis were required:

- Modification of the additionality principle for e-fuels and hydrogen

Variant on GHG-intensity target in transport "MIX-GHG"

Scenario basis	MIX 55
Model	PRIMES-TREMOVE and PRIMES biomass
Scenario aim	Modify the basis for the target of the transport emissions reductions
Scenario specifications	Dismantling of: • Part A ambition stemming from NECPs [No MS would follow up on their ambition if no policies are in place] • Part B ambition/caps stemming from NECPs [same as above] • Impact of multipliers in REDII RES-T formula • Enabling conditions for advanced biofuels
2030 targets	Achieve same GHG intensity for transport
Number of runs (until May 13th 2021)[1004]	1

Ex-ante and ex-post work for the scenario

- Verification of splits between part A and part B
- Additional reporting for the reporting of GHG intensity and development of GHG intensity by fuel type and transport mode

[1003] The number of variants run are the number of reruns required to address comments and changed specifications of the EC.
[1004] The number of variants run are the number of reruns required to address comments and changed specifications of the EC.

RE policy failure scenario

Scenario basis	MIX -40
Model	Full PRIMES modelling suite
Scenario aim	Impact of RE policies; effects of lack of RE policies
Scenario specifications	Additional specific RE policies from MIX are eliminated to verify the gap of the additional RE policies included in the package
2030 targets	Targets are not met
Number of runs (until May 13th 2021)[1005]	**1**

RES H&C Variant

Scenario basis	MIX -40
Model	Full PRIMES modelling suite
Scenario aim	Modification of renewable heating and cooling advance in the time period to 2030
Scenario specifications	Strict application of the increase of 1.1% per annum increase of the RES H&C share by Member State.
2030 targets	Main aim: achievement of 1.1% in RES-H&C per MS; other targets are not binding
Number of runs (until May 13th 2021)[1006]	**1**

Results

All scenario results were delivered in excel form to the European Commission via the online platform of E3Modelling used for the exchanges of secure information with the Commission. Further, E3M has delivered additional excel files in order to aid the calculation of variants of formulas for the calculation of the different sectoral RES share targets.

[1005] The number of variants run are the number of reruns required to address comments and changed specifications of the EC.

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