METIS 3 – Dissemination event

Research on the EU energy sector integration in the context of the clean energy transition

DG ENER

3-Jun-24

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History of the METIS project

METIS 1
(2015 – 2019)

- Power and gas system/market modelling
- First delivery and training of METIS to the EC
- Publication of the METIS database and documentation

METIS 2
(2018 – 2022)

- Integration of transmission and distribution grid modules
- 2050 scenario development and assessment
- Web-based results sharing
- Assistance to Impact Assessment for the Fit-for-55 Package

METIS 3
(2020-2024)

- Integrated multi-energy, multi-sector modelling (power, gas, hydrogen),
- Enhanced demand-side representation
- Pathway optimisation
- Web-based interface

METIS 4
(2024-2027)

- Enhanced representation of electricity markets:
  - Short-term market sequence
  - Price formation
  - Cross-border capacity calculation
- Representation of global H2 trade
- Enhanced representation of demand-side flexibility

The METIS pilars

Multi-Energy

Multi-energy model with detailed representation of **sector coupling**

Hourly

An hourly time resolution, that is well adapted to capturing flexibility needs

User-friendly

Web-based interface including **customised KPI views** and **interactive maps**

Transparency

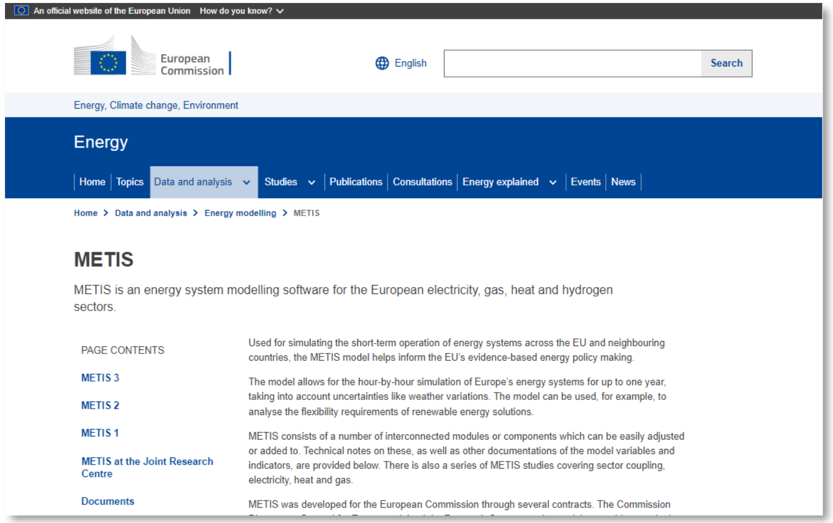
Open-book approach including extensive data and study **publications** on the European Commission website

METIS builds upon the *Artelys Crystal Super Grid* platform!
Learn more on the Artelys website:

METIS interfaces. Interactive maps & main KPI views

The current METIS tool

- Since then, METIS has become a key asset to **inform EU policymaking**, combining strong analytical capabilities with a high level of transparency.
  - **10+ studies** using METIS published by the JRC to date
  - **40+ studies** conducted by Artelys for DG ENER and DG CLIMA over the years, including around thirty METIS 1-2-3 studies and **a dozen additional studies.**
  - Supporting the impact assessment of **key policy packages**: Clean Energy Package, Hydrogen and Decarbonised Gas Package, 2040 GHG target.
  - Extensive **datasets and documentation** available on the European Commission website.



METIS page on the European Commission website

- Today, the METIS tool and associated datasets include:
  - The **EU-27 perimeter** and neighbouring third countries (CH, UK, NO, Balkans)
  - The possibility to focus on specific years (e.g. 2030, 2050) or perform **pathway optimisation** over several decades (e.g. 2030-2035-...-2050)
  - A comprehensive range of energy vectors through an extensive modelling of the **electricity, gas, hydrogen** and **heating** sectors.

More METIS contents are available on the European Commission website!
[Link]

Agenda

Time	Duration	Topic	Speaker
Welcome and introduction			
14.00 – 14.15	15’	Opening remarks	DG ENER
14.15 – 14.30	15’	Objectives of the METIS project	Artelys
Insights from the METIS studies			
14.30 – 15.10	40’	2050 insights on the industry transition	Fraunhofer & Dante Powell (ENTSOG)
15.10 – 15.55	45’	Assessing 2030 hydrogen infrastructure needs under REPowerEU ambitions	Artelys & Stefano Astorri (ACER)
15.55 – 16.05	**10’**	**Coffee Break**	
16.05 – 16.35	30’	Impact assessment of 2040 climate targets	Artelys & Francesco Ferioli (DG ENER)
16.35 – 17.20	45’	Outlook on short-term EU gas and power adequacy	Tractebel & Andreas Zucker (DG ENER)
Live demo & Concluding remarks			
17.20 – 17.50	30’	Live demo of METIS	Artelys
17.50 – 18.00	10’	Concluding remarks	DG ENER

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Fraunhofer Institute for Systems and Innovation Research ISI

Artelys | OPTIMIZATION SOLUTIONS

METIS III dissemination 2024-04-17

Results of METIS III study S5 “Industry transition”

Tobias Fleiter, Khaled Al-Dabbas, Andreas Clement, Matthias Rehfeldt

Fraunhofer Institute for Systems- and Innovation Research

Agenda

Introduction: Overview of Methodology and Modelling Framework

Scenario definition: Industry and Energy sector key assumptions

Results: Key results from the models (FORECAST and METIS3)

Conclusions: Summarizing key findings

Methodology

Input parameters | Computation | Results analysis

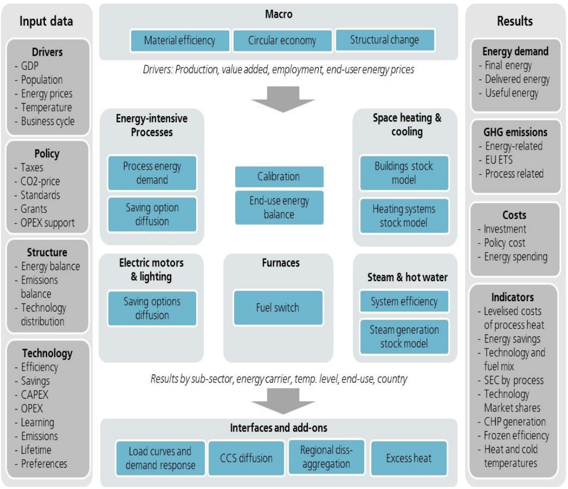
Data Collection & Analysis

- Techno-economic characteristics of Supply , storage and Demand side technologies
- Renewable energy Profiles and potentials
- Data disaggregation and integration in models

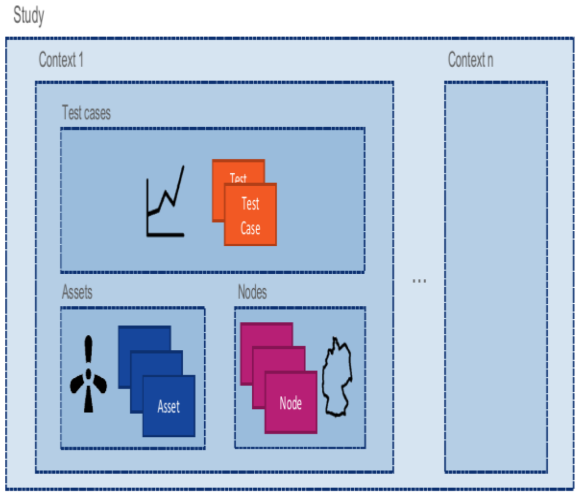
Scenarios Definition

- Energy efficiency
- Material efficiency
- Circular economy assumption
- Technology Diffusion
- Demand Projections
- CO2 and commodity prices

Modelling Industry sector Simulation (FORECAST)



Modelling Supply sector Optimization (METIS 3)



Results analysis

- RES Investments
- Infrastructure Investments
- Operation Management of power, hydrogen and gas systems

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Model and scenario setup

Model Set-up

Primes Mix-H2 scenario as basis for framework data and energy demand of transport and buildings sectors

↓

FORECAST-Industry to calculate detailed scenarios for industry transition and required energy demands

↓

METIS to optimize supply system based on energy demand from FORECAST for industry and Mix-H2 for other sectors

Definition of scenarios

Scenario H2+ (Focus hydrogen): Hydrogen as major decarbonisation option for feedstocks and process heating, while electrification of process heating also has a role, particularly in lower temperature supply of process heat.

- **Sensitivity H2+_lim.Potential** (Supply side, limited renewable potentials): Only 70% of wind and solar potentials available, with 20% minimum deployment of rooftop PV

Scenario Elec+ (Focus electrification): Stronger focus on electrification for decarbonisation of process heat, where technically mature at least at TRL5.

- **Sensitivity Elec+_VC** (Industry sector, new global value chains): Import of sponge iron, ammonia and green ethylene and other HVCs, everything else remains as in the Elec+ scenario. Substantially lower hydrogen demand

FORECAST tool in a nutshell

Bottom-up modelling of energy demand & GHG emissions

›**High technology resolution**

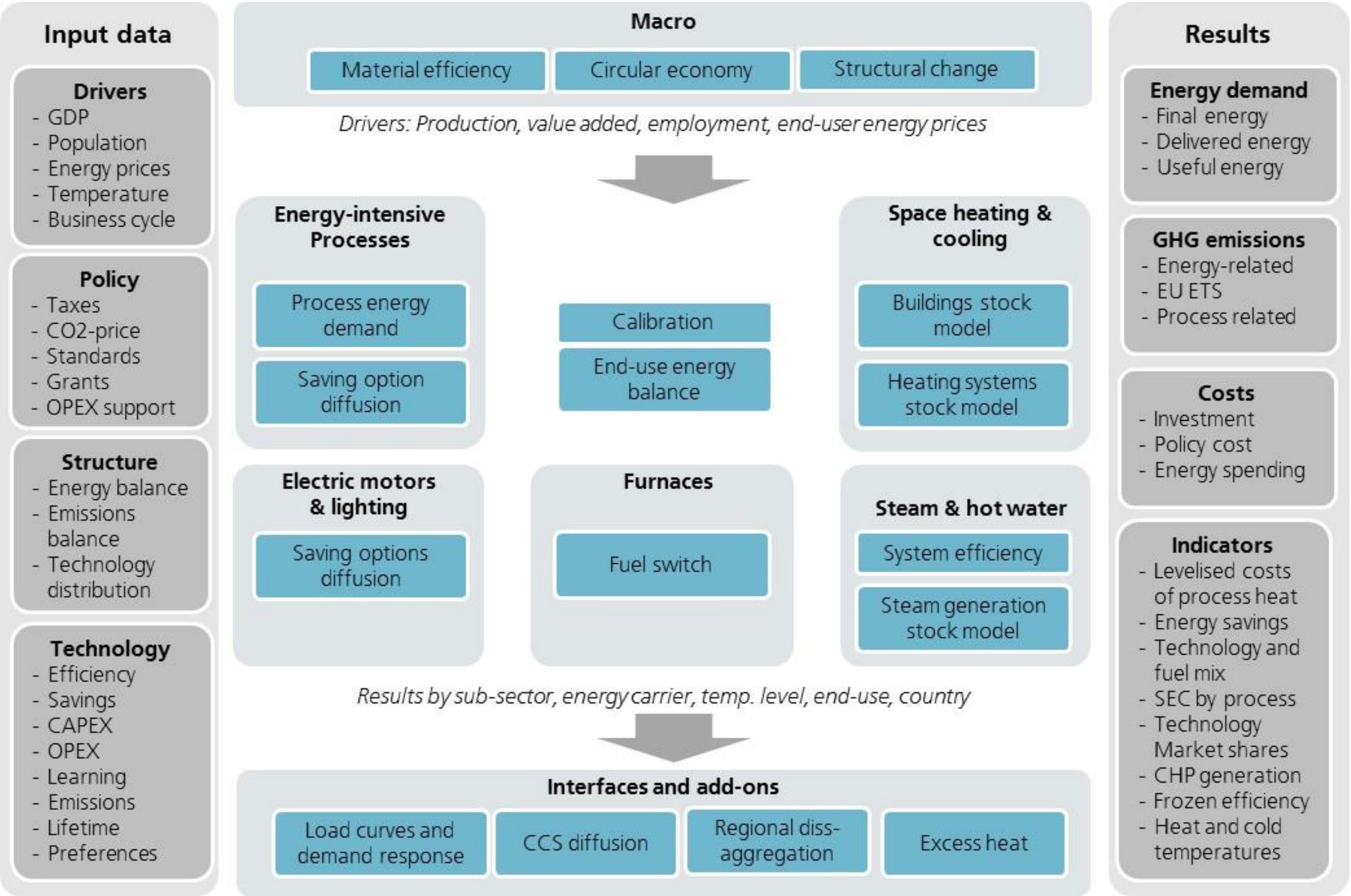
›Consideration of all **important abatement options**

›Energy and greenhouse gas balance

›**Annual results**
until 2050

FORECAST
FORecasting Energy Consumption Analysis and Simulation Tool

https://www.forecast-model.eu



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Industry and Energy sector key assumptions

Overview of key scenario assumptions for industry

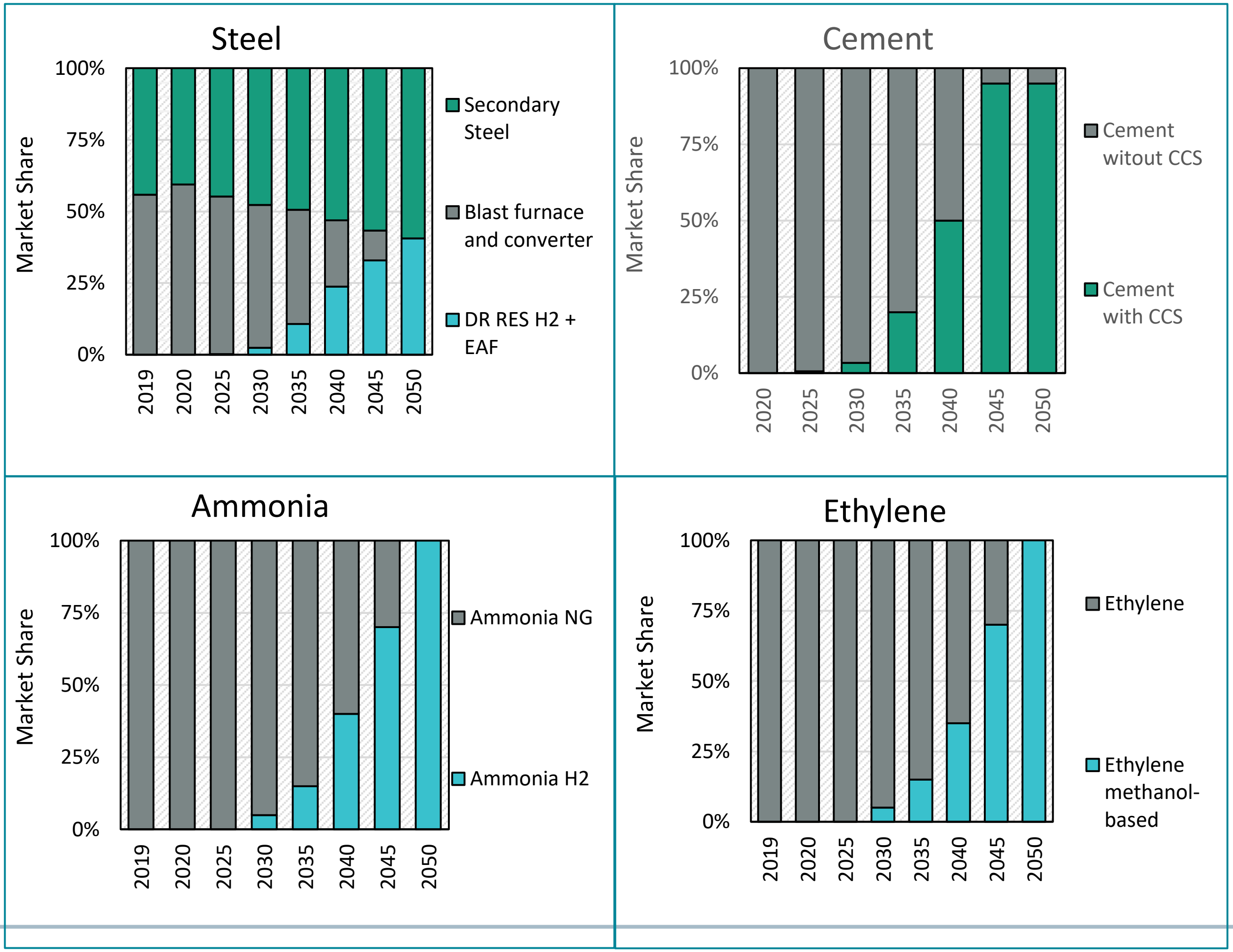
Assumptions

	H2+	Elec+	Elec+_VC
GHG target 2050	At least 95% GHG reduction compared to 1990 for the industry (in line with overall GHG neutrality)		
GHG target 2030	Reduction similar to Primes Mix-H2 scenario meeting overall 55% GHG reduction target		
Economic growth	Continued long-term growth of industry GVA ~0.8%, recovery of Covid-crisis with higher growth before 2030		
Biomass	No particularly strong role / limited use of biomass		
Energy and material efficiency and circular economy	Ambitious progress		
CCS and CCU	Included for cement and lime plants only		
Process, fuel and feedstock switch	Priority hydrogen	Priority electrification	Priority Electrification But: Import of sponge iron, green ammonia and green HVCs like ethylene

Process switch: Full diffusion of low-carbon processes by 2050

Assumptions

Product	Elec+	H2+
Steel	100% of H-DR share of primary steel by 2050	
Cement and lime	Strong diffusion of CCS reaching ~90% of production capacity by 2050	
Chemical feedstocks	100% Feedstock H2 for Methanol, ethylene/HVCs, ammonia and other feedstocks	
Glass	70% Electric furnaces by 2050	Higher share of hybrid furnaces
Steam generation	Electric boilers and heat pumps, limited biomass	H2 boilers, hybrid boilers, electric heat pumps, limited biomass



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Industry sector results

Industrial transformation requires high quantities of CO2-neutral energy

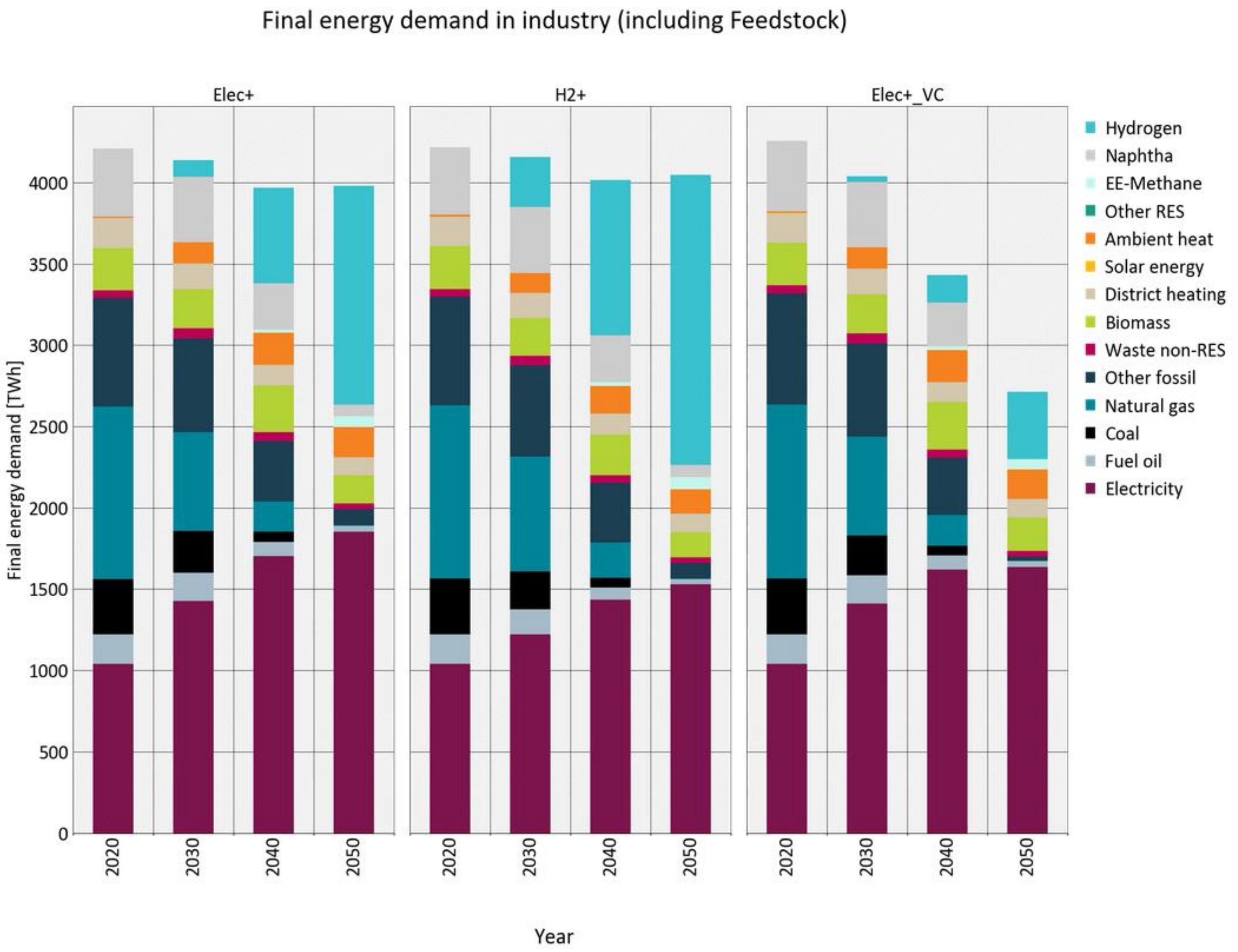
Results: Total industrial energy demand

Energy demand in 2050 is dominated by electricity and hydrogen (with some role for ambient heat, biomass, district heating, solar and geothermal)

Electricity increases from ~1000 TWh in 2020 to ~1855 TWh (Elec+) and ~1520 TWh (H2+)

Hydrogen increases to 1785 TWh (H2+) and 1340 TWh (Elec+)

The scenario Elec+_VC shows substantial imports of green interim products reducing direct H2 demand to ~416 TWh
(imports: 14 Mt ammonia, 20 Mt green ethylene and 32 Mt iron sponge)



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Hydrogen demand is dominated by chemical industry in all scenarios

Results: Hydrogen

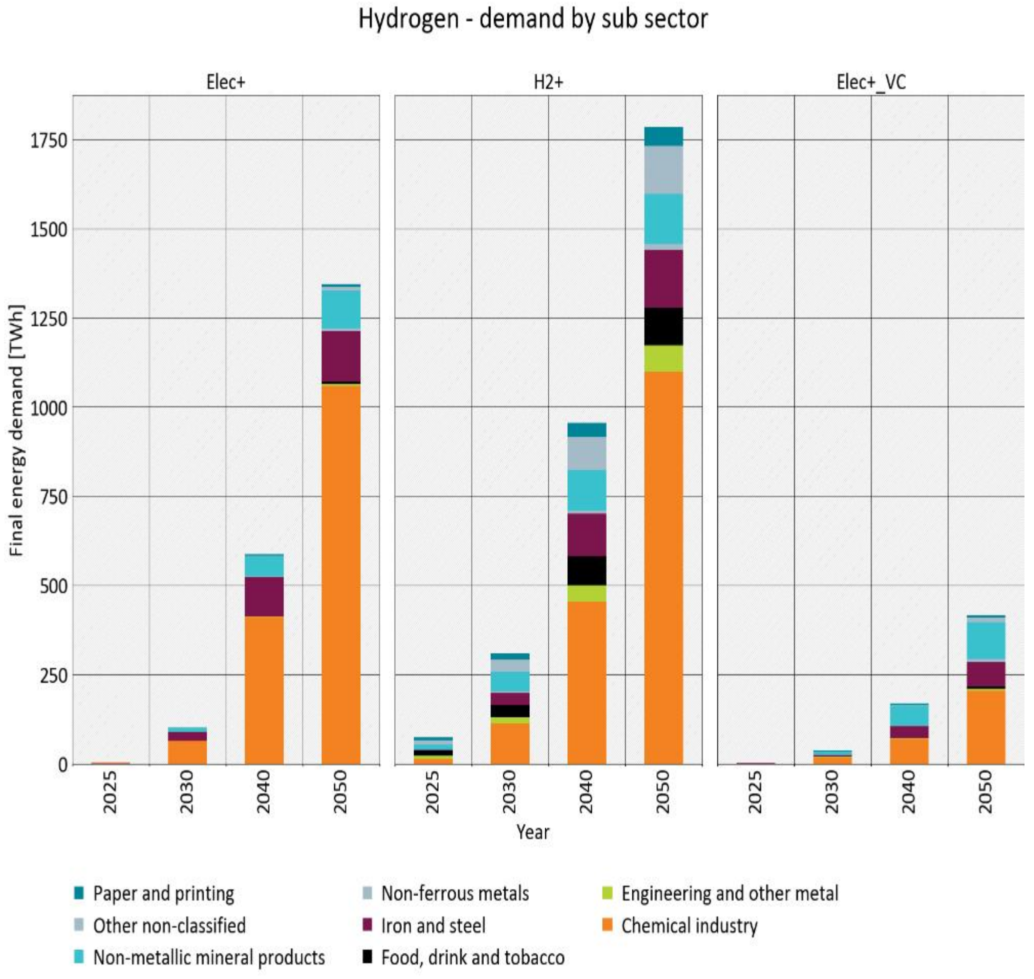
Hydrogen plays an important role in feedstock supply and for process heating in all scenarios ranging from ~450 to 1750 TWh in 2050

Largest demand sector is the chemical industry with up to ~1100 TWh for feedstock use for high value chemicals (e.g. ethylene). However demand for hydrogen as a feedstock is prone to uncertainty

Changing value chains with import of H2 derivatives (ammonia, naphtha, iron sponge) can reduce H2 demand substantially (~95 TWh)

Hydrogen demand as a reducing agent and energy carrier for steelmaking (~150TWh)

H2 demand as energy carrier for process heating adds about ~170 to 650 TWh depending on take-up of direct electrification



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Conclusions for industry sector

Conclusions

1. **GHG reduction of at least 95% is possible in the industry sector by 2050**: a fully net-zero industry might require compensation for remaining smaller sources of process emissions from diverse processes.

2. **Energy and material efficiency and circular economy are important strategies to reduce the need for carbon-free secondary energy carriers**. A moderate reduction in FED is possible, but energy efficiency potentials are limited energy efficiency alone is not a sufficient strategy

3. **Green electricity, hydrogen and/or clean gas are needed in large quantities to enable low-carbon production**

4. **Direct use of electricity becomes most important energy carrier;** electrification of process heating overcompensates efficiency gains in other end-uses

5. **Hydrogen** and/or derivatives are required for low-carbon production in **chemicals and steel**, If parts of the chemical value chain are offshored and products like green methanol, ammonia or ethylene are largely imported, the demand for domestic hydrogen from Europe's industries could be drastically lower

Energy Supply: Metis results

Wind and solar energy Cost-potential curve, EU 27 + UK

From METIS 3 data collection

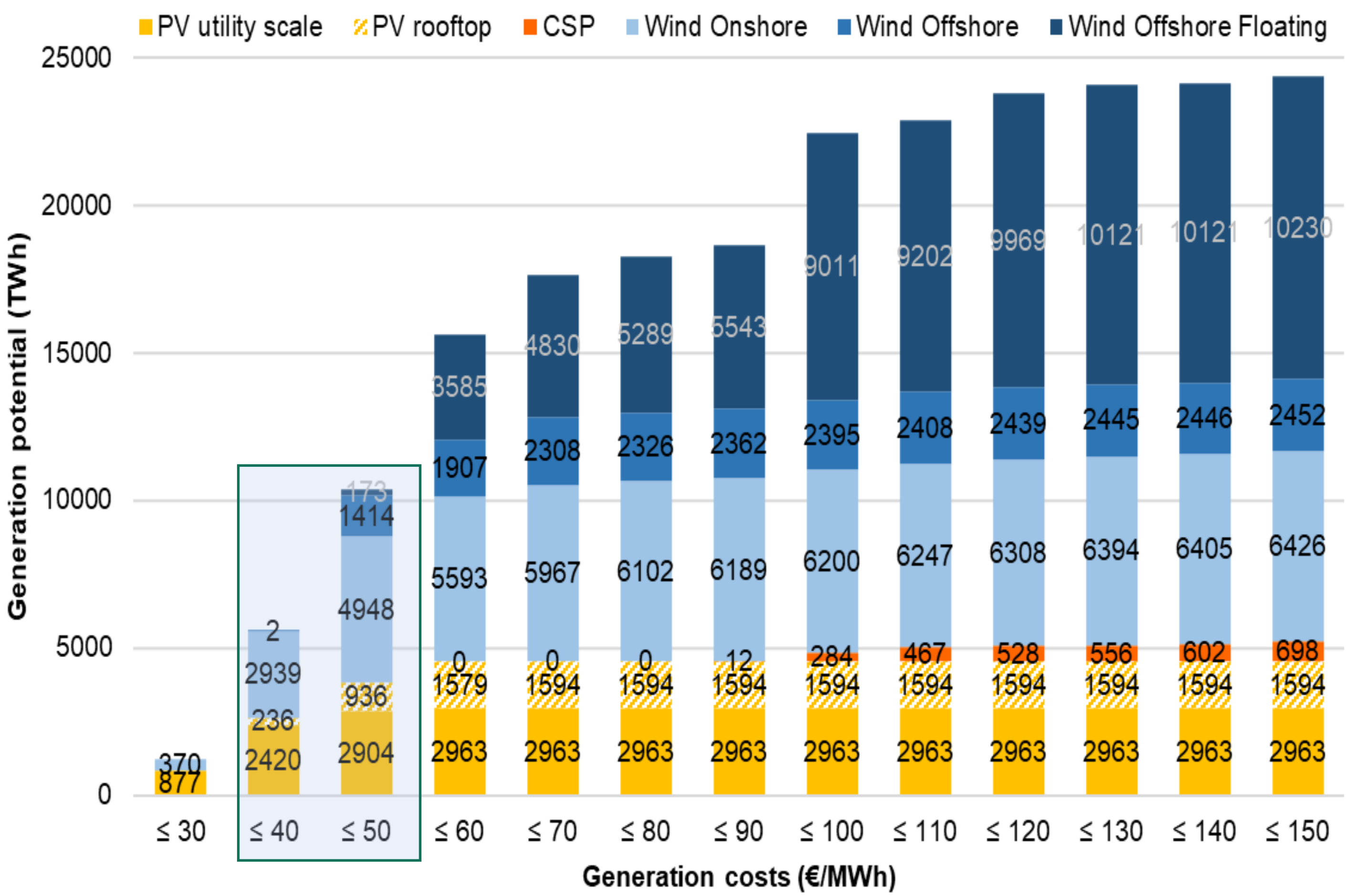
Dedicated METIS assessment of RES potentials shows:

Europe has a significant amount of renewable energy. with technical potential of 10,000 TWh below 50€ / MWh, primarily onshore wind and utility-scale PV

The assessment has:

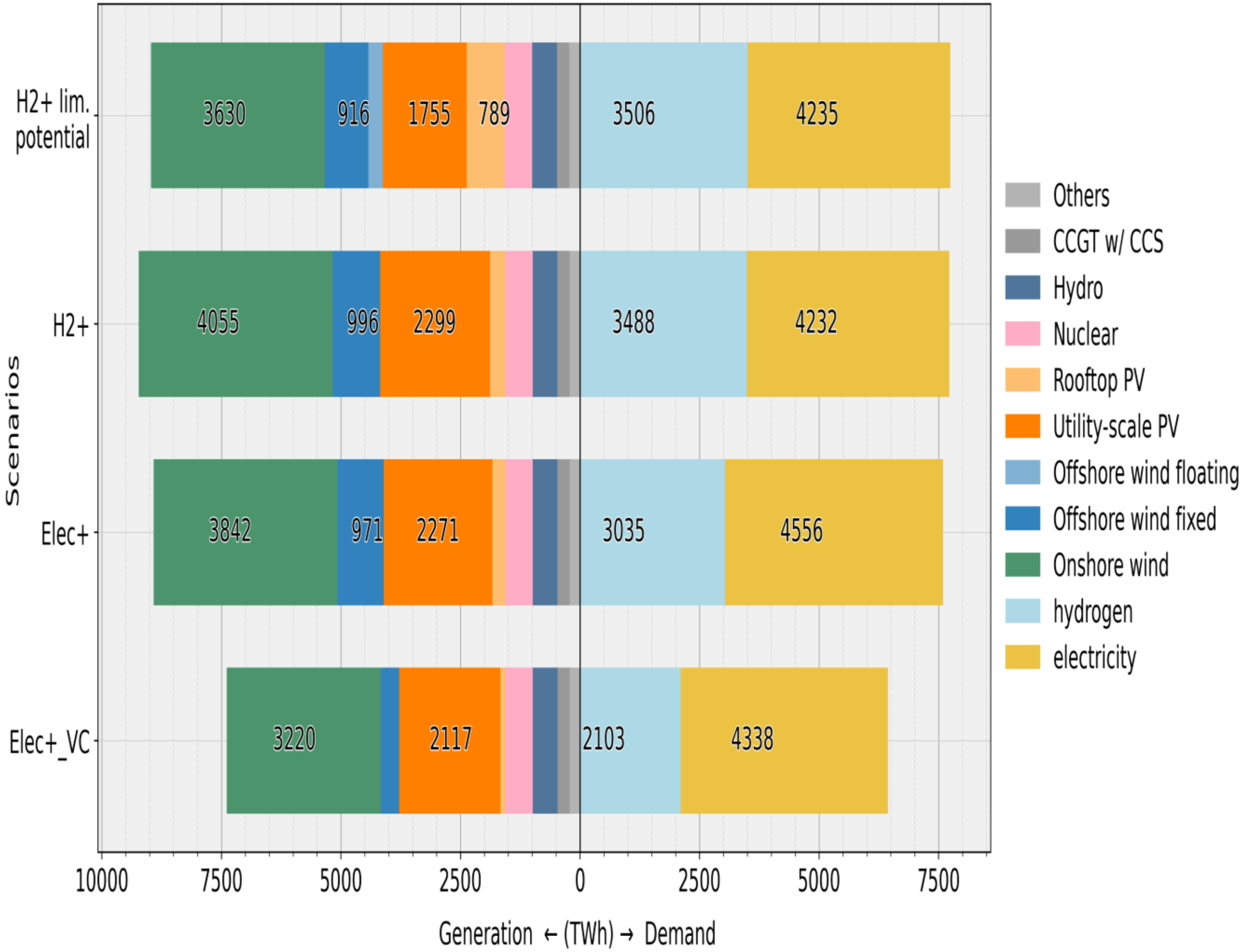
- High regional resolution (hectare-level)
- Technology assumptions for 2050 (costs, land-use restrictions,..)
- Three weather years (2010, ’12, ’15)

-> See data report



Renewable sources will contribute about 90 % of overall electricity production, thereof 82% are wind and solar

- Hydrogen is emerging as a key energy carrier it could potentially make up 28-32% of final energy demand.
  - Outsourcing of feedstocks like green ethylene/HVCs and green ammonia as well as iron sponge reduces domestic EU demand for hydrogen by ~1000 TWh
- Differences between Elec+ and H2+
  - Electricity generation is 400 TWh higher in the H2+ scenario, due to lower efficiency in the hydrogen energy chain
  - The increase is mainly supplied by wind onshore (+200 TWh)
  - In Elec+_VC the generation from onshore and offshore wind decreases by 60%.



Utility-scale PV is the most widely installed technology with about 44% of installed capacity

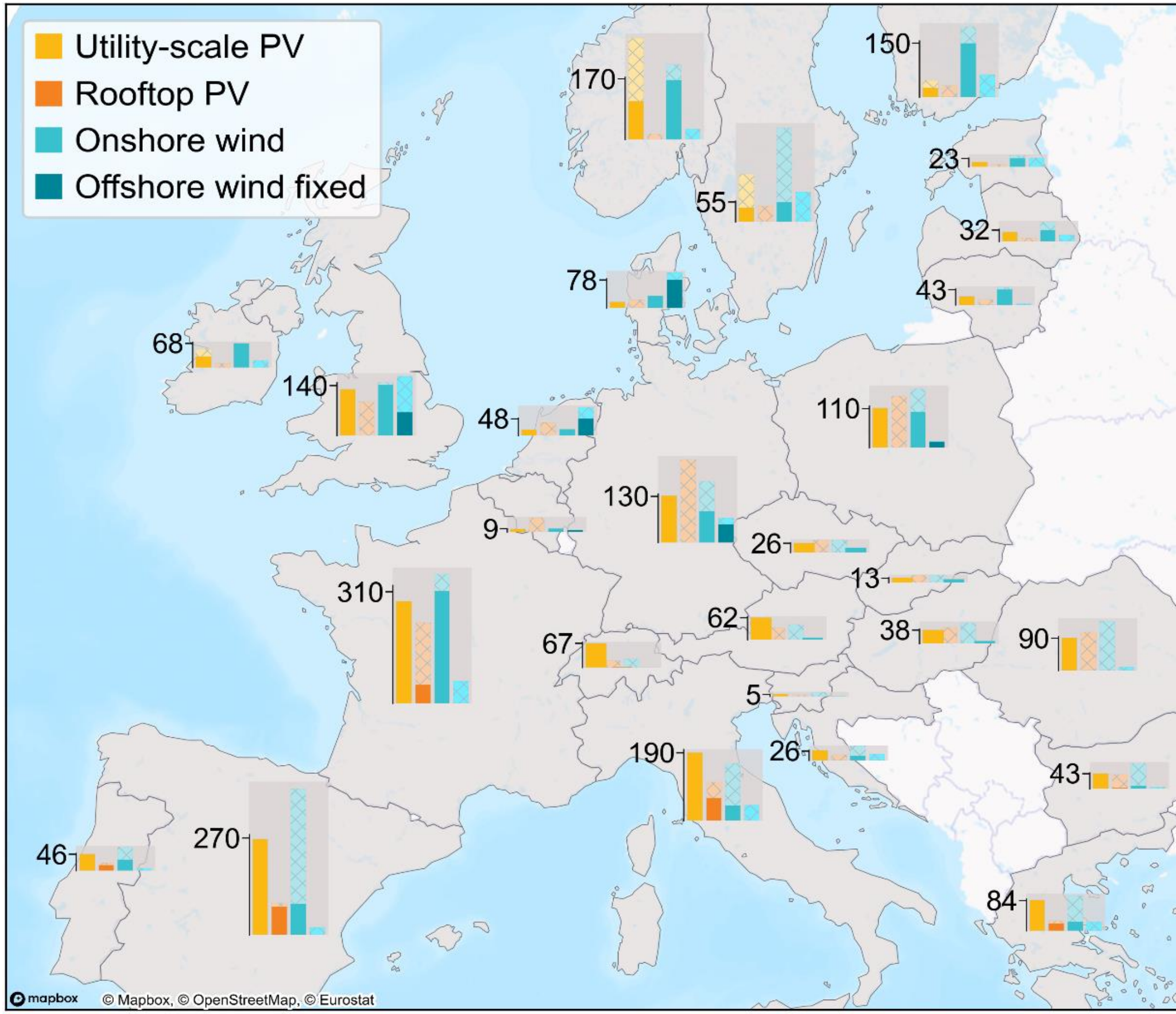
Supplying all European energy demand domestically is possible in an optimal scenario
It requires ambitious RES deployment:

- All countries use full **utility-scale PV potential**, except Nordics
- **Onshore and offshore wind** is strongly deployed in all North-Western countries with good wind potential
- **Rooftop PV** is only used in southern Europe with the highest solar radiation

** Hatched bars show each country's potential for the respective RES technologies

Wind and PV capacities and potentials (NO capped) [GW]

H2+



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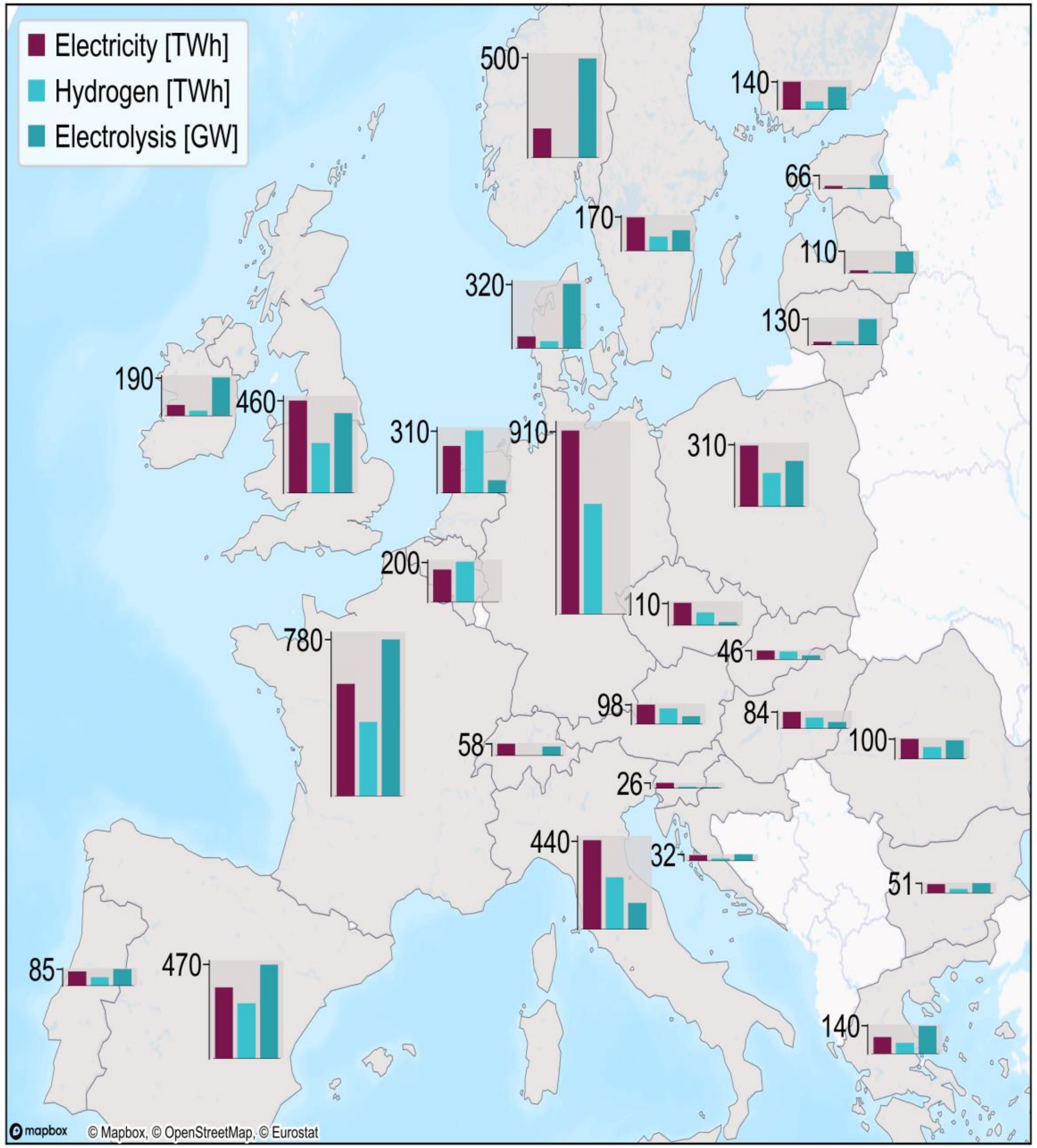
Hydrogen production is allocated close to large RES potentials

The entire European hydrogen demand is produced domestically, requiring significant amounts of renewable electricity, a total of 810 GW and 915 GW of electrolysis capacity installed in the Elec+ and H2+ scenarios

From a cost-optimization perspective, long-distance transport of hydrogen to central demand centers is more efficient than local production

- Countries with large chemical and steel industry import most of their hydrogen demand, see Germany, Netherlands and Belgium
- Hydrogen production is allocated in countries with high RES potentials and exported, see France, Spain, UK, Norway, Denmark, Finland, Baltics
- Electricity transport infrastructure is deployed to its maximum defined constraint at most interconnectors



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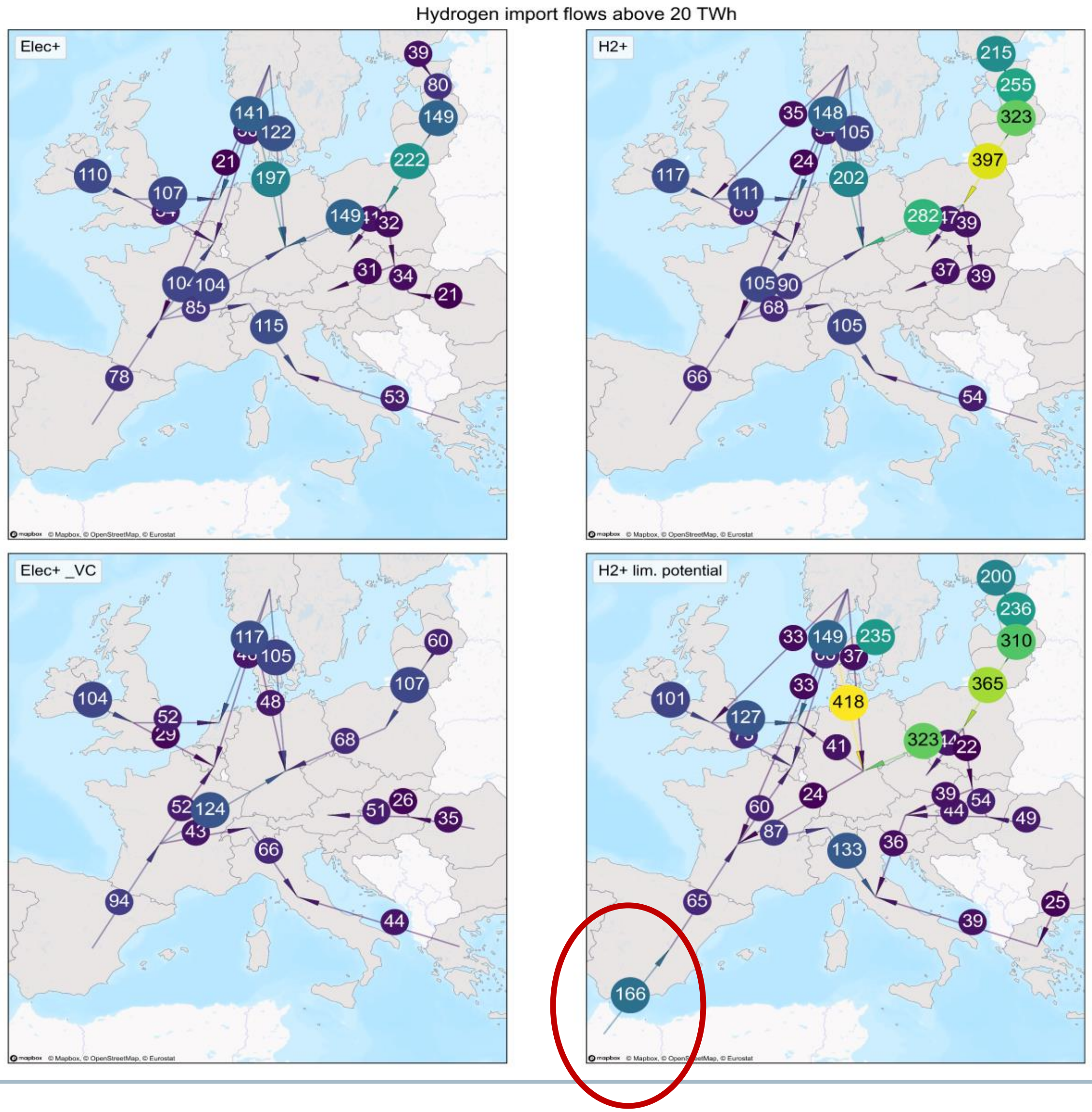
A pan-European hydrogen network supplies a low-carbon industry in central Europe

The pan-European hydrogen network connects demand centers in central Europe with large, low-cost potentials for renewable generation

- Important transport corridors are: Baltics, Scandinavia, UK, Iberian/France
- Also the scenario Elec+ shows a high demand for pan-European hydrogen transport
- The additional H2 demand in the scenario H2+ is mainly supplied via Baltics
- In H2+ Limited potentials the higher cost for domestic hydrogen production make non-EU imports cost-competitive
- First imports can be seen: **166 TWh of hydrogen are imported from Morocco**



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Conclusions

- Massive increase in demand for electricity and hydrogen shapes the system
- Results show a system based on cost optimisation, form a technical perspective Renewable energy sources have the potential **to meet all of Europe's energy demand** at competitive costs
- **Solar and Wind** potentials are deployed massively and allow fully domestic production of hydrogen and electricity
- **Domestic hydrogen production** is available at lower cost than assumed H2 import prices; only when RES deployment is sub-optimal/constrained, imports of hydrogen become cost-competitive
- The **European hydrogen system supplies industrial clusters in central Europe** by connecting to large-scale RES potentials in other EU countries
- **A pan-European hydrogen network is feasible the results show a robust hydrogen corridors** are connecting Nordics, Baltics, UK and Iberian Peninsula and France with Germany, Benelux, Austria and Italy
- The **hydrogen system provides seasonal storage and short-term flexibility** and facilitate integration of volatile renewables - Electrolysers are operated flexibly and combined with large-scale storage

Thank you for your attention!

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The external view

Dante Powell – ENTSOG

Innovation Manager, System Development

Q&A Session

2050 insights on the industry transition

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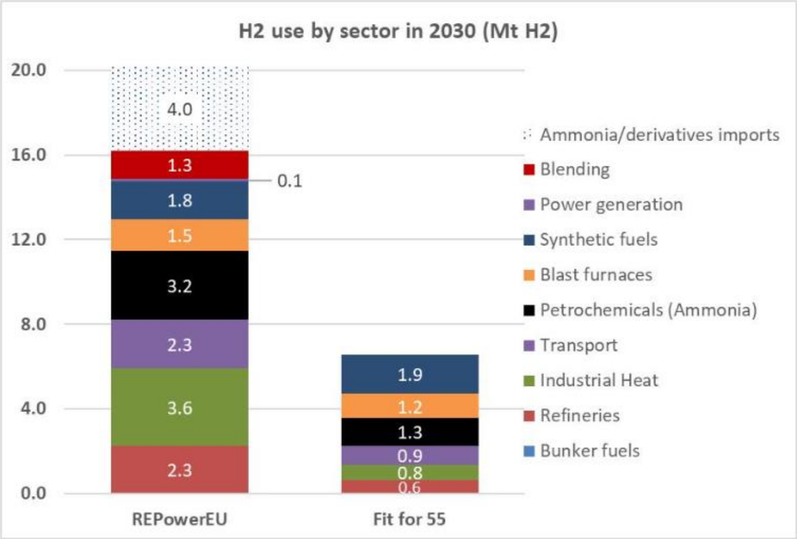
Study context

- Following the Russian invasion into Ukraine in February 2022, the **REPowerEU** Plan aims to phase-out natural gas imports from Russia by 2027
- REPowerEU foresees an accelerated uptake of hydrogen compared to Fit-for-55 target for 2030
  - Increased hydrogen demand: 16 Mt + 4 Mt hydrogen derivatives
  - Hydrogen imports: 6 Mt and additional 4 Mt as hydrogen derivatives
  - Accelerated RES development: 45% RES share compared to 40% under Fit-for-55
- The study aims at:
  - **Assessing hydrogen storage and transport infrastructure needs** in the beginning of the 2030s
  - Considering the **cost-optimal allocation** of electrolysers and RES capacities
  - Adopting the **REPowerEU** scenario as main framework of the modelling assumptions
  - Based on a capacity optimization approach using the METIS model



Source: REPowerEU communication

Overview of the methodology

The analysis is based on the **METIS** model:

Input parameters

- Electricity generation: installed capacities for RES, nuclear, hydropower, existing infrastructure, etc. Similar inputs for gas infrastructure and supply.
- Catalogue of investment options
  - Hydrogen infrastructure
    - Electrolysis
    - Hydrogen pipelines (including repurposing)
    - Hydrogen storage
    - Additional RES capacity (up to 2035 scenario capacities)
  - Gas-to-power peak capacity
  - Electricity interconnectors
  - Battery storage
- Technical and economic characteristics
- Demand projections
- CO_2 price and commodity prices

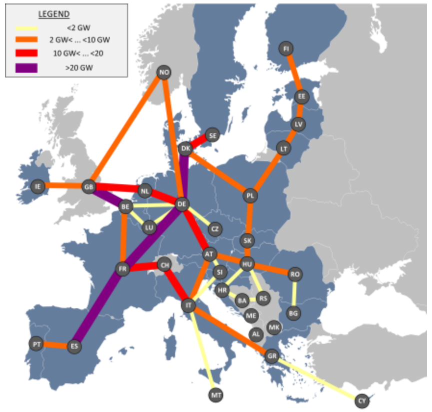
Computation

Objective

Optimise investments and operations (cost-minimization approach) using an hourly time resolution in order to meet all energy demands

Key results

- Investments



- Operational management of the power, gas and hydrogen systems (hourly dispatch, flows, etc.)

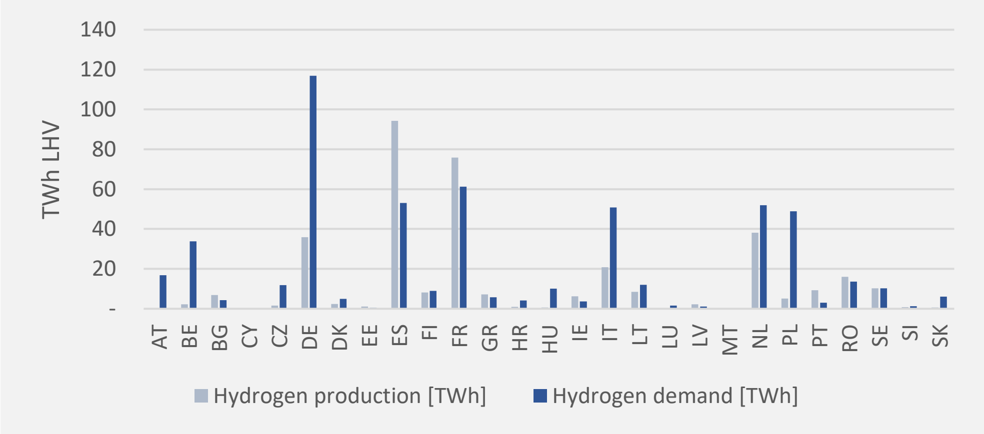
Modelling framework

- Modelling scope:
  - Hourly supply and demand modelled for hydrogen, electricity and gas
  - EU 27 + neighbouring countries
- Hydrogen demand:
  - 16 Mt for EU 27 following REPowerEU scenario
  - 4 Mt additional hydrogen derivatives imports are not modelled (derivatives are consumed as such and not converted back to gaseous hydrogen)
- Hydrogen imports:
  - 6 Mt hydrogen imports
  - Imports available from Norway, North Africa, Ukraine, and via shipping to the Netherlands
  - Optimization of the geographic allocation of imports, not the volume of imports
    - ↳ The overall level of hydrogen imports is fixed to that of the REPowerEU scenario
- Part of RES capacities can be reallocated compared to the REPowerEU 2030 scenario
  - Co-optimisation of the geographic allocation of electrolysers and part of RES capacities
  - Maximum capacities based on REPowerEU 2035

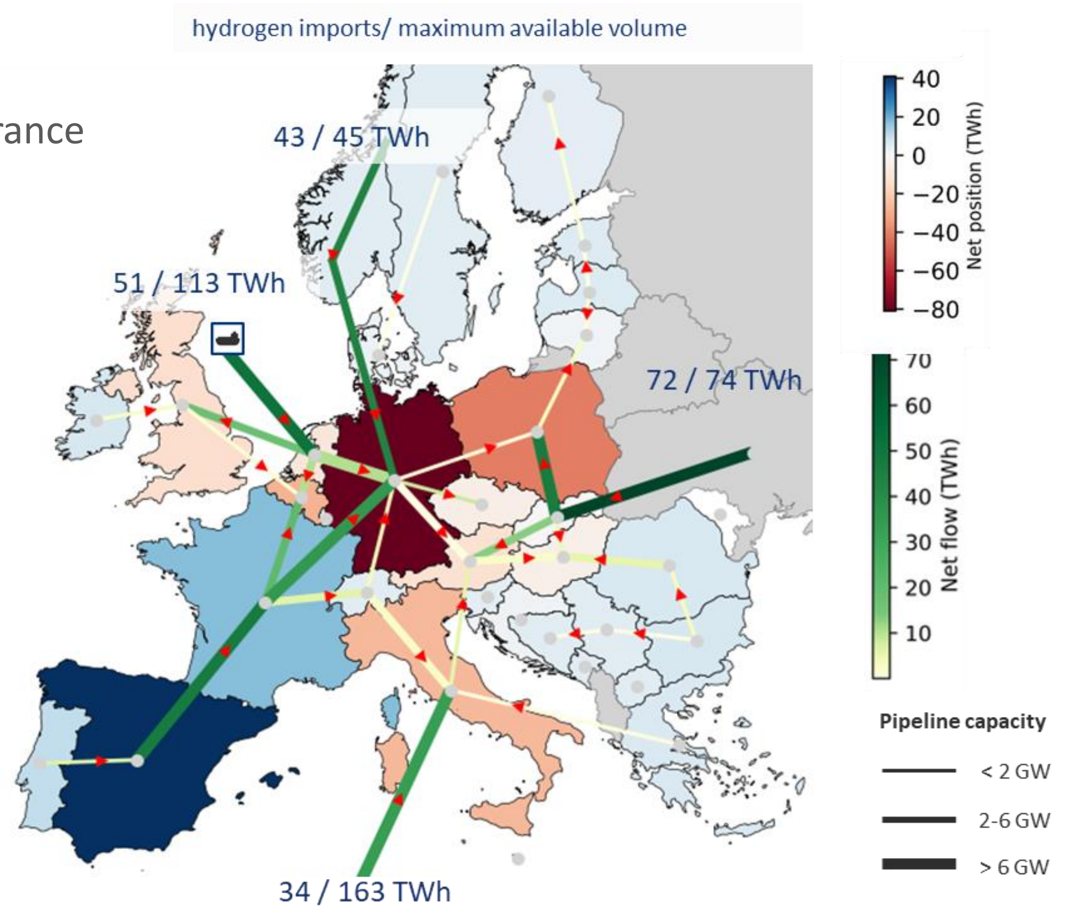
Key result 1

A pan-European hydrogen network allows to produce hydrogen in the most favourable sites and to distribute hydrogen imports to where they are most needed

- Central Europe is the main importing zone
  - Driven by high hydrogen demands in Germany, Poland, the Netherlands and Belgium
- Most of hydrogen production is located in the Iberian peninsula and France
  - Driving significant hydrogen flows towards Germany, the Netherlands and Belgium
- Extra-EU hydrogen imports are most needed in Central Europe
- The aggregated capacity of the hydrogen network reaches 83 GW
  - Almost 50% of pipelines capacities result from repurposing of existing pipelines



Hydrogen production and demand per member state

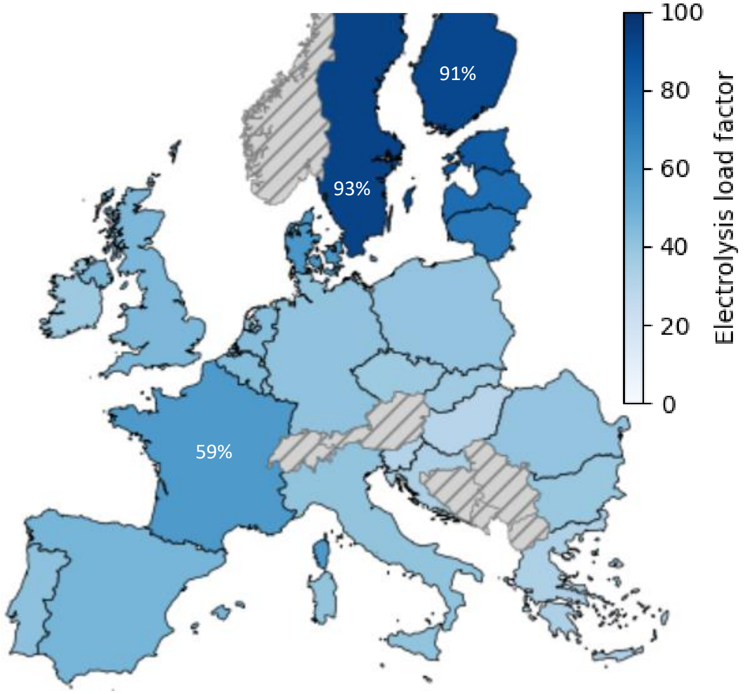


Hydrogen flows through Europe

Key result 2

Hydrogen system flexibility allows to benefit from low carbon electricity potentials and accommodate RES variability

- EU 27 electrolysis capacity reaches 85 GW H2 LHV / 127 GW electricity
- Electrolysers showcase relatively low load factors, reflecting a flexible operation
  - Average electrolyser load factor is approximately 47%
  - Load factors are higher in countries which rely mostly on nuclear and hydro capacities

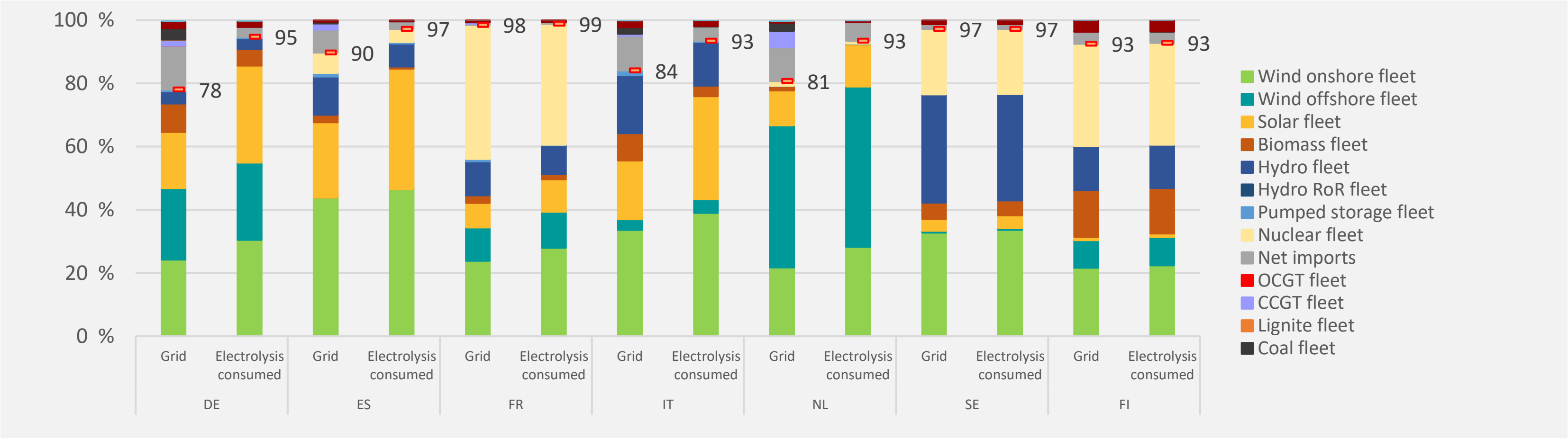


Electrolysers load factor across EU member states

Key result 2

Hydrogen system flexibility allows to benefit from low carbon electricity potentials and accommodate RES variability

- From a total system cost perspective, it is cost-efficient to oversize electrolysers and to operate them when low-carbon and cheap electricity is available
- Flexibility of the hydrogen system allows to **integrate renewable energy sources**:
  - The share of RES in the electricity mix consumed by electrolysers is higher than that of the average mix available from the grid
  - Hydrogen is mostly produced in countries showcasing low electricity carbon contents



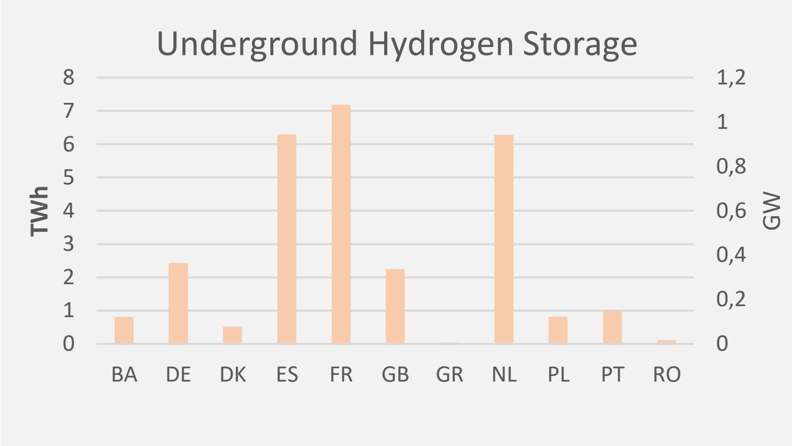
Average electricity mix available from the grid and consumed by electrolysers in selected countries

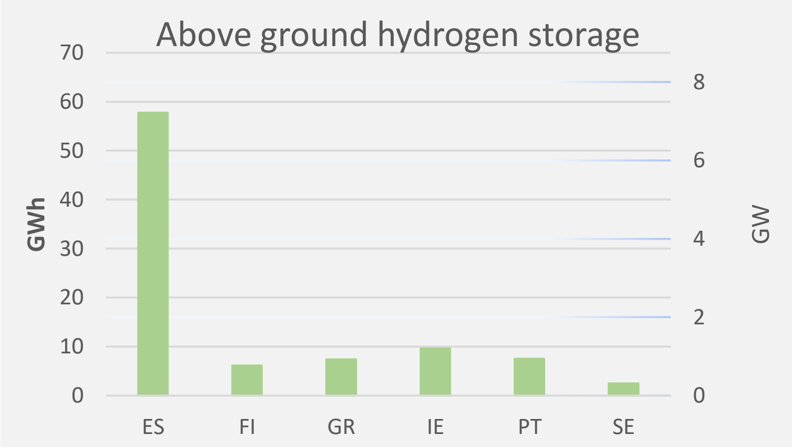
- The ability to operate electrolysers in a flexible way also depends on **hydrogen storage potentials**

Key result 3

Both long term and short term hydrogen storage are needed to enable flexible operation of the hydrogen system

- Both underground (salt caverns) and above ground hydrogen storage are considered in investment options
  - Above ground storage showcases higher investment costs but higher cycling capacities (assumption of 8h discharge time at full capacity vs 1000 h discharge time for salt caverns)
  - Salt caverns are not available in all countries, depending on geological potential constraints
  - Other types of underground hydrogen storage not considered due to lower TRL
- Total storage capacity:
  - 24 TWh H2 LHV salt caverns / 24 GW
  - 95 GWh H2 LHV above ground / 12 GW
- Salt caverns are installed mainly in countries showcasing either high hydrogen generation or demand
- Above ground hydrogen storage is installed:
  - In countries with significant hydrogen generation and no salt caverns potential (e.g., SE, FI, BG, IE)
  - In complement of salt caverns, mostly in Spain



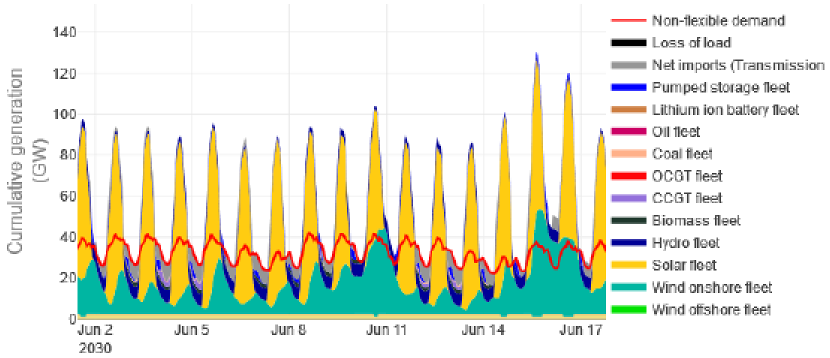


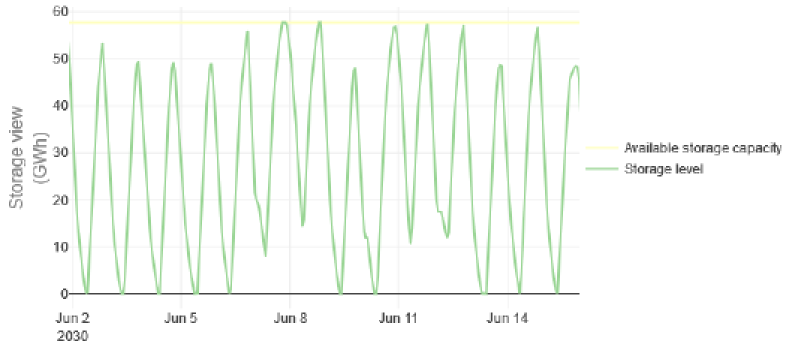
Storage capacity [left axis, TWh and GWh] and Injection capacity [right axis, GW] of hydrogen storage infrastructure

Key result 3

Both long term and short term hydrogen storage are needed to enable flexible operation of the hydrogen system

- Storage in salt caverns displays seasonal patterns:
  - Storage levels tend to increase during summer and are impacted by periods of high wind power generation
  - Salt caverns perform around 3 cycles per year (ratio of yearly output to storage capacity)
- Above-ground storage showcases rather short-term storage dynamics:
  - Short-term operation thanks to high cycling capacities
  - Assets perform around 100-300 full cycles per year depending on countries
  - In correlation to solar PV production patterns

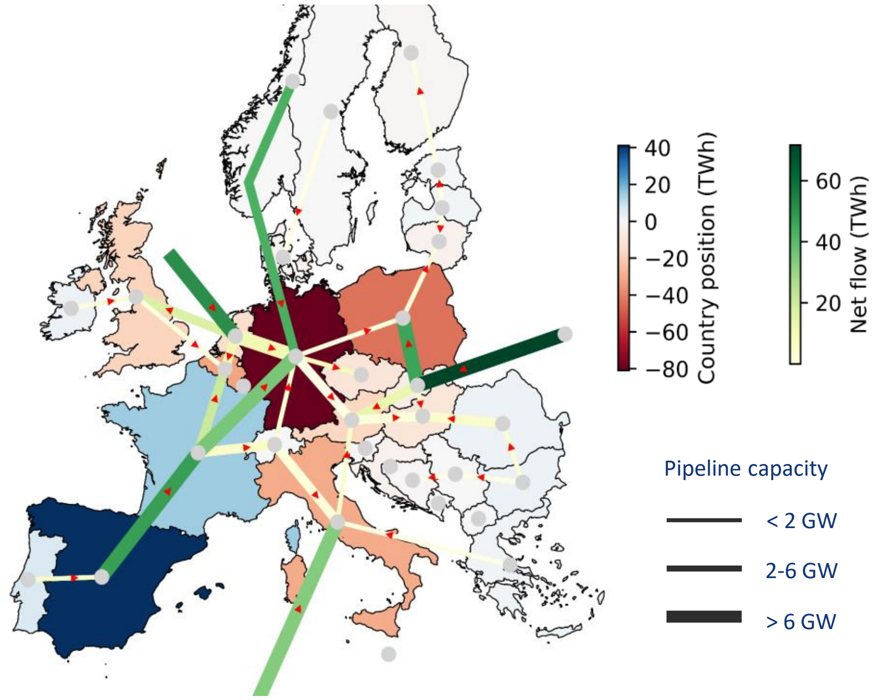




Example of above ground hydrogen storage and power generation dynamics in Spain

Conclusions

- A pan-European hydrogen network is cost-efficient:
  - It allows to produce hydrogen in the most favourable Member States,
  - And redistribute it to main consumers.
- From a total system cost perspective, a flexible operational management of the hydrogen system is cost-efficient
  - The costs of operating hydrogen infrastructure with limited load factors are outweighed by the associated benefits, as the hydrogen system provides flexibility to the power system.
- A flexible operation of electrolysers facilitates the integration of VRES capacities. It allows to preferably produce hydrogen during hours of low electricity prices and carbon intensity.
- Significant capacities of hydrogen storage are required to enable the flexible operation of the hydrogen system.
  - Underground and above-ground storage complement one another, the first storing high volumes of energy with seasonal dynamics, and the latter providing short-term flexibility thanks to high cycling capacities.



METIS3 S8 - Key results		
Hydrogen storage	**Storage capacity**	**Injection capacity**
Underground - EU27	24 TWh	24 GW
Above ground - EU27	95 GWh	12 GW
Electrolysis	**Installed capacity**	**Average load factor**
EU27	85,3 GW	47,5%
Hydrogen pipelines	**Total capacity**	**% of repurposed**
Europe	82 GW	48%
Hydrogen production	**Production**	**Imports**
EU 27	355 TWh	233 TWh

Main quantitative results [Reference scenario, EU27]

ACER

European Union Agency for the Cooperation of Energy Regulators

The external view

Stefano Astorri – ACER

Policy Officer – Infrastructure Team

Q&A Session

Assessing 2030 hydrogen infrastructure needs under REPowerEU ambitions

Time for a break!

Agenda

Time	Duration	Topic	Speaker
		Welcome and introduction	
14.00 – 14.15	15’	Opening remarks	DG ENER
14.15 – 14.30	15’	Objectives of the METIS project	Artelys
		Insights from the METIS studies	
14.30 – 15.10	40’	2050 insights on the industry transition	Fraunhofer & Dante Powell (ENTSOG)
15.10 – 15.55	45’	Assessing 2030 hydrogen infrastructure needs under REPowerEU ambitions	Artelys & Stefano Astorri (ACER)
15.55 – 16.05	**10’**	**Coffee Break**	
16.05 – 16.35	30’	Impact assessment of 2040 climate targets	Artelys & Francesco Ferioli (DG ENER)
16.35 – 17.20	45’	Outlook on short-term EU gas and power adequacy	Tractebel & Andreas Zucker (DG ENER)
		Live demo & Concluding remarks	
17.20 – 17.50	30’	Live demo of METIS	Artelys
17.50 – 18.00	10’	Concluding remarks	DG ENER

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Impact assessment of 2040 climate targets

- Core goal of latest **impact assessment** was to identify interim **2040 climate target**.

2030	2040	2050
-55% GHG vs 1990	?	Climate neutrality

- **Robust** energy transition **pathways** were identified via **multi-model analysis**.

consortium led by Artelys

AMADEUS-METIS	EU-TIMES	POLES-Enerdata	PRIMES
Artelys, ENGIE Impact	E4SMA	Enerdata intelligence + consulting	European Commission

Soft-linking AMADEUS and METIS models

1 AMADEUS *(Engie Impact)*

Model provides **demand projections**:

- for each year
- at country level
- by energy carrier
- by sector, sub-sector, end-use

Model is **bottom-up**, accounting for:

- Macro-economic conditions
- Substitution trends
- Efficiency gains

2

- Final demand for energy carriers
- Emissions

3 METIS *(Artelys)*

Model optimizes **capacity** and **dispatch**:

- for energy carriers & commodities
- at country level
- on hourly basis
- by technology

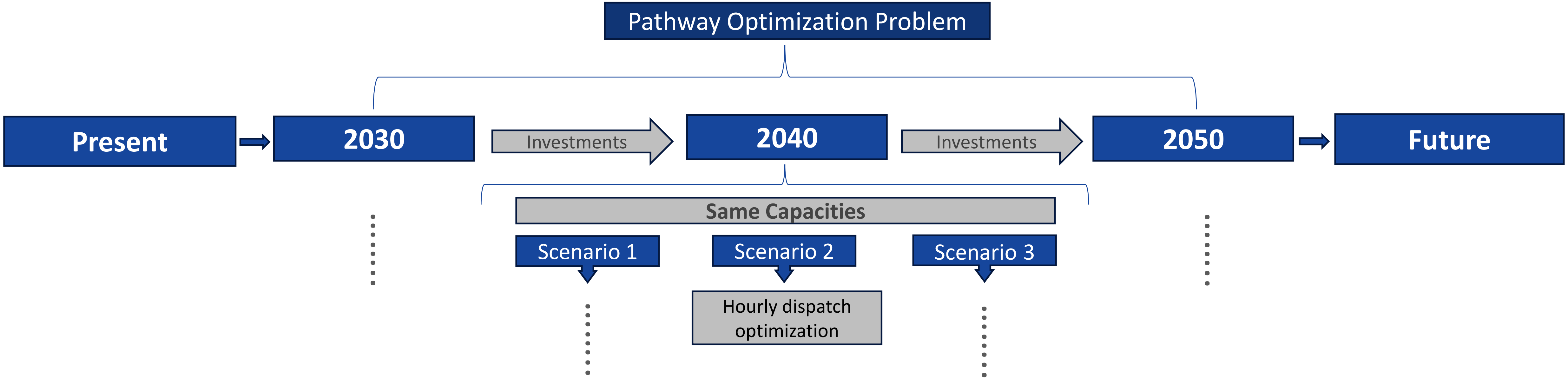
Model accounts for various **constraints**:

- net imports limit
- transmission
- renewable deployment
- emissions quotas

4

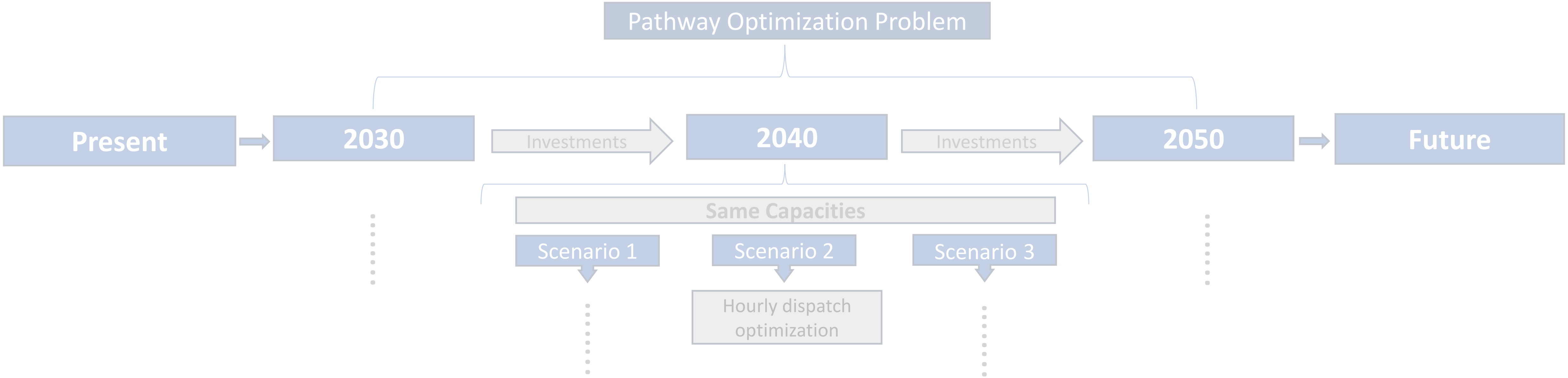
- Prices for energy carriers
- Emissions factors of energy carriers

Pathway optimization modelling



- Optimization problem is formulated as follows:
  - **Investment** and **decommissioning decisions** can be taken in each stage.
  - In each stage, **short-term decisions** are optimized (e.g., hourly dispatch for full year).
  - All stages are **coupled** (e.g., via **capacity** deployment or **emissions** constraints).
  - Pathway optimization problem is solved for **all stages at once**.

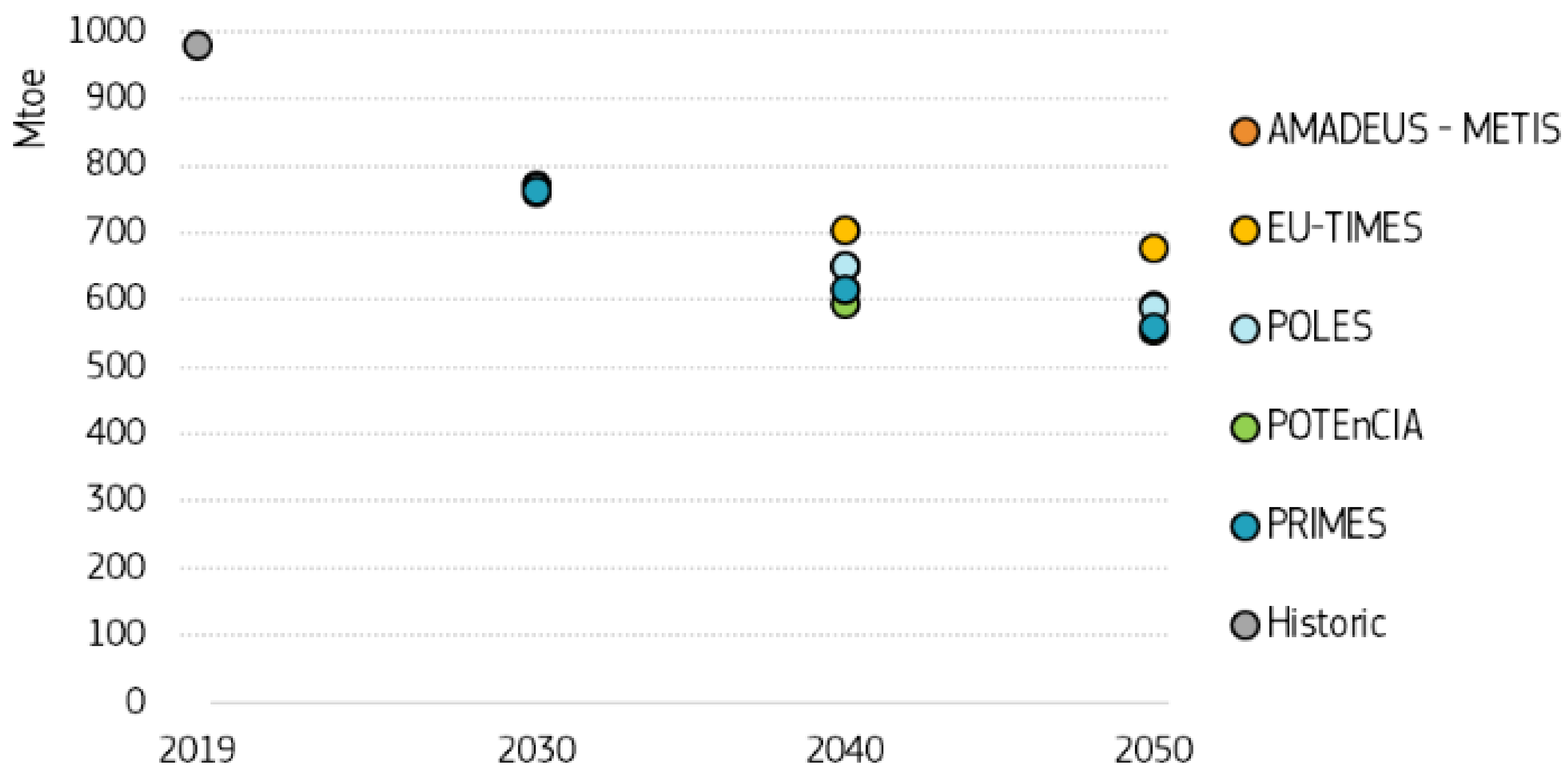
Application to 2040 climate target analysis



- In this case:
  - **Multi-commodity** model (electricity, methane, hydrogen, CO_2, biomass, …).
  - Full **European** energy **system** along with major neighboring countries (e.g., UK, Norway).
  - Capacity **expansion** planning between 2025 and 2050, in **5-year** steps (represented via single year).
  - Investment decisions taken based on **hourly** operational decisions in each step.

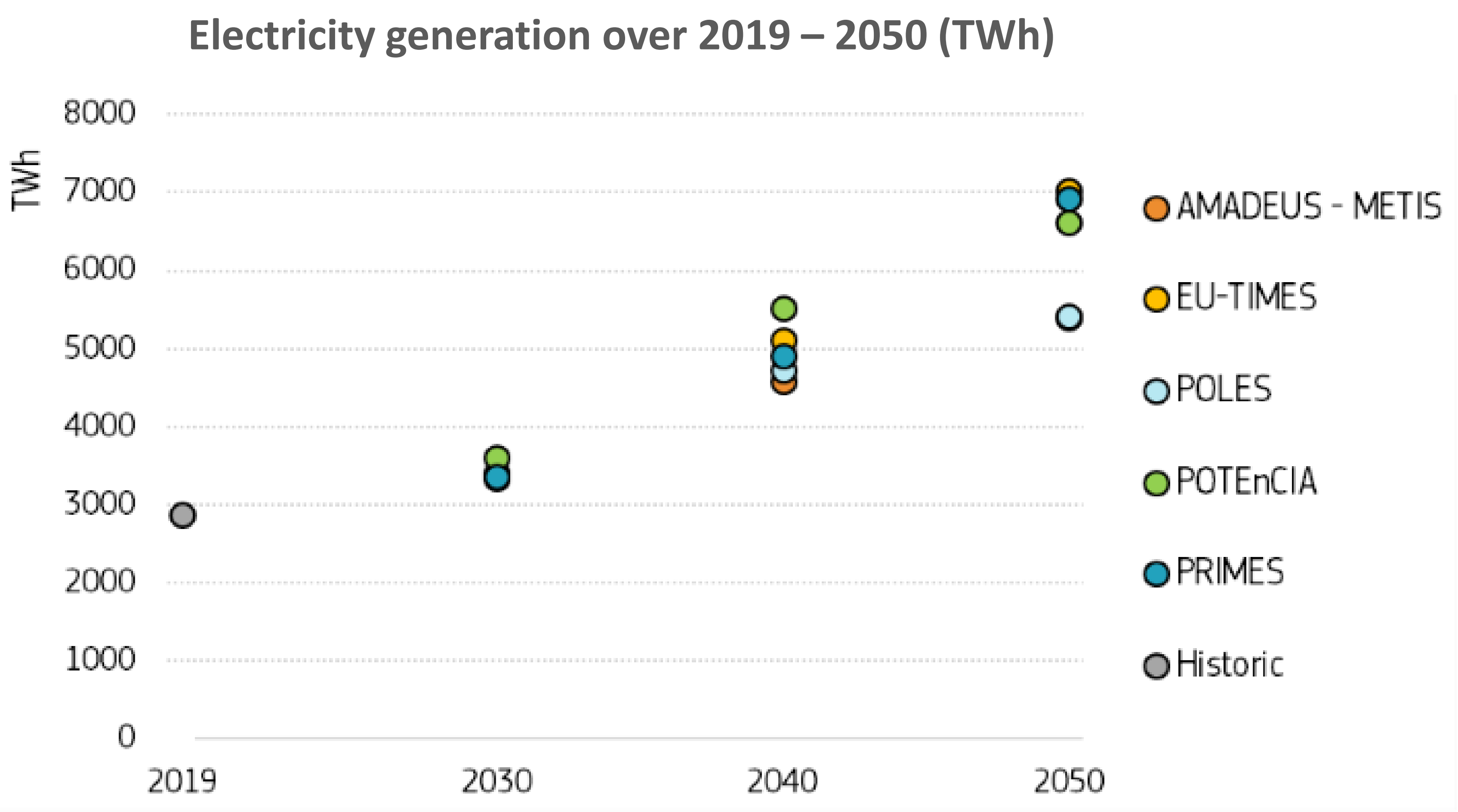
FEC decreases massively, driven by electrification of end-uses

Final energy consumption over 2019 – 2050 (Mtoe)



Source: 2040 climate target impact assessment, Annex 8, Figure 35

Power generation grows strongly, partly driven by e-fuels use



Source: 2040 climate target impact assessment, Annex 8, Figure 26

European Commission

The external view

Francesco Ferioli– DG ENER

Policy Officer – Chief Economist Unit

Q&A Session

Impact assessment of 2040 climate targets

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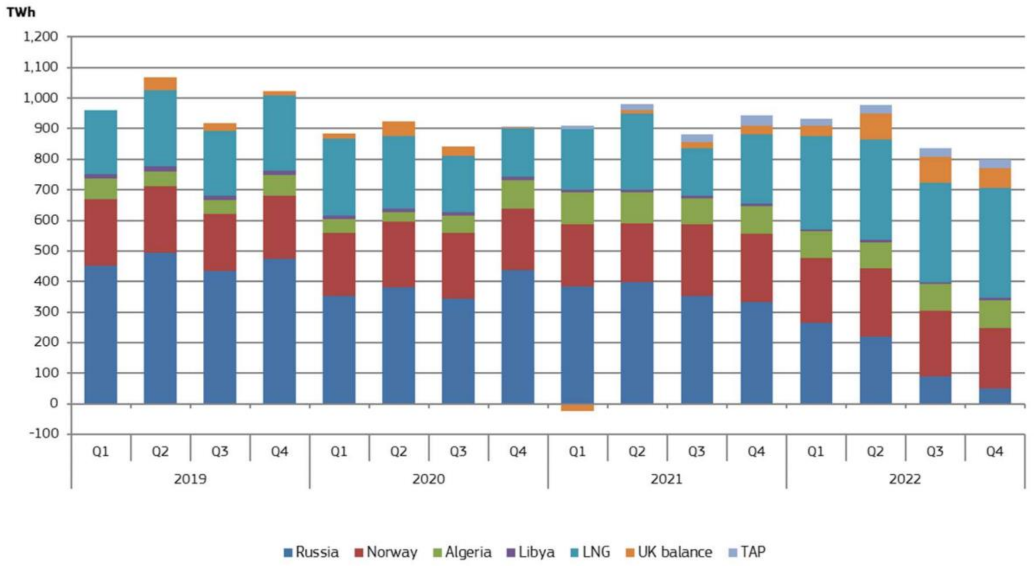
Study context

- In 2022, Europe faced **extreme price volatility** caused mainly by the collapse of Russian gas imports combined with the lower nuclear availability in France and water levels in Europe.
- These events are expected to have a lasting impact, hence there is a **need to understand how the energy system can adapt in the short to medium term**.
- This study is the **demonstration of METIS tool** to evaluate several potential **short-term evolutions** of the European power and gas sectors and assess the impact of different policies.



Evolution of the gas imports for the EU27 (European Commission (DG Energy), 2022)

Key result 1

A simultaneous occurrence of various risk factors would call for sourcing additional gas supply to meet the demand in winter 2024

- Around 60 TWh (6 bcm) of **additional gas supply*** would have to be secured for the winter 2024 in case of combination of multiple factors in play (“**stress scenario**”):
  - Colder weather than expected
  - Non-compliance with gas reduction measures
  - Additional gas demands (e.g. support to Ukraine and Moldova)
- Structural **gas demand reduction** measures will be key to avoid gas shortages and/or price spikes in the short term.
- A **colder year** would increase the gas demand and the import needs, with limited impact on the electricity generation mix.

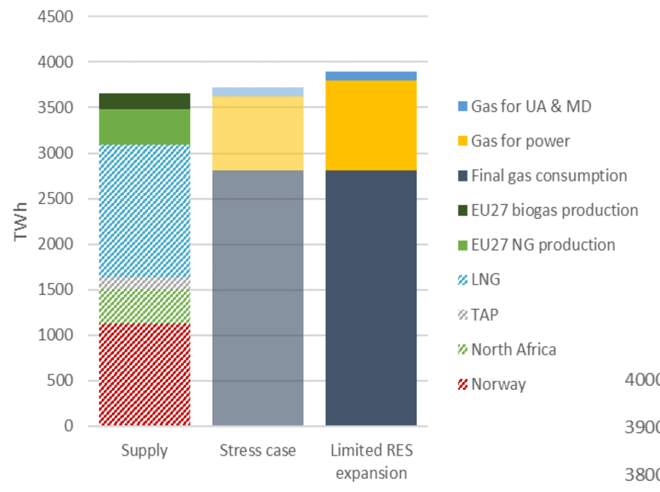
EU gas supply-demand balance in 2024

* Available gas supply based on IEA, How to avoid Gas Shortages in the European Union in 2023

Key result 2

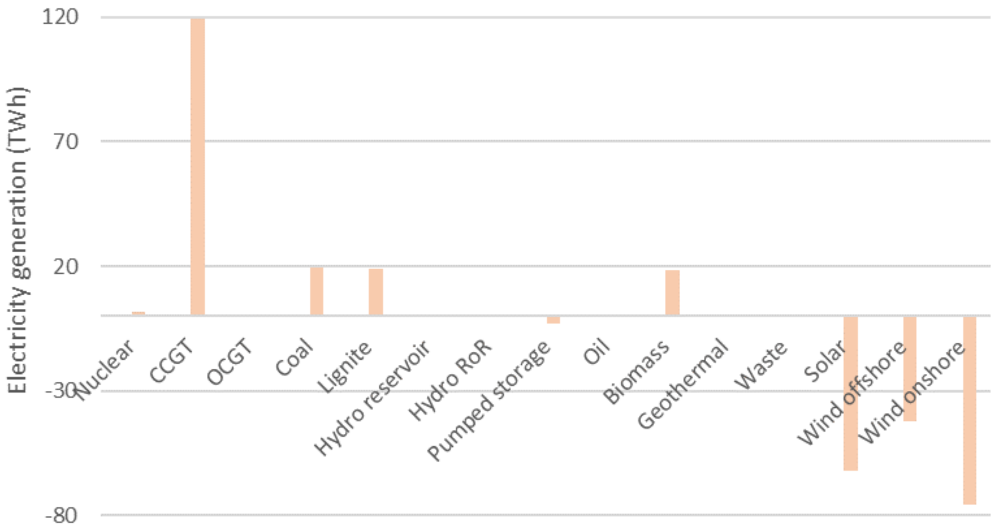
Around 24 bcm additional gas would be required to meet the demand if further **renewables capacity expansion** is restricted in 2024 under the stress case

- The gas shortage could reach around 240 TWh (24 bcm) if further **expansion of renewables** is restricted, under the stress case.



Gas supply-demand balance

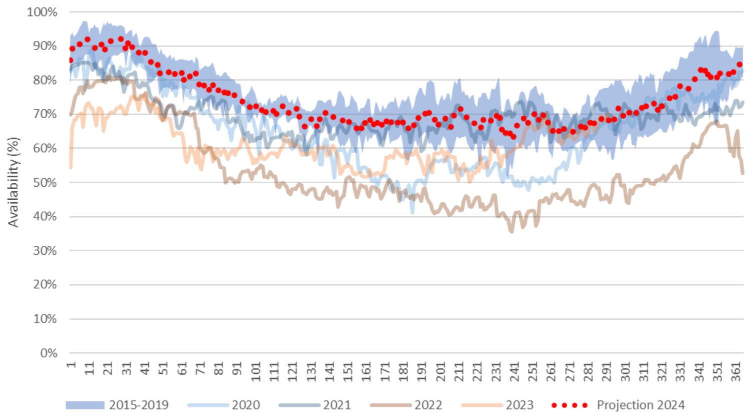
- Renewable capacity installed in 2024 significantly limit the need for thermal generation. They allow to reduce of 18 bcm (20%) the gas consumption for power generation compared to a case where they are not installed.



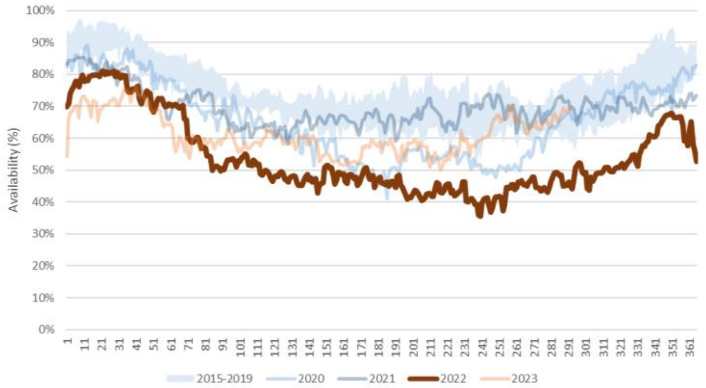
Electricity generation per technology
Difference between the "Limited RES expansion" and the "Stress case"

Key result 3

Around **11 bcm additional gas** would be required if the availability of French nuclear remains at 2022 levels while restoring to historical average would lead to **surplus of around 1 bcm**

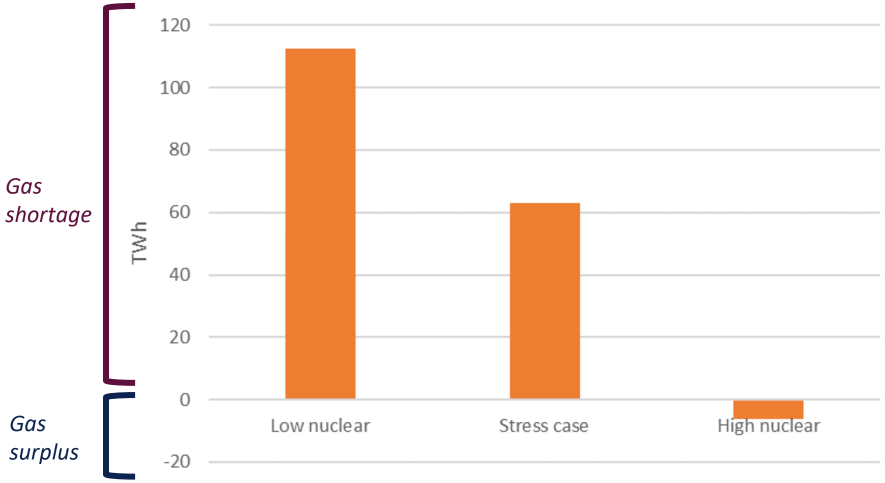


High FR nuclear availability (average 2015 -2019)



Low FR nuclear availability (based on 2022 profile)

- A **low nuclear availability** would <u>increase</u> the gas demand by 50 TWh (5 bcm), leading to shortage of **11 bcm under the stress scenario**.
- On the other hand, restoring to **higher nuclear availability** would <u>reduce</u> the gas consumption of 70 TWh (7 bcm), leading to surplus of around 1 bcm.

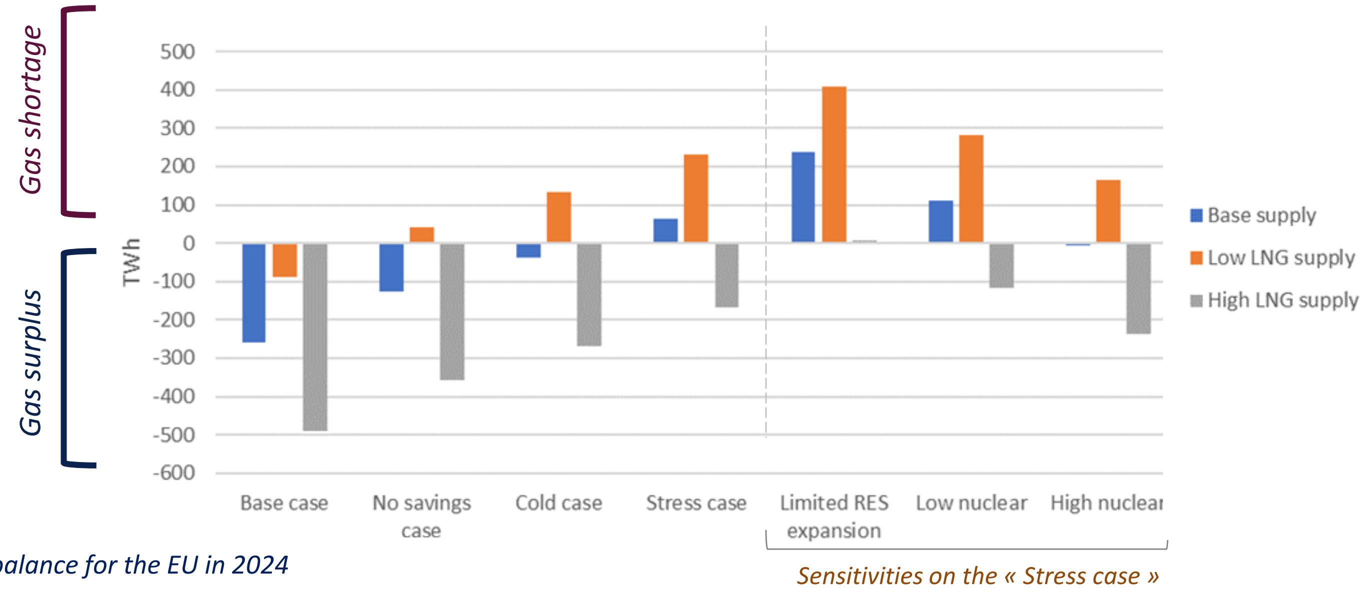


Gas supply-demand balances

Key result 4

Minimum availability of LNG supply for EU in the international market can lead to gas inadequacy under most scenarios

- There is an uncertainty of **about 400 TWh*** on the LNG supply available for the EU due to various factors including the **likelihood of commissioning** of new liquefaction capacities, the growth of Asian gas demand, the maintenance shutdowns of terminals and labour strikes at liquefaction terminals.
- If the LNG supply is minimal (170 TWh less), the gas supply is insufficient in almost all the scenarios. Only the scenario with mild weather and gas savings measures can close the gas supply-demand gap.
- If the LNG supply is maximal (230 TWh more), the gas supply is sufficient for all the scenarios.



Gas supply-demand balance for the EU in 2024

** Source: IEA (2022)*

Conclusion

- No major adequacy issue is expected in 2024, however extreme cases due to the simultaneous occurrence of various risk factors would call for sourcing additional supply.
- Risk on the availability of LNG supply for EU in the international market necessitates the need to have continued support for renewable capacity expansion, ensuring compliance of gas demand reduction measures, and maintaining sufficient nuclear availability level remain key to maintain adequate gas demand and supply balance.

The external view

Andreas Zucker – DG ENER

Policy Officer – Chief Economist Unit

Q&A Session

Impact assessment of 2040 climate targets

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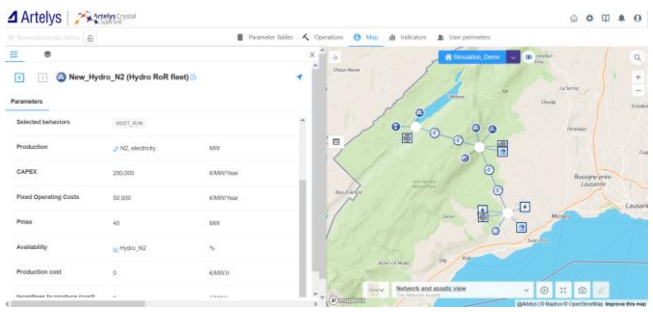
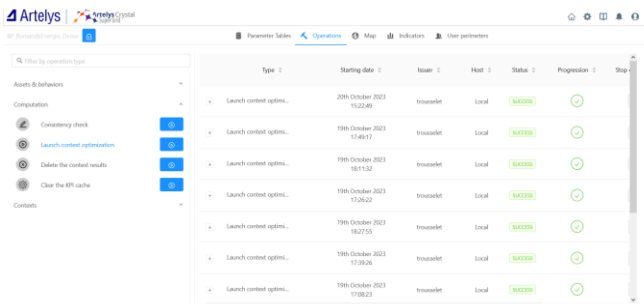
Live demo of the tool

- Basic workflow in 3 steps

Parametrization and mapping of the energy system

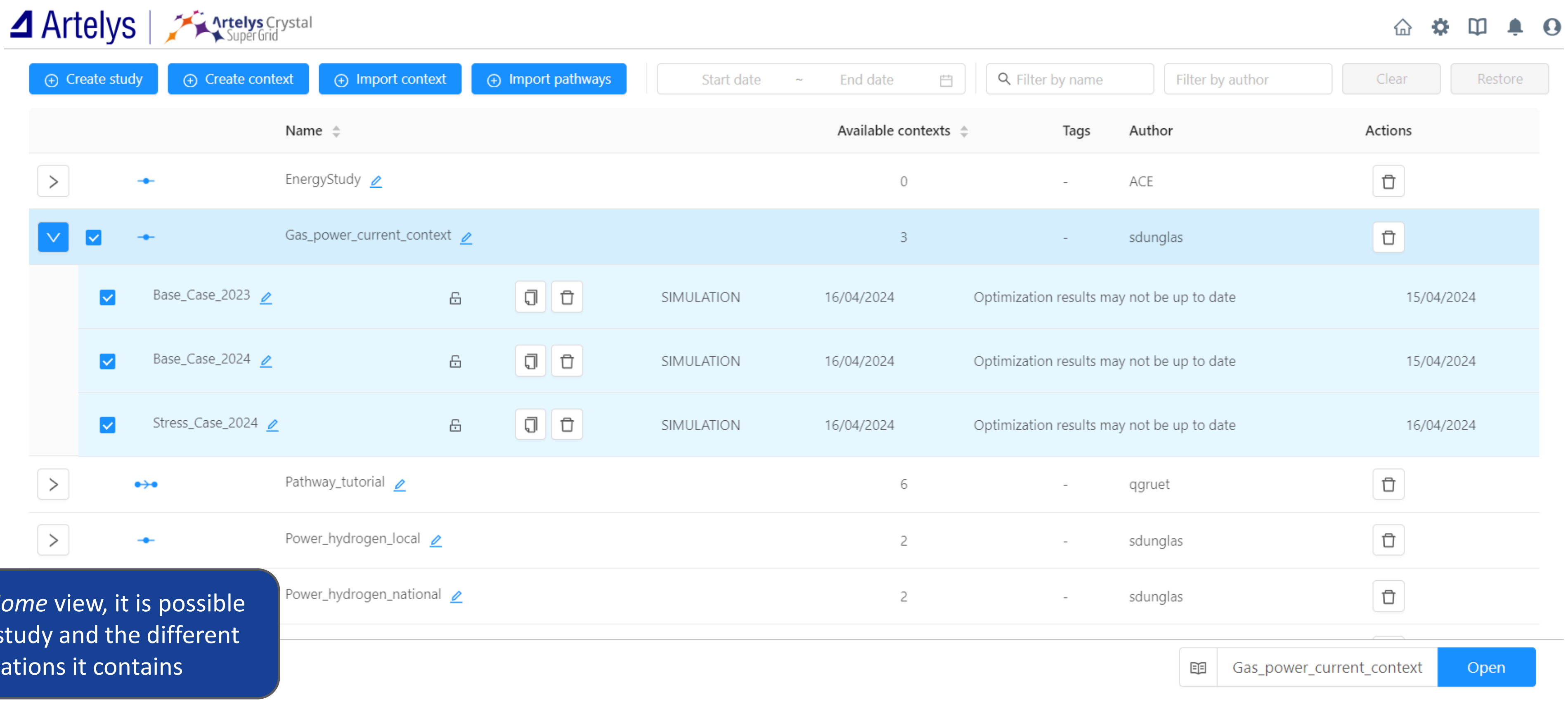


Launch optimization



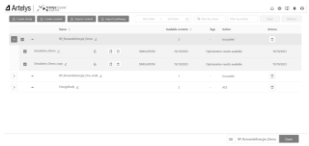
Analyse temporal and aggregated results

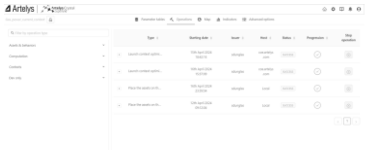
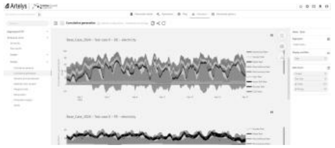
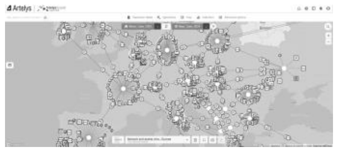
Live demo of the tool – Study Opening

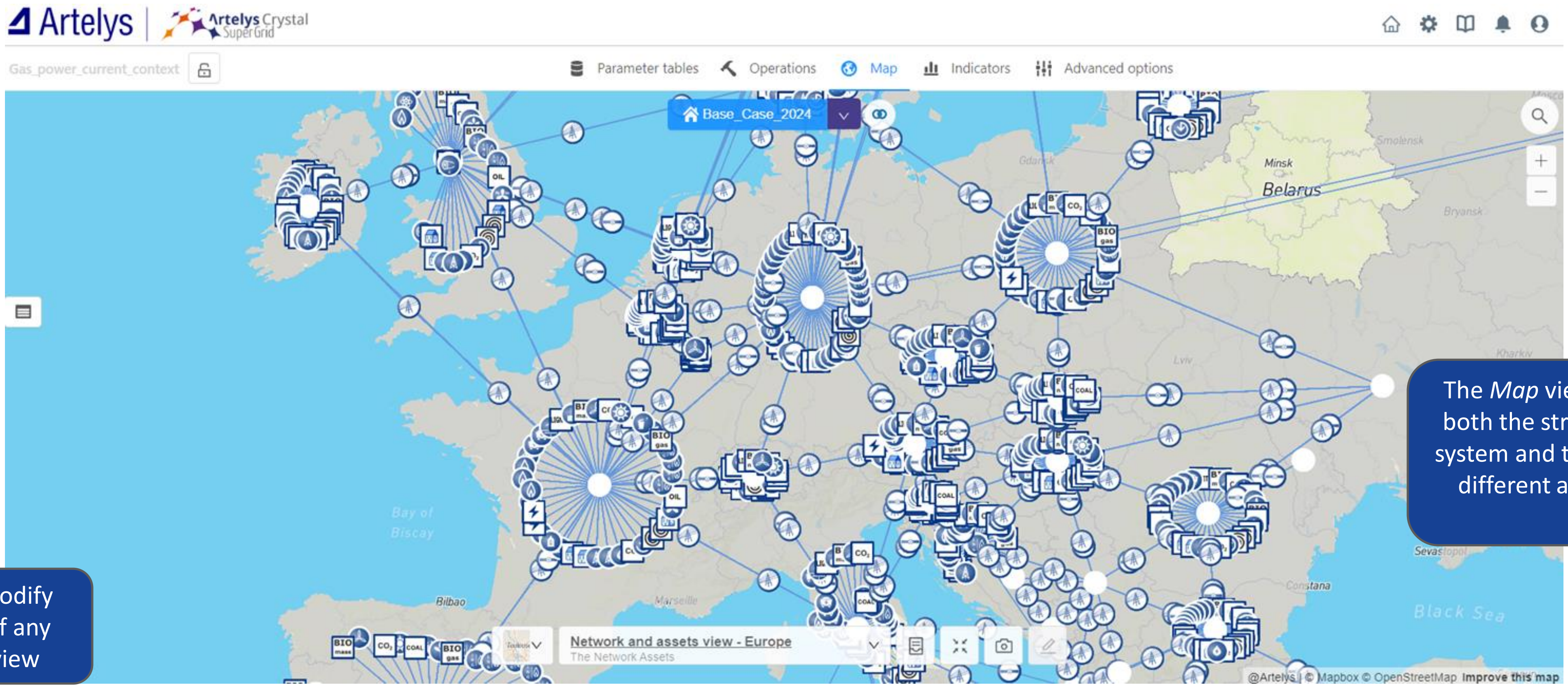


From the *Home* view, it is possible to open a study and the different simulations it contains

Live demo of the tool – Maps & Parameters



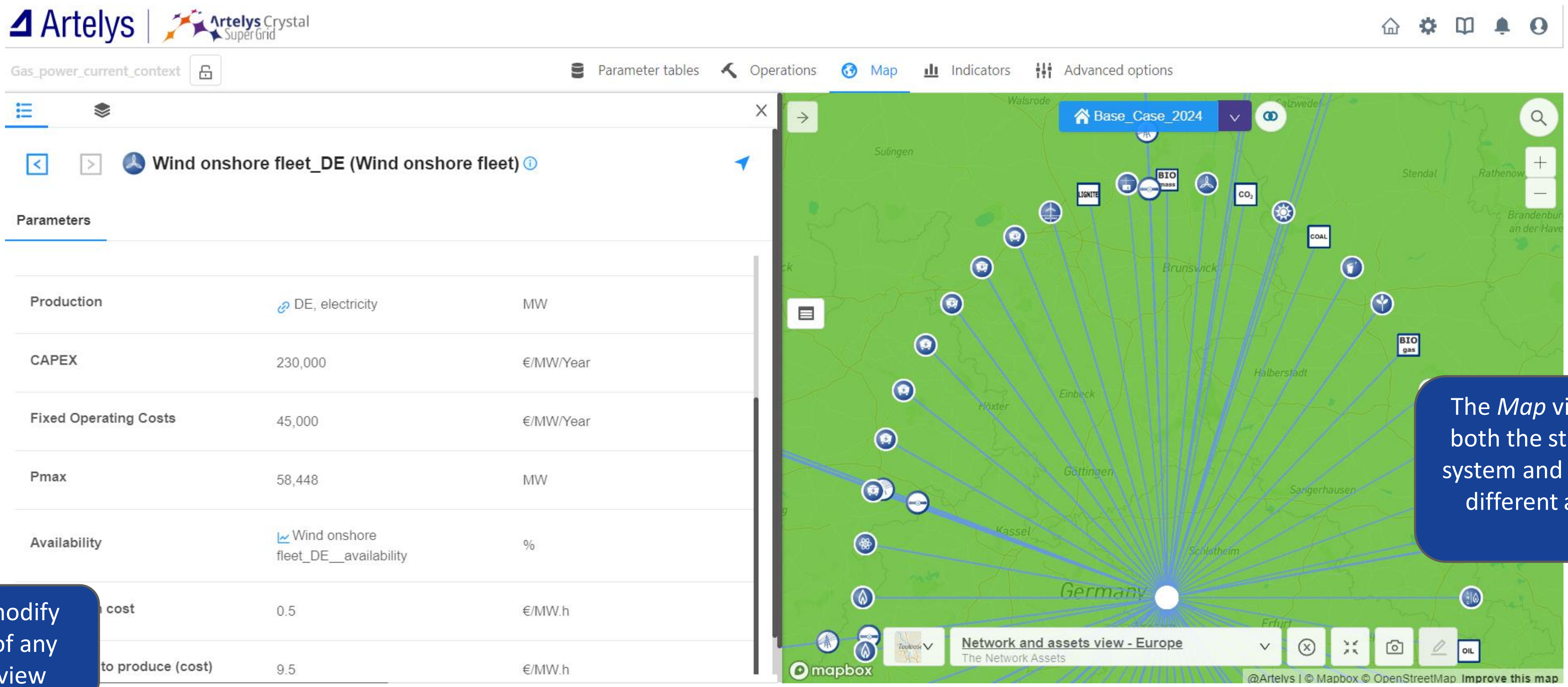




The *Map* view enables to access both the structure of the energy system and the parameters of the different assets by clicking on them

It is possible to modify the parameters of any asset from this view

Live demo of the tool – Maps & Parameters



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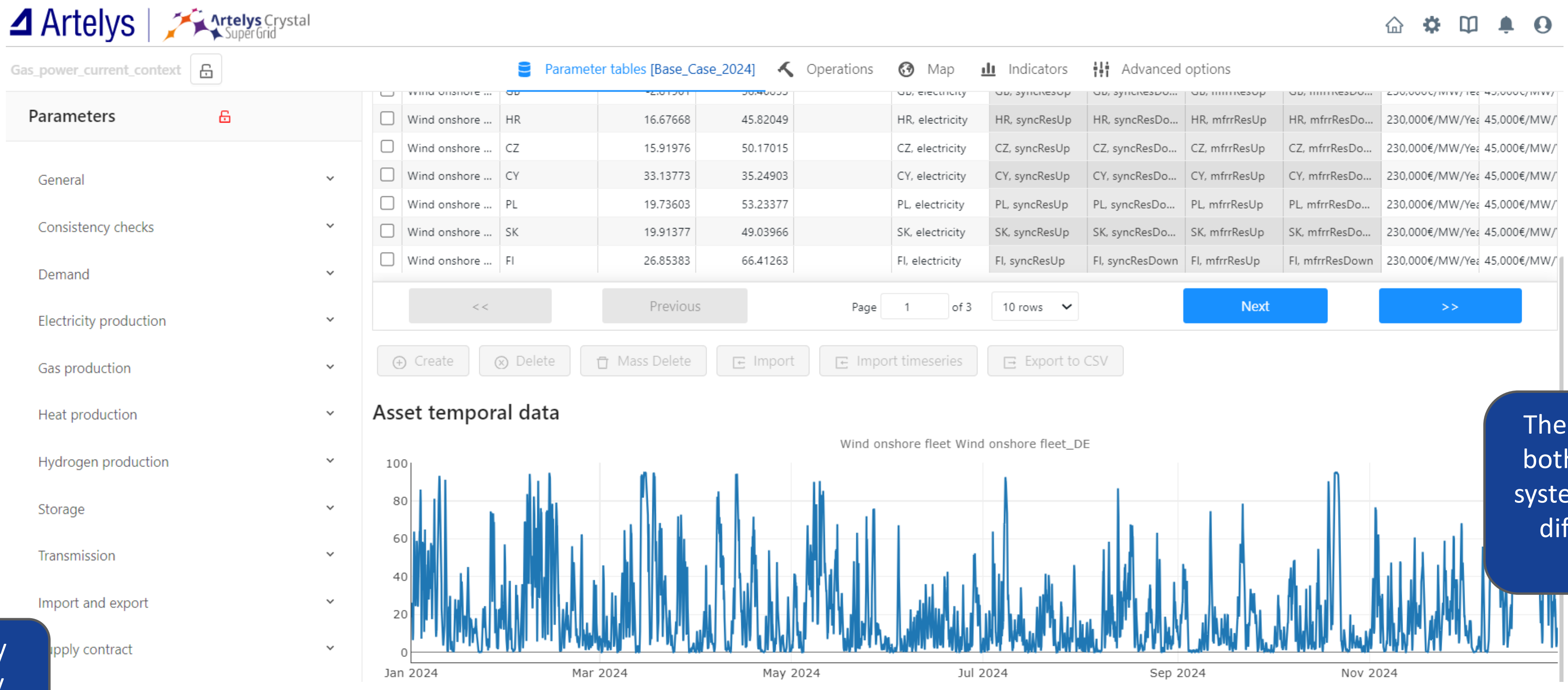
Live demo of the tool – Maps & Parameters



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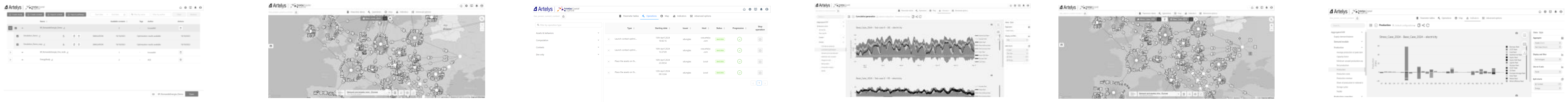
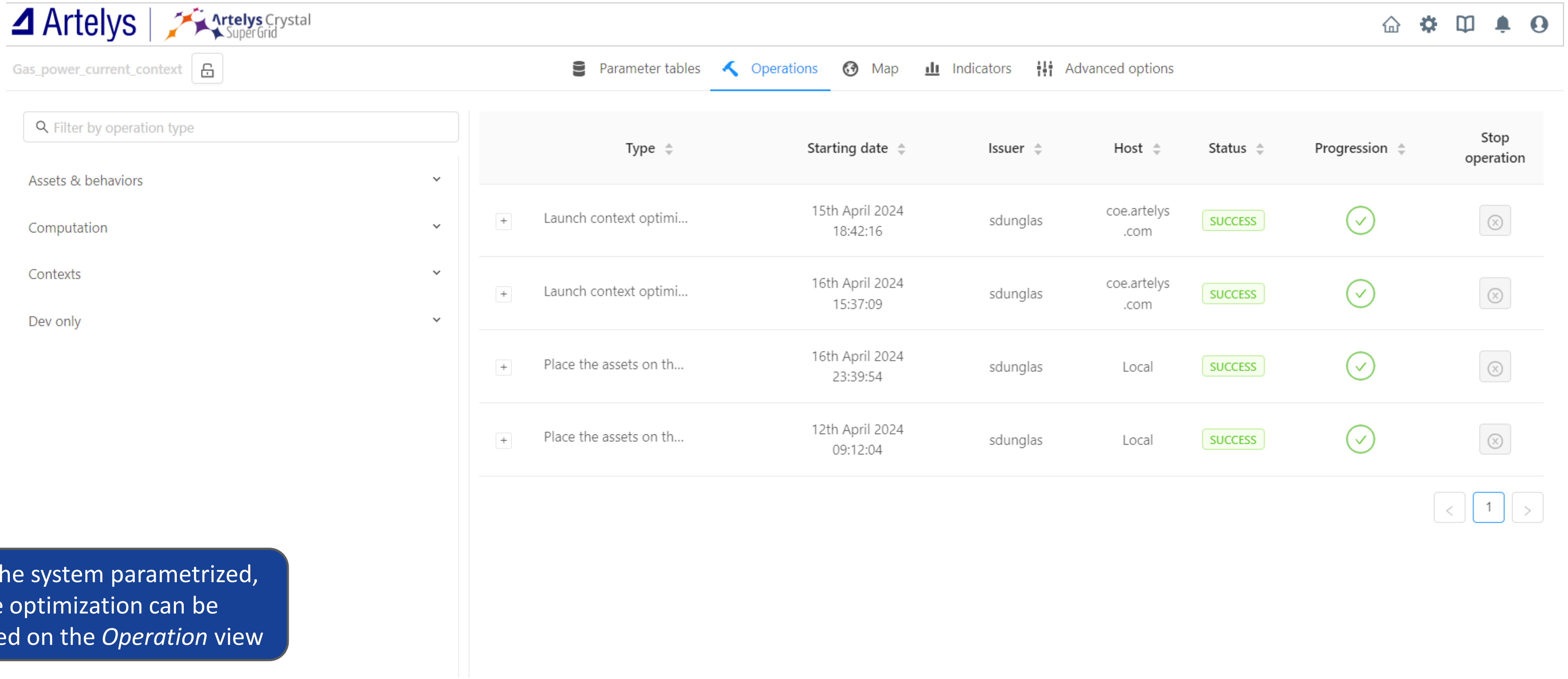
The *Map* view enables to access both the structure of the energy system and the parameters of the different assets by clicking on them

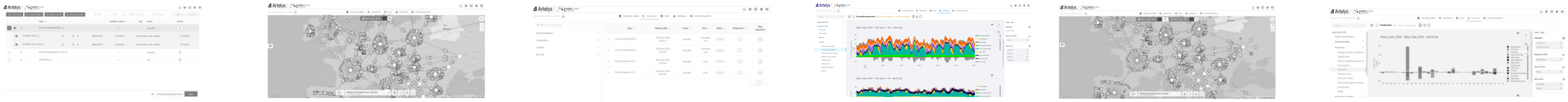
Live demo of the tool – Launch optimization





Once the system parametrized, the optimization can be launched on the *Operation* view

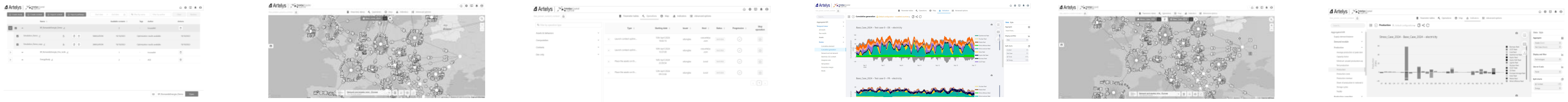
Live demo of the tool – Results Analysis

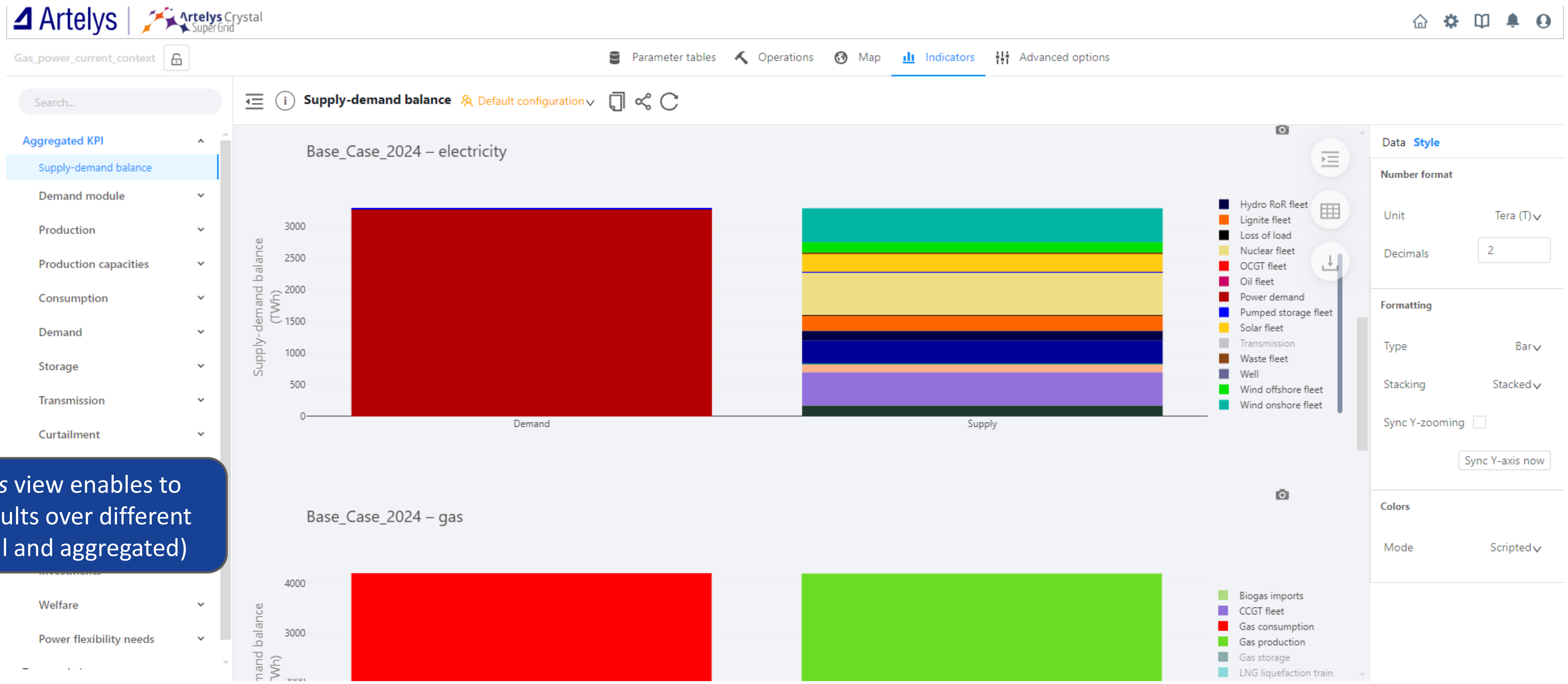


The *Indicators* view enables to look at the results over different KPIs (temporal and aggregated)

This view show the Hourly production of the different assets as well as power demand

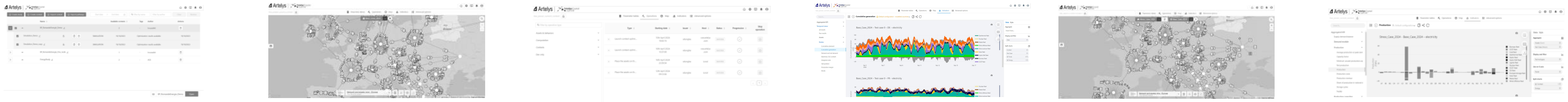
Live demo of the tool – Results Analysis





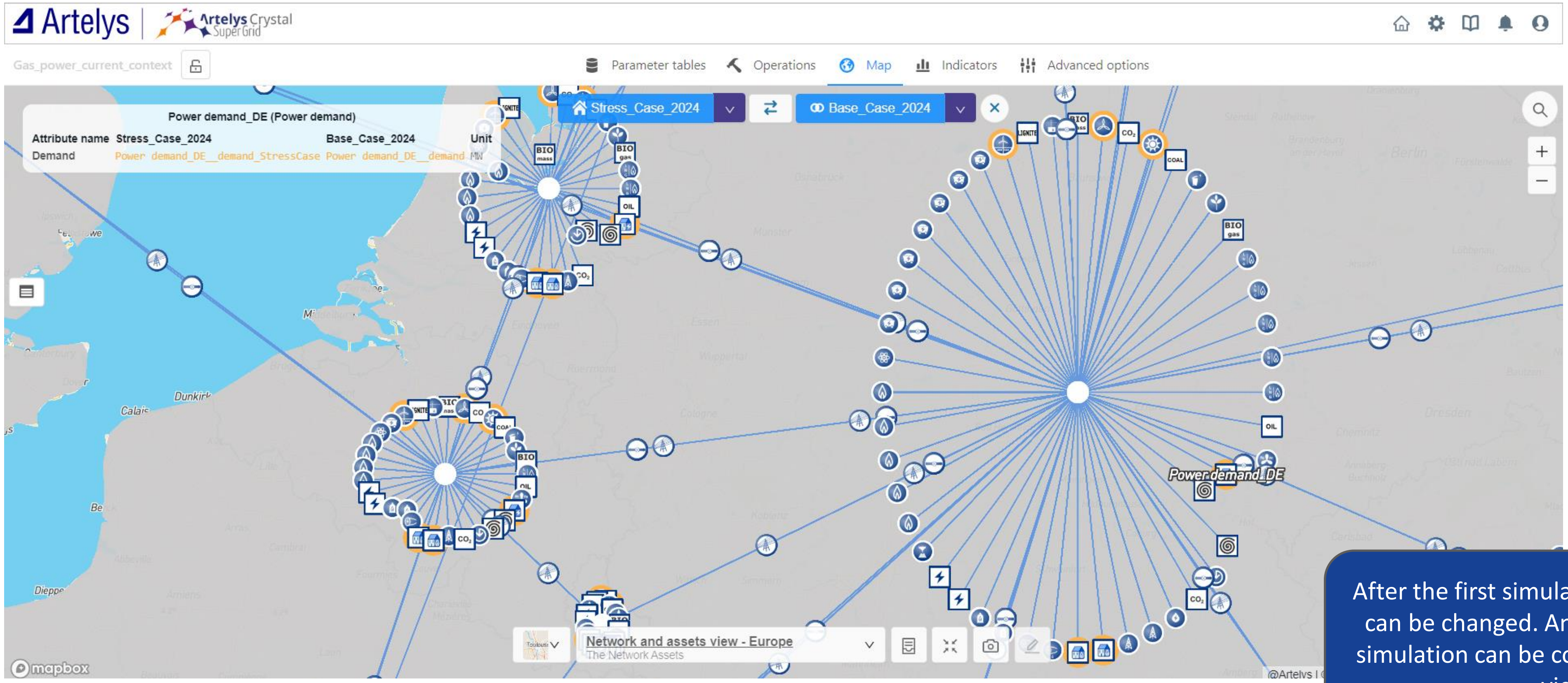
The *Indicators* view enables to look at the results over different KPIs (temporal and aggregated)

Live demo of the tool – Results Analysis



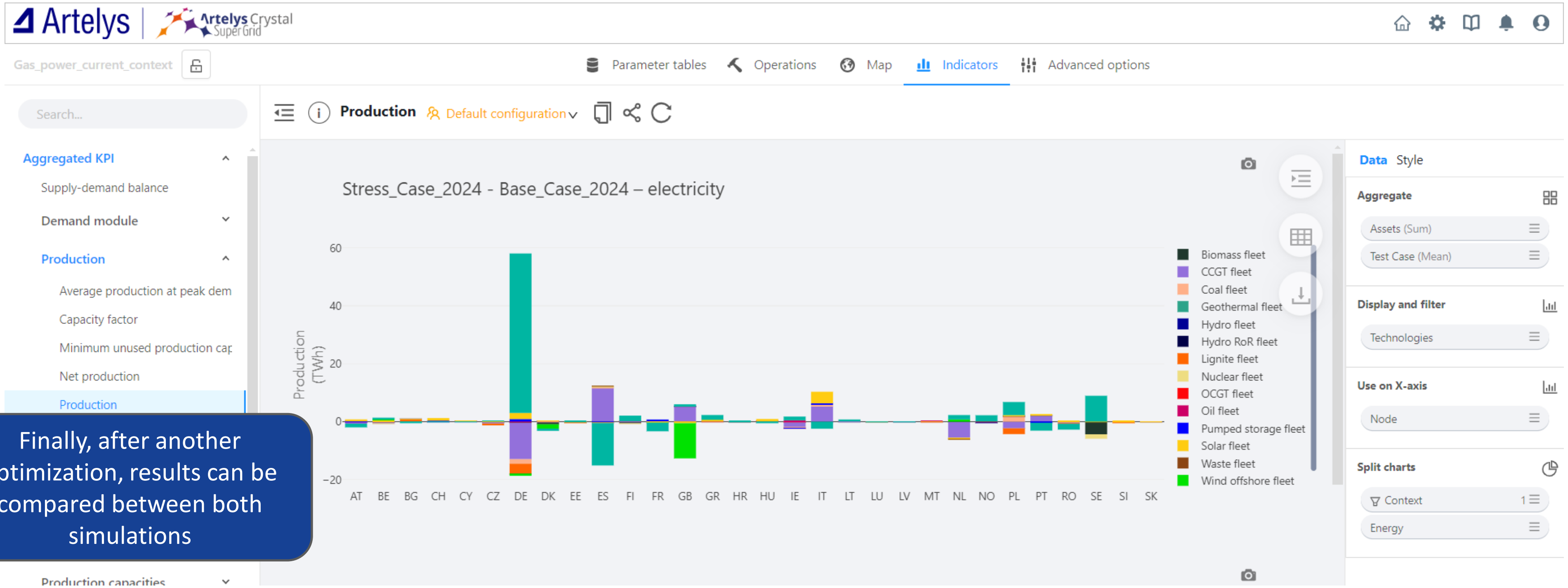
The *Indicators* view enables to look at the results over different KPIs (temporal and aggregated)

Live demo of the tool – Sensitivity Analysis



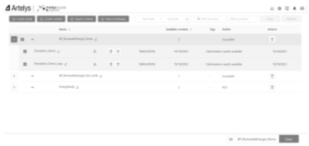
After the first simulation, any parameter can be changed. And the inputs of the simulation can be compared in the map view.

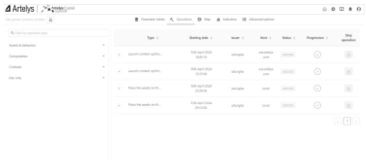
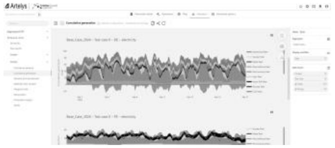
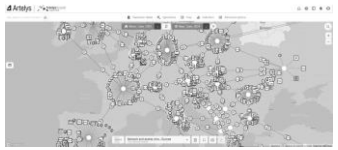
Live demo of the tool – Sensitivity Analysis

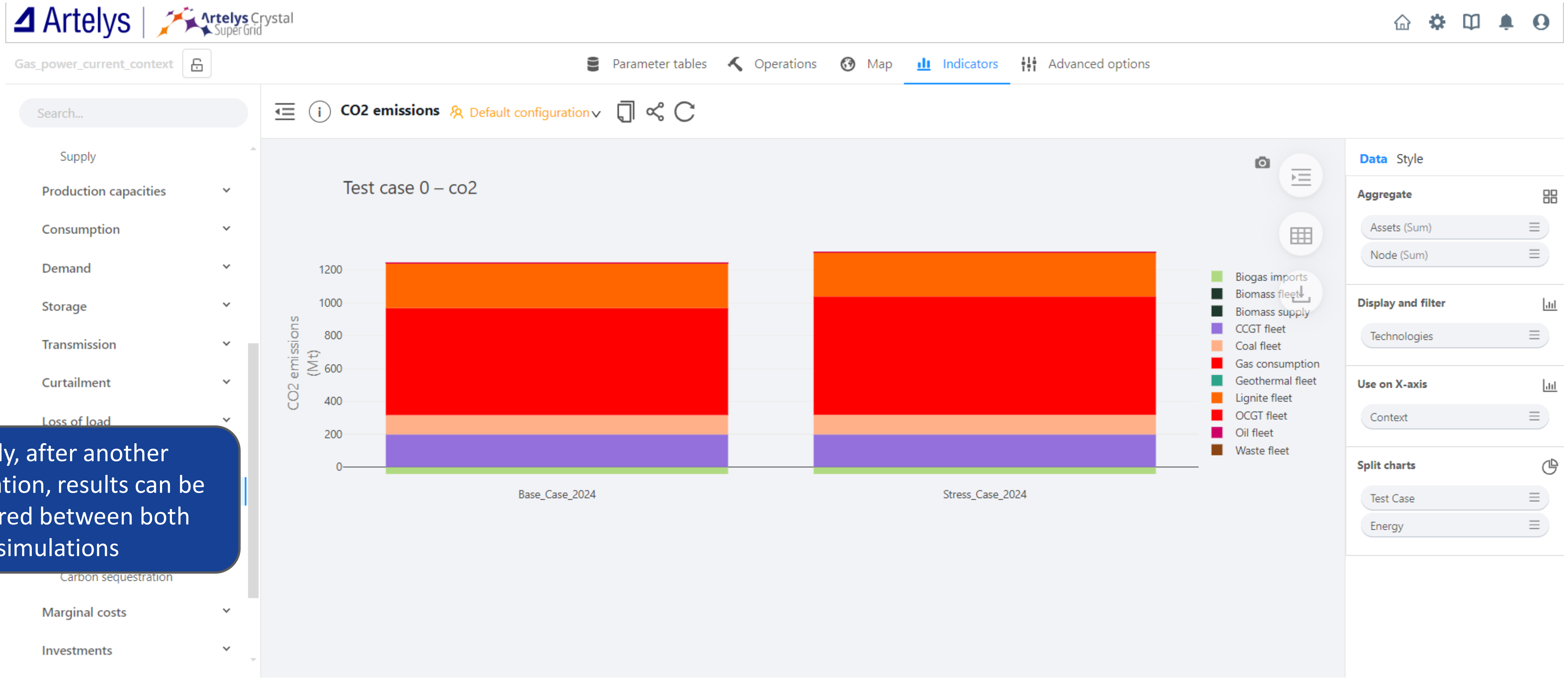


Finally, after another optimization, results can be compared between both simulations

Live demo of the tool – Sensitivity Analysis



Finally, after another optimization, results can be compared between both simulations

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Concluding remarks

- Since its inception, METIS has been trusted to provide valuable insights in key policy-making processes (CEP, Revision of REDII, H2 and Decarbonised Gases package, 2040 GHG Target). This is quite an achievement!

- The METIS modelling tool is **available to DG ENER and JRC modelling teams**! Recent JRC studies conducted with METIS include:
  - "The impact of decarbonising the iron and steel industry on European power and hydrogen systems", 2024.
  - "Climate variability on Fit for 55 European power systems", 2023.
  - "The Merit Order and Price-Setting Dynamics in European Electricity Markets", 2023.

- The **fourth METIS project** has already started and will last until 2027! The main objectives of METIS 4 include:
  - Improved representation of electricity markets:
    - Sequence of short-term electricity markets
    - Price formation dynamics
    - Integration of electricity grid constraints
  - Improved representation of global H2 trade
  - Improved representation of demand-side flexibility

All studies using METIS are available online!
[Link]

Thank you for your attention!

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Check-out the METIS website!

[Link]