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COORDINATED ENERGY INFRASTRUCTURE DEVELOPMENT – AN ANALYSIS WITH TIMES PANEU

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MOTIVATION

EXISTING STUDIES REGARDING INFRASTRUCTURES

Addressing 2040 opportunities cuts RES energy surplus and CO_2 emissions, increases electricity exchanges and price convergence between countries

142 Infrastructure is key to enabling the integration of renewable generation and electrification of energy demand, and to unlocking the benefits of market integration, including a more optimal operation of the EU power system (reducing congestion management costs, redispatching costs and other such costs) and sharing flexibility. These benefits should in principle outweigh the costs of making the required infrastructure investments.

Effective grid planning. ENTSO-E agrees that effective grid planning is essential to guide upcoming investments and, in cooperation with all relevant stakeholders, is committed to delivering high-quality Ten-Year Network Development Plans (TYNDPs). ENTSO-E believes that through each improved issue of the TYNDP, the European planning of the transmission network can reliably identify cross-border capacity needs in Europe. While

Source:
TYNDP 2024 / Infrastructure Gaps Report / Opportunities for a more efficient European power system by 2050

Source:
ACER_2024_Monitoring_Electricity_Infrastructure.pdf

Source:
European Parliament Report on Electricity Grids: ENTSO-E Welcomes the Spotlight on Accelerating Grid Transformation

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MOTIVATION
INTERCONNECTION TARGET

EU electricity interconnection target

The EU has set an interconnection target of **at least 15% by 2030** to encourage EU countries to interconnect their installed electricity production capacity. This means that each country should have electricity infrastructure in place that would allow it to import, from its neighbouring EU countries, an equivalent of at least 15% of the electricity production capacity on its territory.

To achieve its climate and energy goals, Europe needs to improve cross-border electricity interconnections. Connecting Europe's electricity systems will allow the EU to boost its security of electricity supply and to integrate more renewables into energy markets.

Soruce: Electricity interconnection targets

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MOTIVATION
INTERCONNECTION TARGET

Two definitions:

- $Interconnection\ level = \frac{Nominal\ transmission\ capacity}{peak\ load\ 2030}$ (electricity **demand** and **import** need)
- $Interconnection\ level = \frac{Nominal\ transmission\ capacity}{Installed\ renewable\ generation\ capacity\ 2030}$ (electricity **supply** and **export** potential)

The interconnection target is only a "suggestion", it is not legal-binding!

⇩

Should the interconnection target be legal-binding?

⇩

How will/can the interconnection target affect the energy system?

Source: report_of_the_commission_expert_group_on_electricity_interconnection_targets

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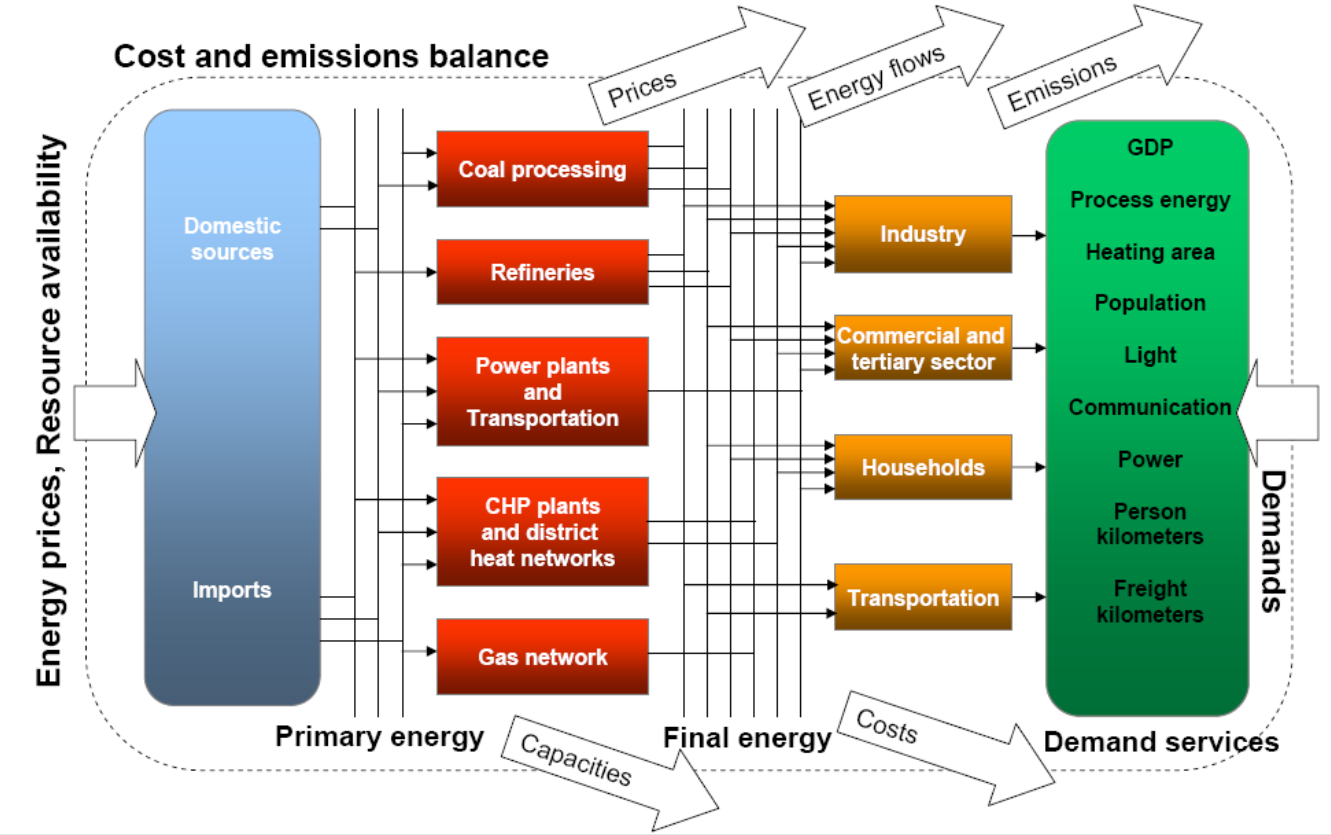
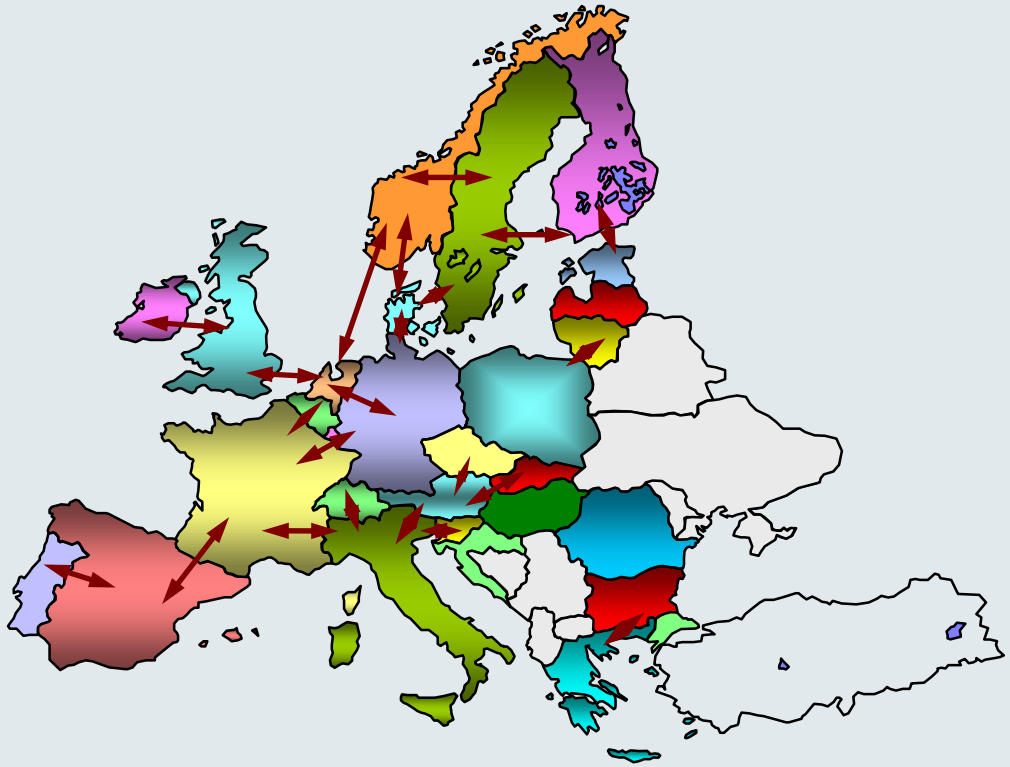
METHODOLOGY

MODEL DESCRIPTION – TIMES PANEU





- Bottom-Up Energy System Modell, model language GAMS
- Multi-regional (EU27 + UK, CH, NO)
- Time horizon 2010-2050
- Commodity Trade between regions
- All relevant sectors and full competition between technologies and energy carriers
- Infrastructure for electricity, gas, hydrogen

→ detailed energy system analysis for Germany/Europe

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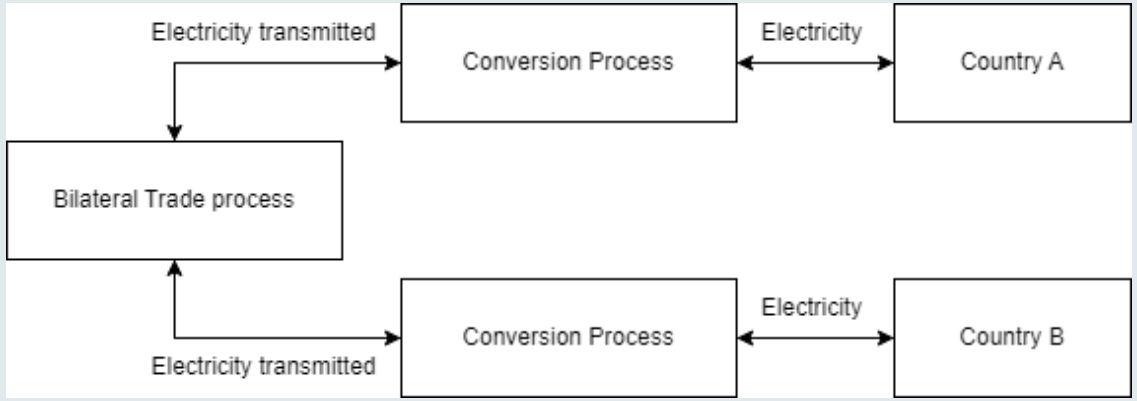
METHODOLOGY

GRID INFRASTRUCTURE MODELLING – ELECTRICITY GRID

- Countries as nodes, modelling the interconnection of both AC and DC as bilateral trade processes
- Investment costs are calculated based on the real and concept projects by TSOs in the unit of [M€/GW]
- The capacity of the bilateral trade processes is constrained in accordance with the ten-year development plan



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DATASET AND SCENARIOS

CAPACITY DEVELOPMENT FROM ENTSO-E

Source: TYNDP 2024 / Infrastructure Gaps Report / Opportunities for a more efficient European power system by 2050

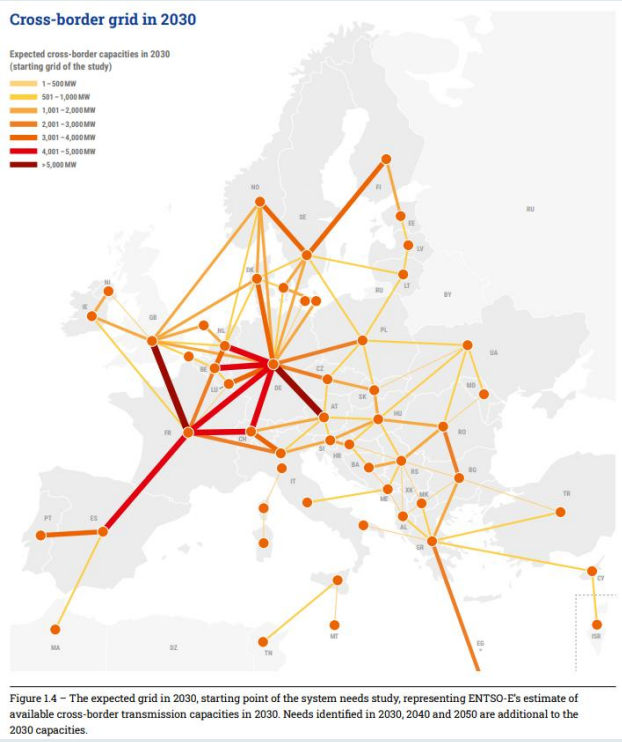


Figure 1.4 – The expected grid in 2030, starting point of the system needs study, representing ENTSO-E's estimate of available cross-border transmission capacities in 2030. Needs identified in 2030, 2040 and 2050 are additional to the 2030 capacities.

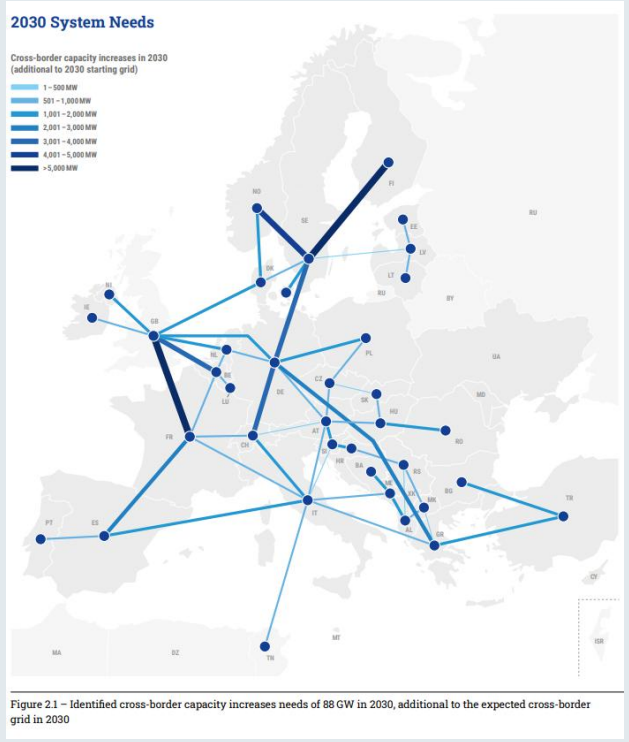


Figure 2.1 – Identified cross-border capacity increases needs of 88 GW in 2030, additional to the expected cross-border grid in 2030

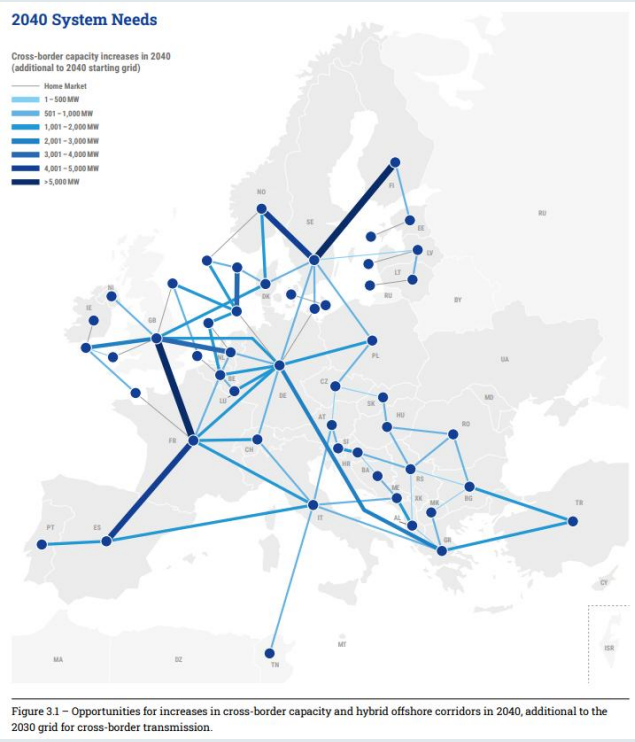


Figure 3.1 – Opportunities for increases in cross-border capacity and hybrid offshore corridors in 2040, additional to the 2030 grid for cross-border transmission.

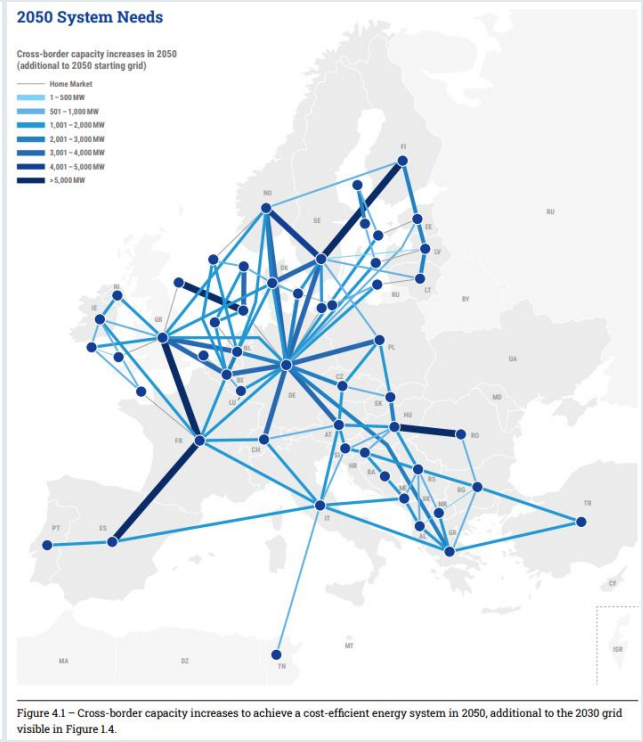


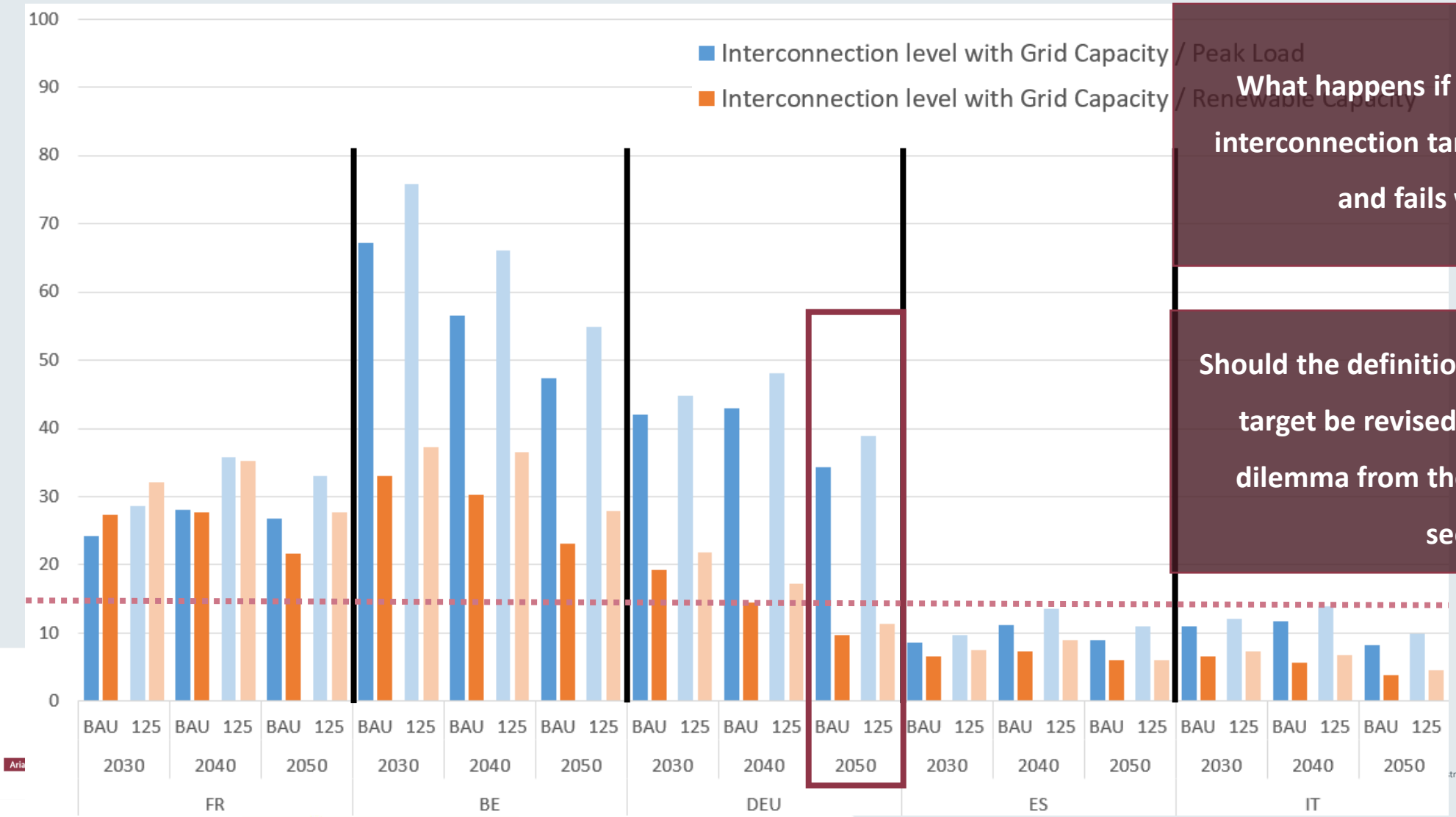
Figure 4.1 – Cross-border capacity increases to achieve a cost-efficient energy system in 2050, additional to the 2030 grid visible in Figure 1.4.

Scenarios

- **Business-as-usual (BAU):** countries build up capacities according to existing plans from ENTSO-E
- **High interconnection level (125%):** countries realize the importance of interconnection and start to make regulations on national levels and build up grids massively and quickly, assumed 25% more than existing plans starting from 2030 to 2040

RESULTS

INTERCONNECTION LEVEL ACCORDING TO EXISTING DEFINITIONS



What happens if a country reaches the interconnection target with one definition and fails with another?

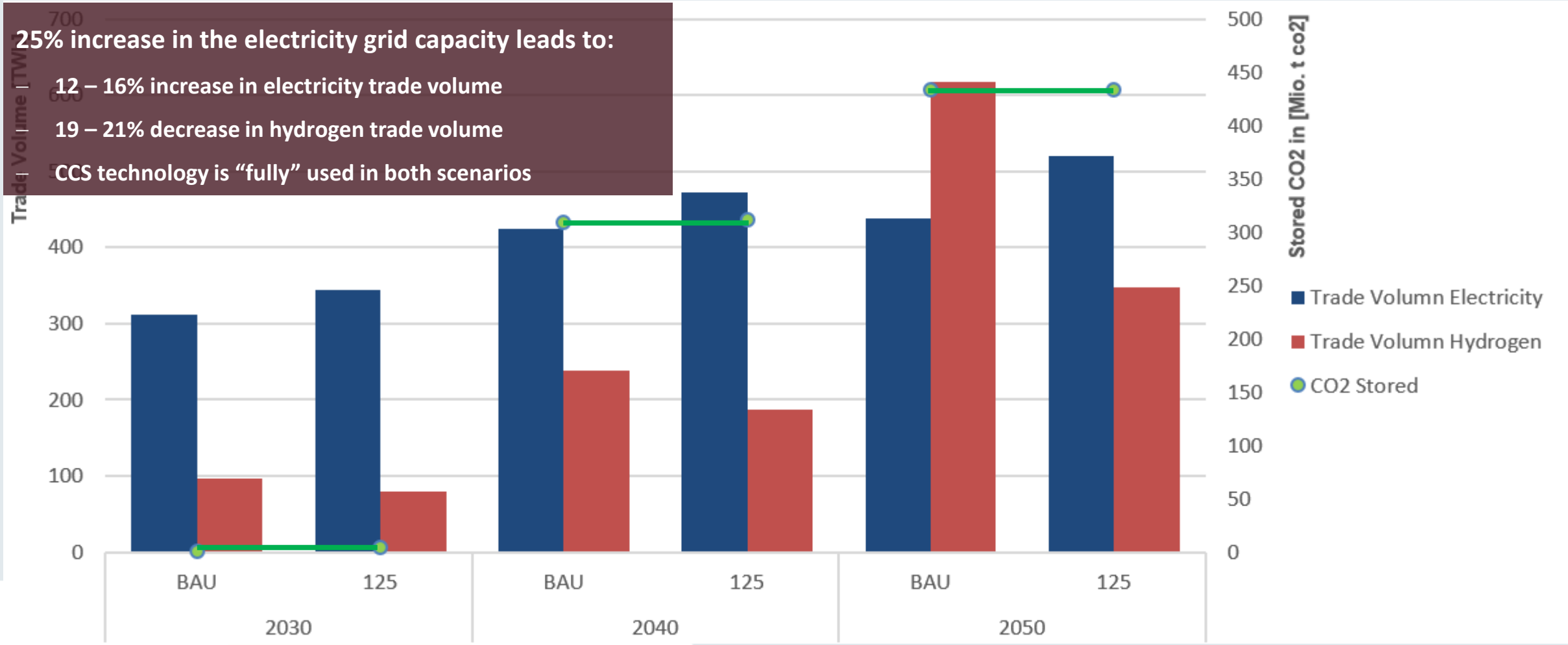
Should the definition of the interconnection target be revised in order to avoid the dilemma from the definition of energy security?

RESULTS

NET ELECTRICITY AND HYDROGEN TRADE IN TWH AND STORED CO2 IN THE EU IN MIO. T CO2

25% increase in the electricity grid capacity leads to:

- **12 – 16% increase in electricity trade volume**
- **19 – 21% decrease in hydrogen trade volume**
- **CCS technology is “fully” used in both scenarios**



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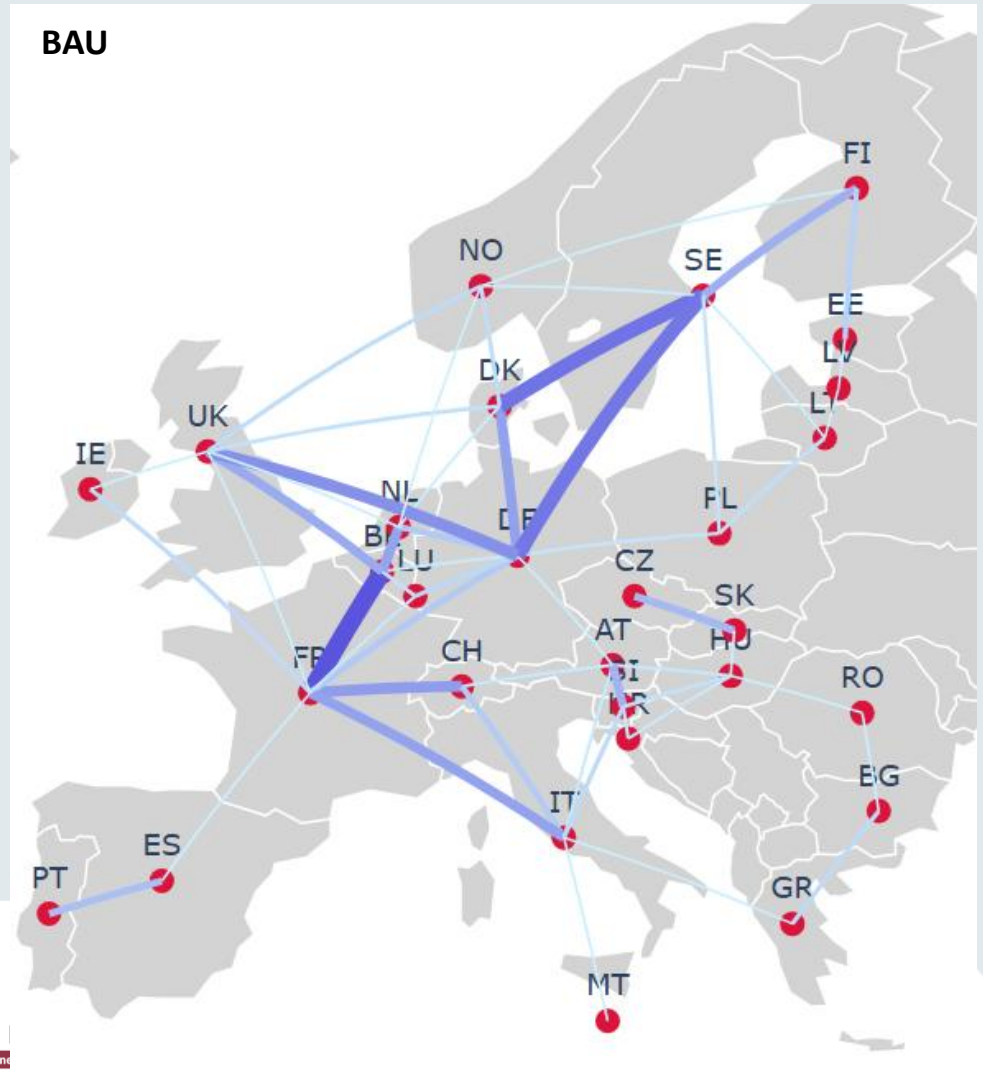
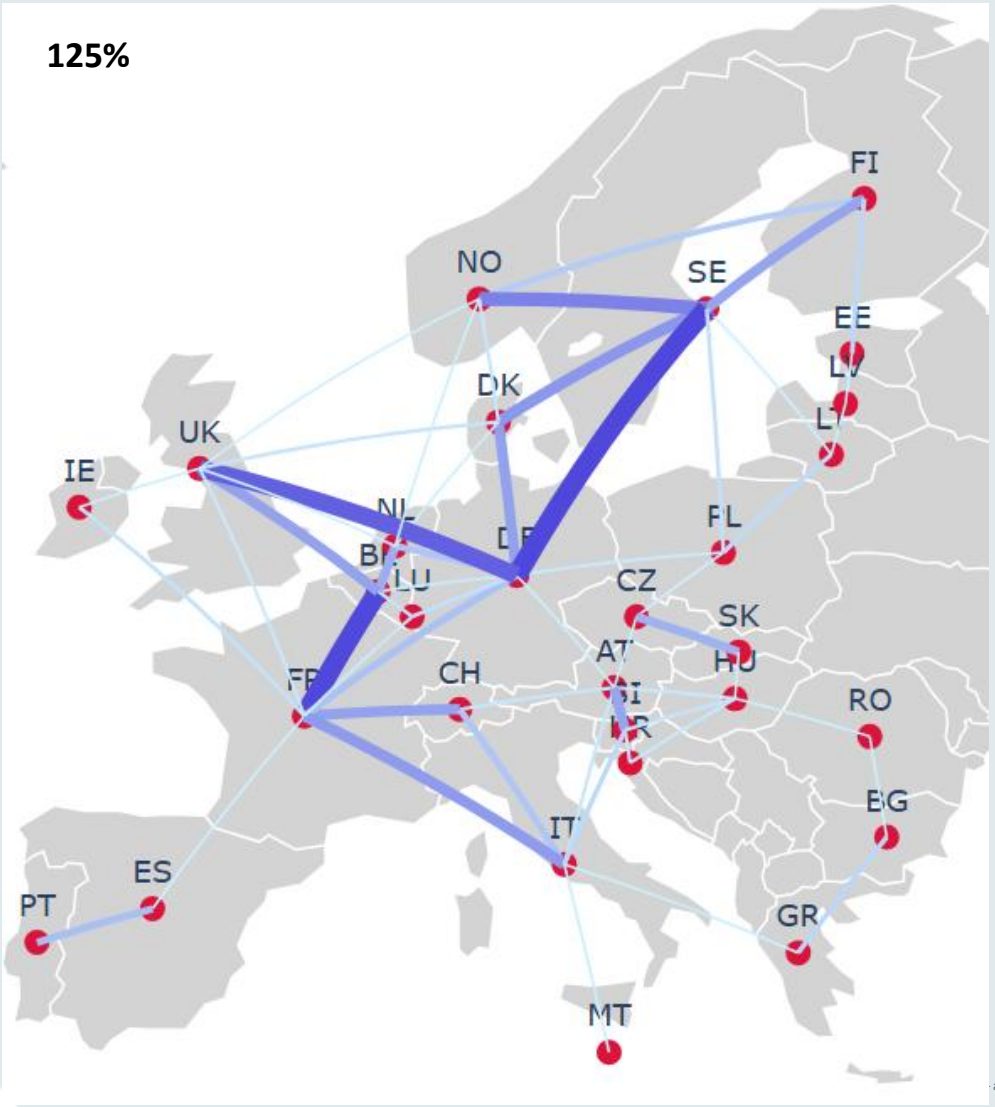
RESULTS

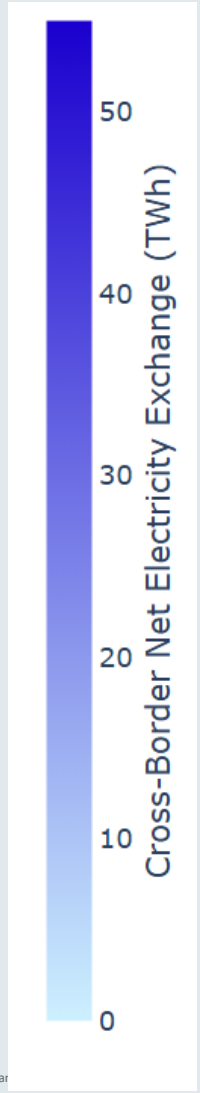
CROSS-BORDER NET ELECTRICITY EXCHANGE IN TWH – 2040

BAU



125%





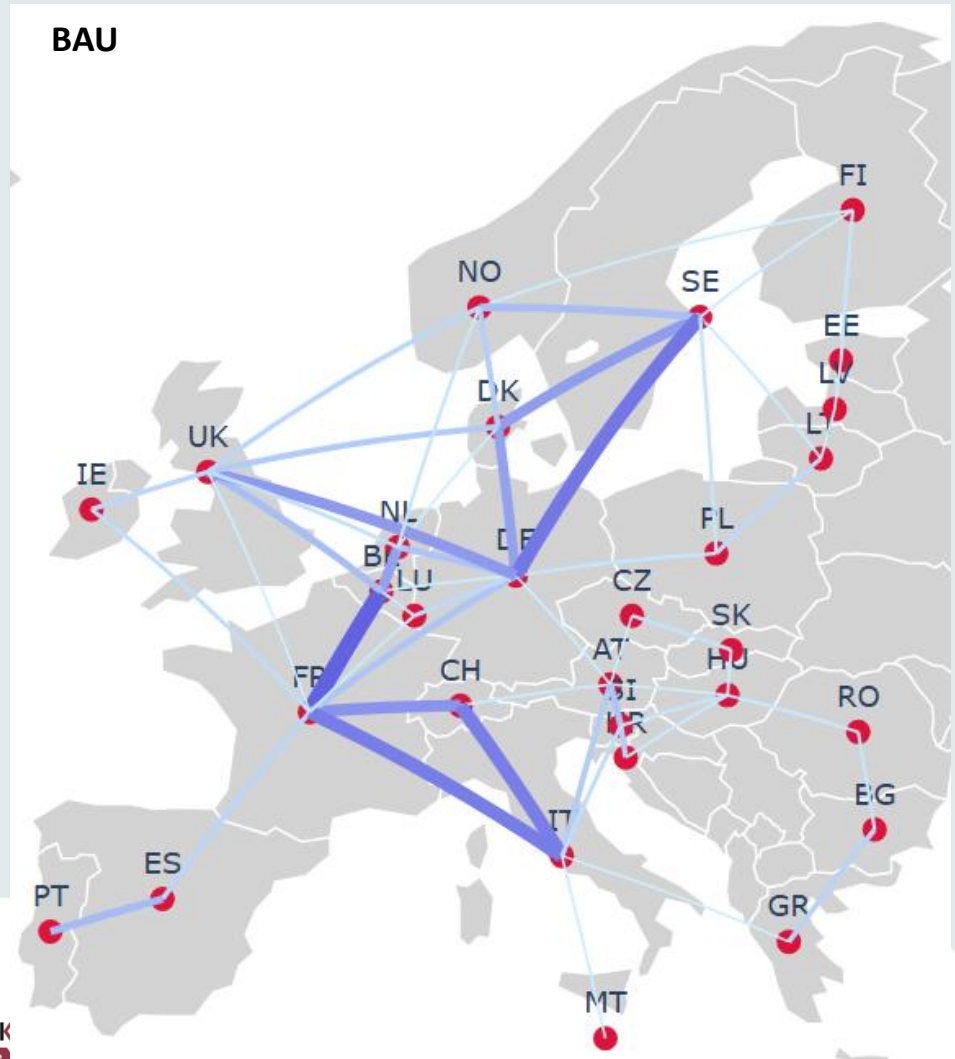
RESULTS

CROSS-BORDER NET ELECTRICITY EXCHANGE IN TWH – 2050

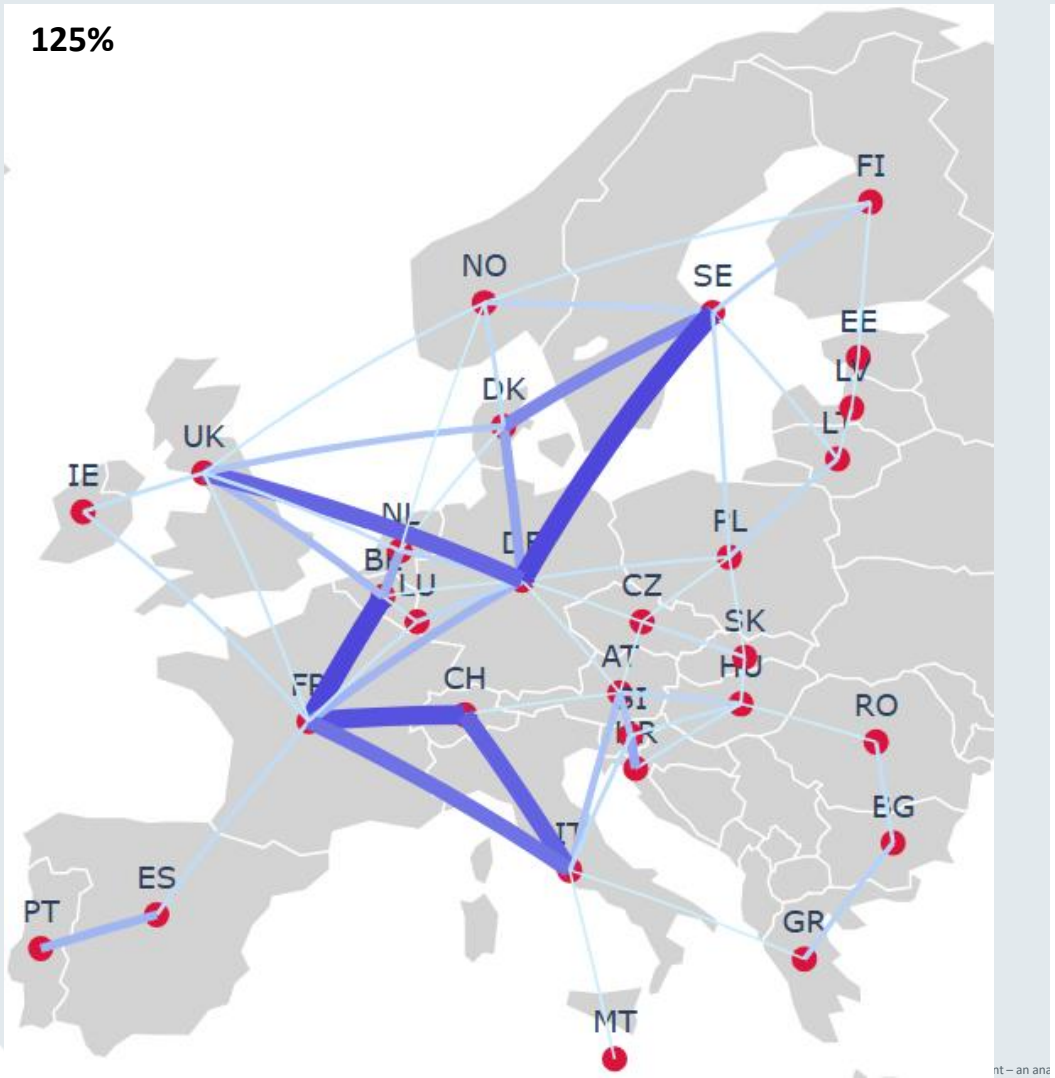
Capacity change: 25% ↑

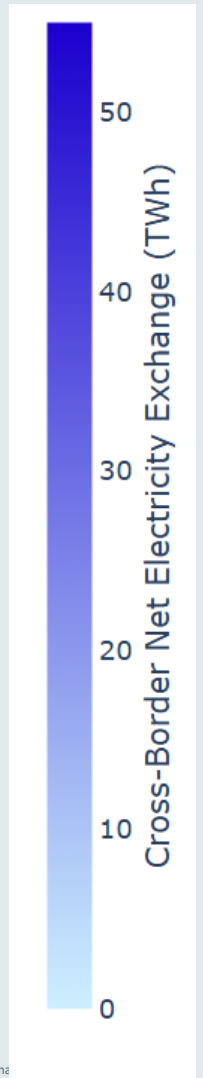
Investment cost: 25% ↑

BAU



125%





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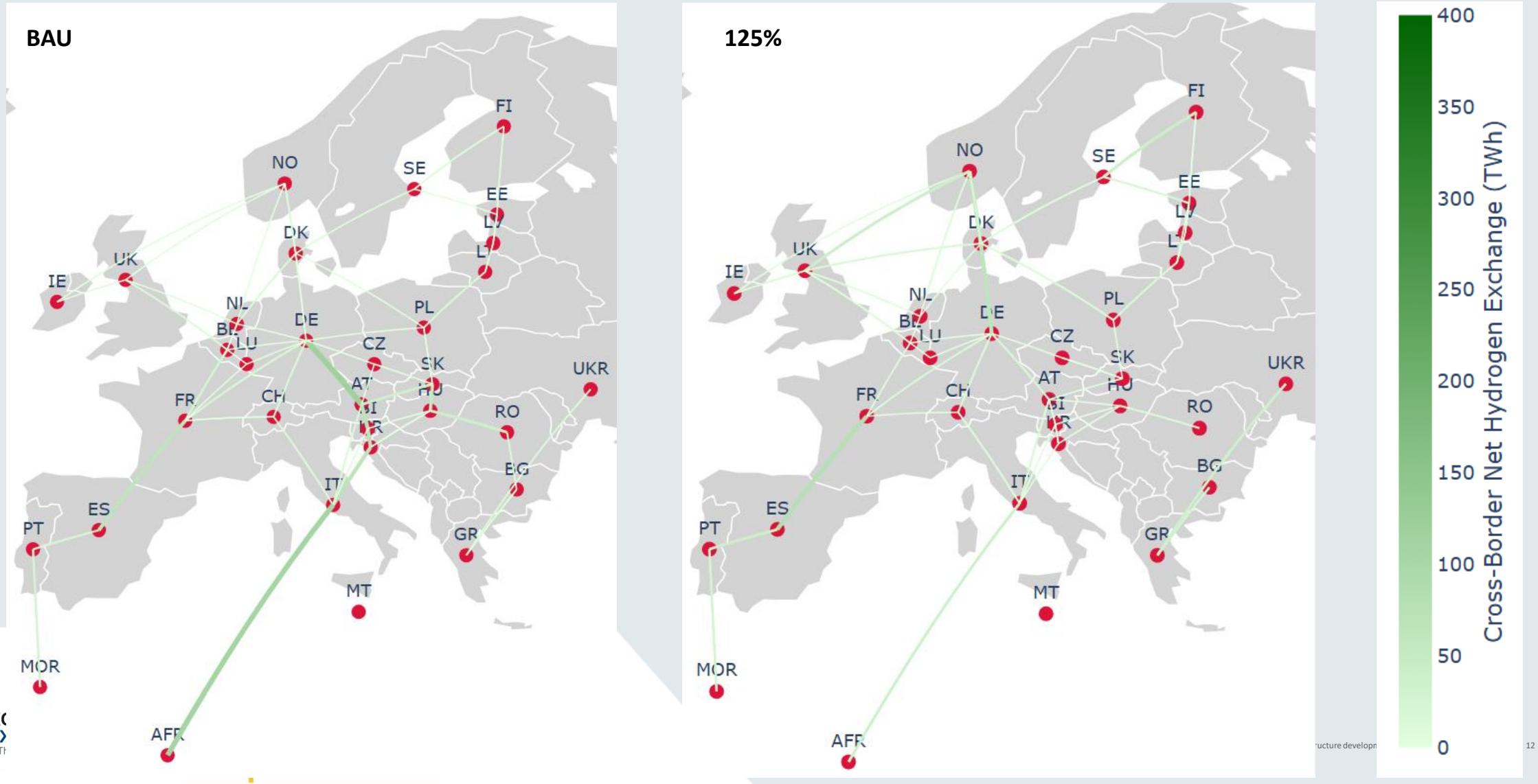
RESULTS

CROSS-BORDER NET HYDROGEN EXCHANGE IN TWH – 2040



RESULTS

CROSS-BORDER NET HYDROGEN EXCHANGE IN TWH – 2050

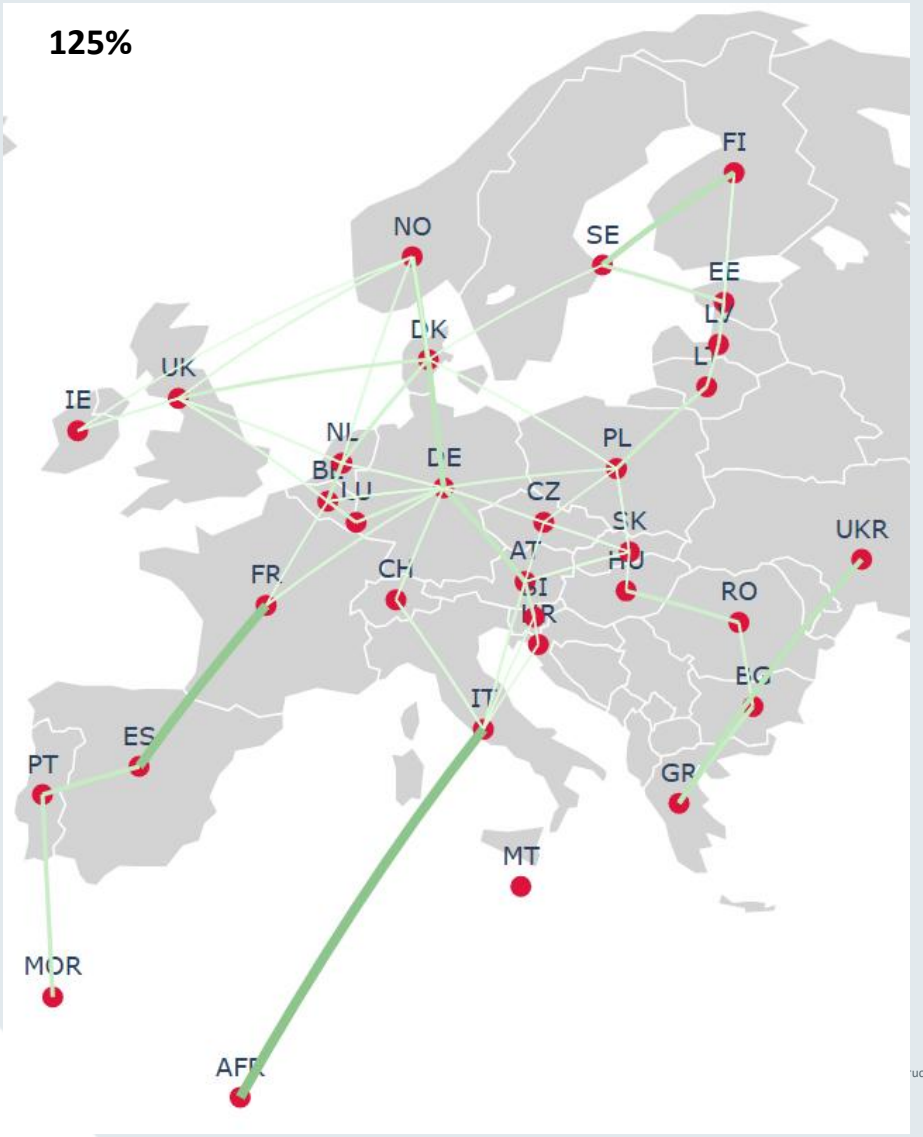
Capacity change: 38% ↓

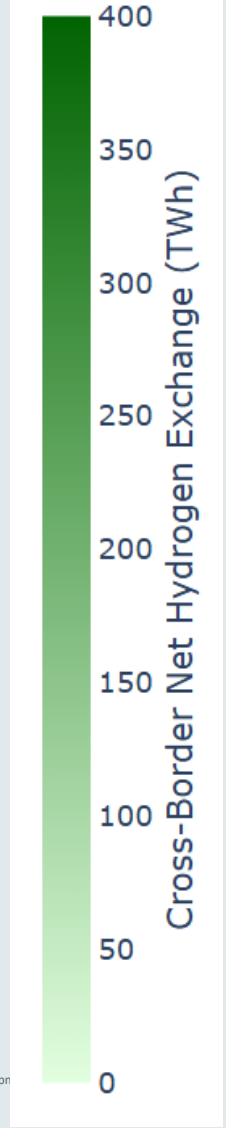
Import from outside EU: 44% ↓

Investment cost: 44% ↓

BAU

125%

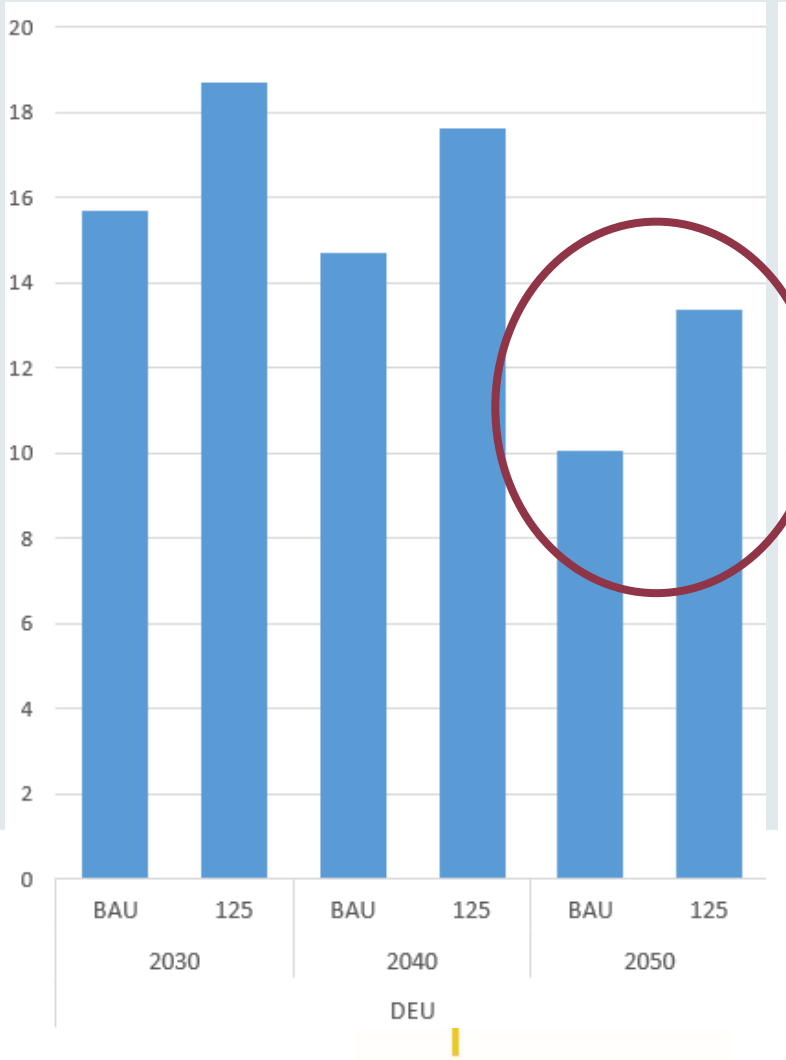




RESULTS
GERMANY AS AN EXAMPLE

Germany as net-importer

Share of Electricity Import to Consumption [%]



Electricity Capacity [GW]

Increase in electricity import

→ Less renewable capacity required

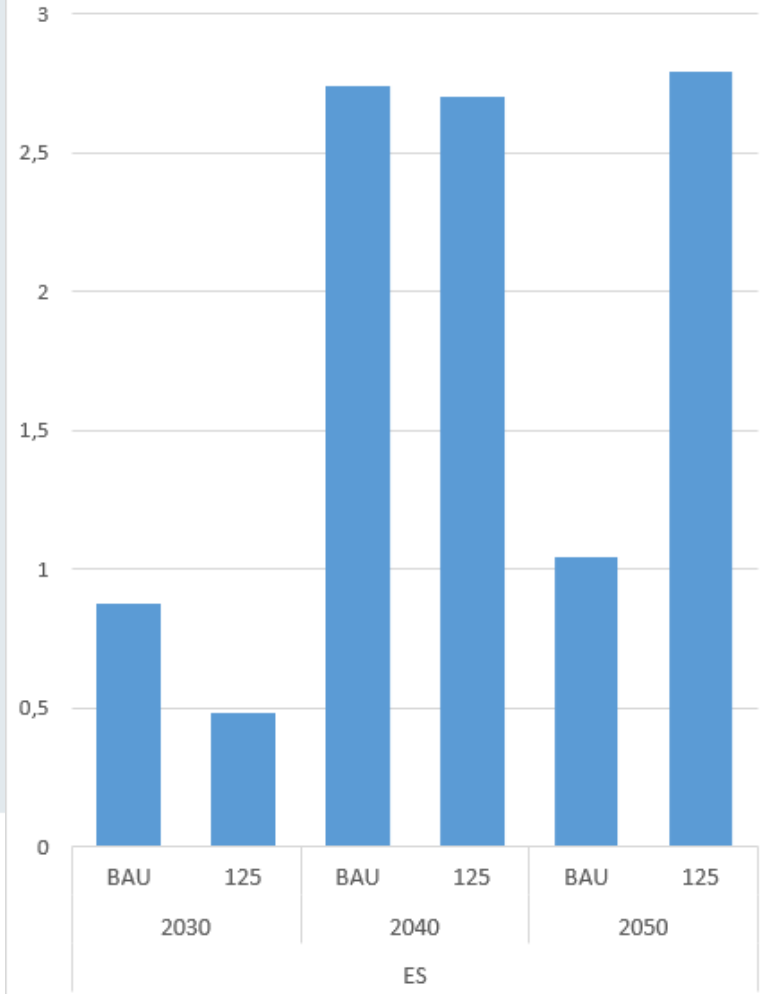
Total system costs:

- **Investment cost: 0.51% ↓**
- **Activity cost: 2.13% ↑**
- **Fixed O&M cost: 0.68% ↓**

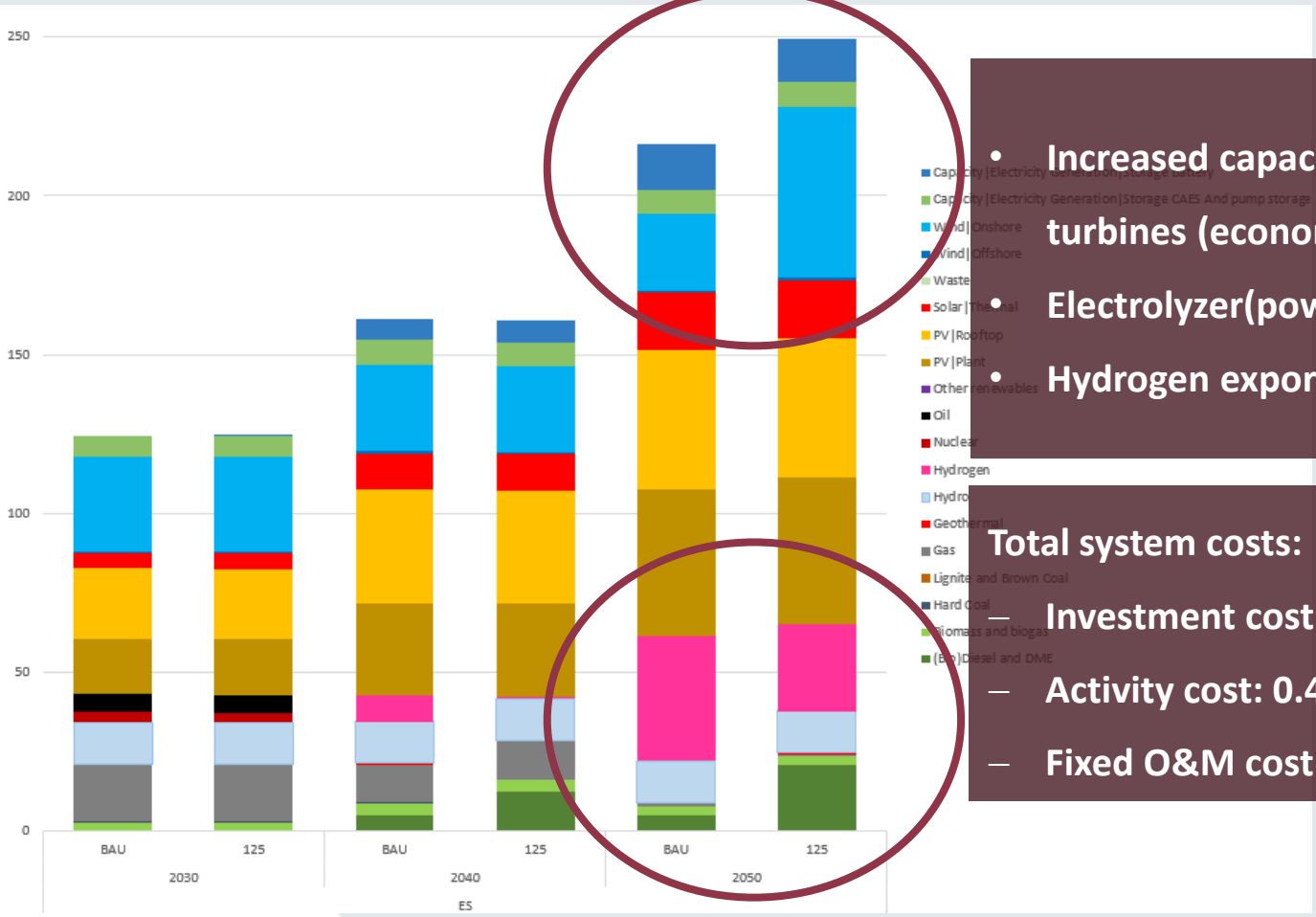
RESULTS
SPAIN AS AN EXAMPLE

Spain as hydrogen exporter

Share of Electricity Import to Consumption [%]



Electricity Capacity [GW]



- Increased capacity built-up of wind turbines (economically favorable)
- Electrolyzer(power-to-H2) usage
- Hydrogen export

Total system costs:

- Investment cost: 1.53% ↑
- Activity cost: 0.45% ↑
- Fixed O&M cost: 1.22% ↑

CONCLUSION
KEY TAKEAWAY MESSAGES

A systemic planning approach that attempts to take all aspects into account can contribute to an economically optimal solution.

The achievement of a interconnection target can be a key enabler of the EU's 2050 climate-neutrality objective, as it supports the efficient integration of renewable energy resources and storages across Member States.

The development of energy infrastructures requires the harmonization between national and EU-level development plans. Infrastructure projects need to accelerate the implementation phase.

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