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Ten-Year Network Development Plan 2020

2020 PCI Process Brief

Power System Needs 2030 **Baltic Energy Market Interconnection Plan**

Where would investing in infrastructure until 2030 deliver the most benefits to Europeans?

The present document presents a selected set of results of ENTSO-E's System needs study for the BEMIP corridor and shows where and to what extent investing would contribute to market integration, improved security of supply and increased sustainability.

This document presents 3 hypothetical states of the electricity transmission network in the year 2030, in the National Trends scenario based on National Energy and Climate Plans:

- **No investment after 2020:** a hypothetical year 2030 where Europe stopped all grid development after mid-2020.
- **SEW-based needs 2030:** a hypothetical year 2030 where the needs for capacity increases after 2025 identified by ENTSO-E's System Needs study have been addressed (Figure 1). These needs represent the combination of cross-border capacity increases that minimises overall system cost. Only part of these needs are addressed by projects of the TYNDP 2020 portfolio.
- **Portfolio 2030:** a hypothetical year 2030 where all projects of the TYNDP 2020 portfolio that are foreseen to commission until 2030 have been built (Figure 2).

For full details on the pan-European system needs identified in 2030 and 2040

tyndp.entsoe.eu/system-needs

For a detailed analysis of the situation in specific countries, refer to the Country Needs Factsheets

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Key messages of the BEMIP PCI Corridor:

1. Climate goals and requirement for decarbonization lead to fundamental change of generation and energy demand, which triggers changed power flows across the region and drives the development of a proper electricity grid infrastructure. The dominant power flow direction will go from North to South.

2. Rapid expansion of both onshore and offshore renewables and decommissioning of nuclear generation in Germany until 2022, and potentially in Sweden by 2040, and the German coal phase-out until 2038, to meet European decarbonization goals triggers related offshore- and onshore infrastructure needs.

3. Flexibility is challenged, however Smart Sector Integration will be part of the solutions in the BEMIP PCI Corridor. Hydro resources could be made better use of as flexibility sources.

4. The above trends require new interconnectors, some of them are already under construction (NO-DE, SE-FI …) and will help market integration, security of supply and integration of renewable energy sources.

5. Baltic countries will be synchronized with Continental Europe by 2025, but security of supply will need to be further enhanced.

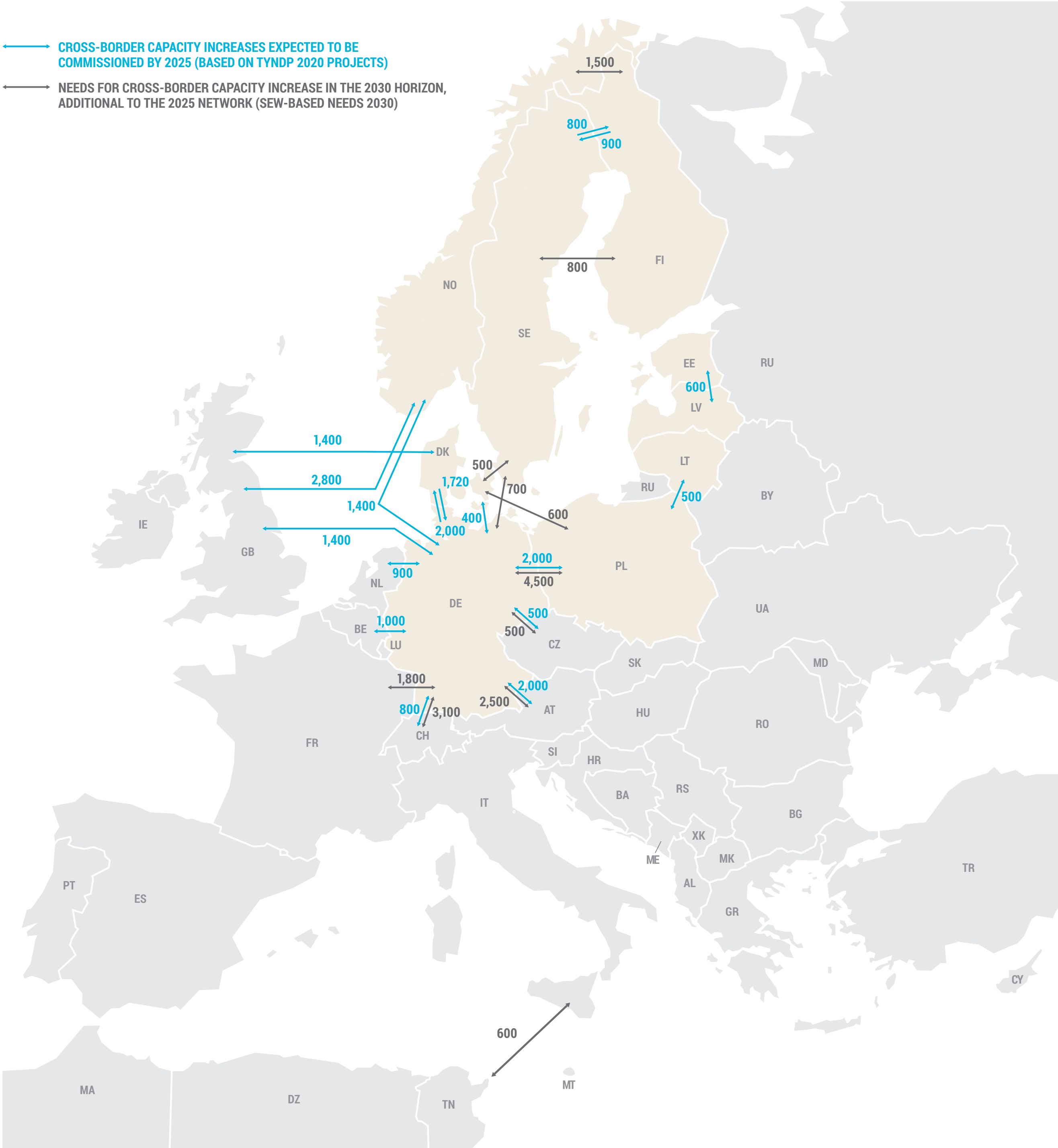

Figure 1 – Needs identified in ENTSO-E's System Needs study for the 2030 horizon. The study investigated the combination of potential increases in cross-border network capacity that minimizes the total system costs. These capacity increases are additional to the 2025 network (composed of projects under construction or in advanced stage and expected to be in service in 2025).

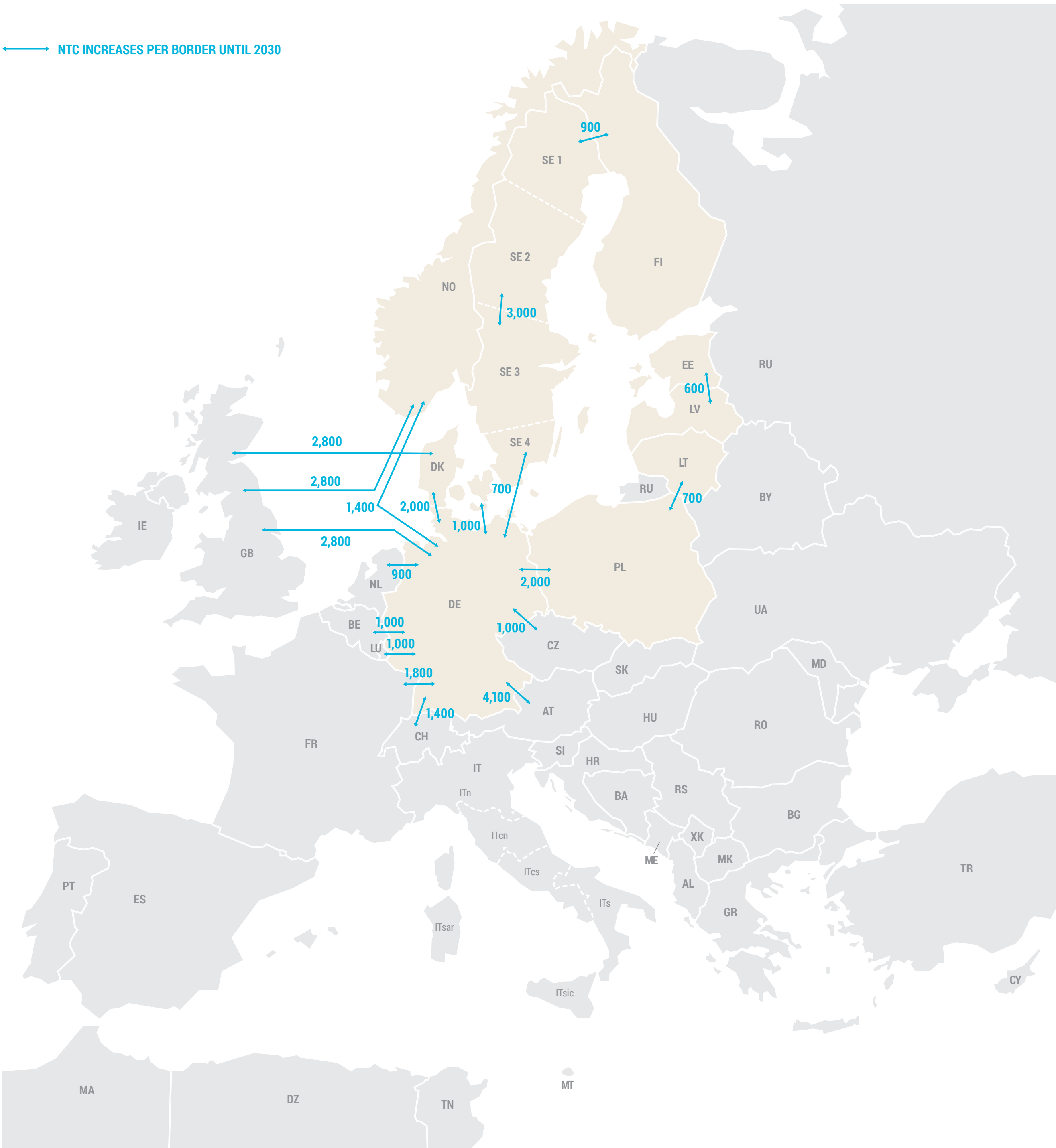

Figure 2 – Sum of NTC increases of projects proposed in the TYNDP 2020 and for which project promoters expect a commissioning date in 2030 or earlier (including projects expected to be in service in 2025). Where the NTC increase is not the same in both directions, only the highest value is included in the map. Some borders have projects competing with each other to address the same need.

Market Integration

Increasing capacity for cross-border electricity flows supports market integration, with price convergence increasing between bidding zones. Increased cross-border exchanges and distributed generation will also create stresses for national grids and trigger needs for internal reinforcements.

Convergence in marginal costs of electricity

By connecting more consumers with more producers, grid development allows a better use of the cheapest generation. As a result, European countries can exchange electricity to replace expensive generation with cheaper one and prices all over Europe tend to converge. On the opposite, limiting exchange capacity alters market integration and would result in splits between regional market prices. Fragmented markets therefore lead to artificially high marginal costs in some countries, with direct impact on consumers' electricity bills. According to the methodology developed by the Interconnection Target Expert Group, need for additional interconnections should be investigated on all borders with a spread above 2 €/MWh.

Increased cross-border transmission capacity in the SEW-based needs and Portfolio 2030 cases tends to reduce the differences in marginal costs in between neighboring bidding zones. This is visible in Figure 3, where the spread in marginal cost is significantly reduced compared to the situation where Europe would stop all investments.

Europe increases its socio-economic welfare by **4.8 billion** euro/year in the SEW based needs case, and by **3.6 billion** euro/year in the Portfolio 2030 case, compared to the "No investment after 2020" case.

In marine areas, the reduction in price difference is limited in the SEW-based needs case, because identified needs included few offshore links due to the methodology employed. In the Portfolio 2030 case, five offshore interconnectors in the Baltic Sea are proposed with commissioning years between 2020 and 2030.

Difference in marginal cost of electricity between neighbouring bidding zones, in €/MWh

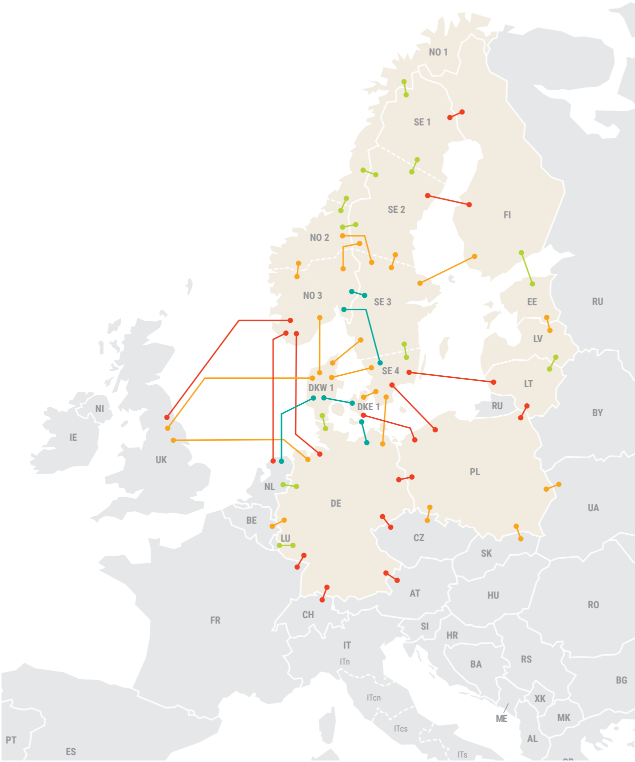

Figure 3a – No investment after 2020

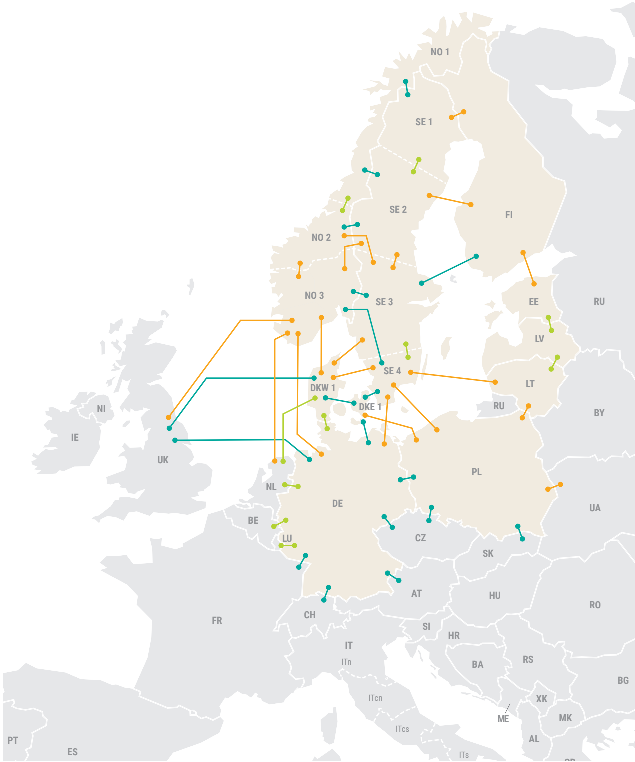

Figure 3b – SEW-based needs 2030

< 2.00 € / MWh
2.00 – 5.00 € / MWh
5.00 – 10.00 € / MWh
> 10.00 € / MWh

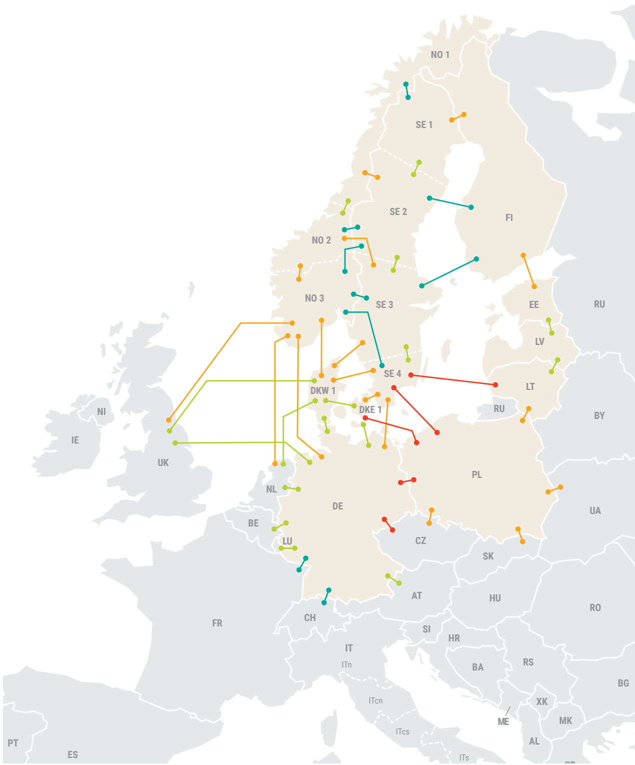

Figure 3c – Portfolio 2030

Because of the trend highlighted above, countries with high marginal costs tend to see these costs decrease and countries with low marginal costs tend to see an increase (Figure 4).

The net annual balance shows that, for most countries, reinforcing the cross-border grid will reinforce the existing tendency to import or export (Figure 5). For Germany, the switch from importer to exporter is due to the possibility to export additional RES in 2030.

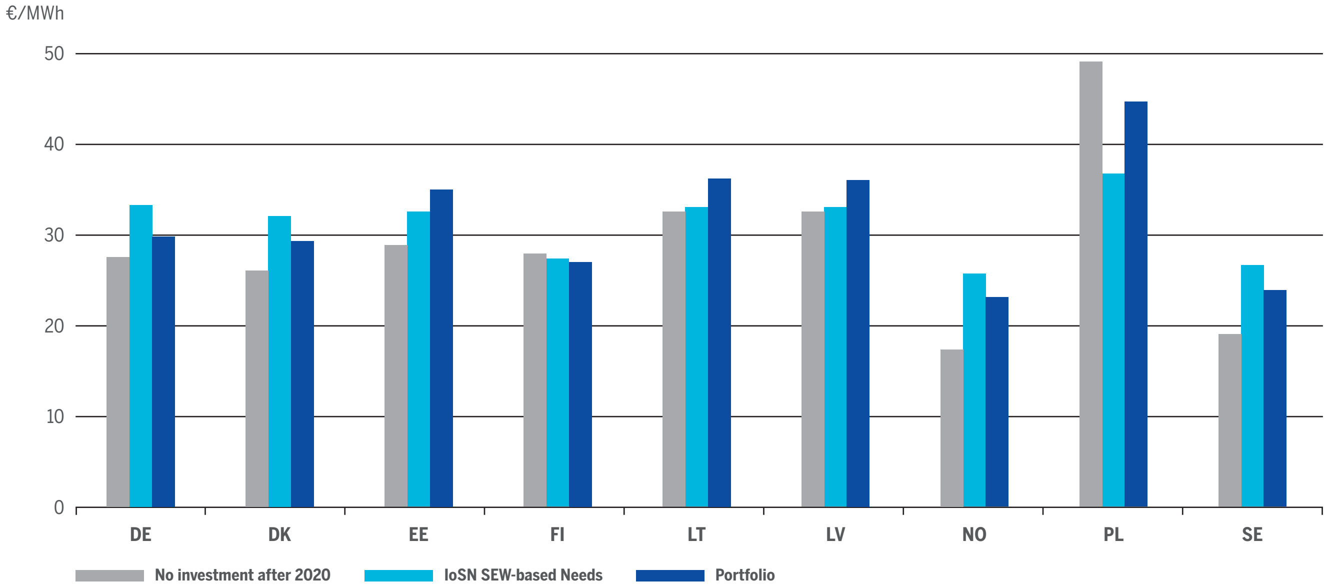

Figure 4 – Average marginal cost per country, in euro/MWh

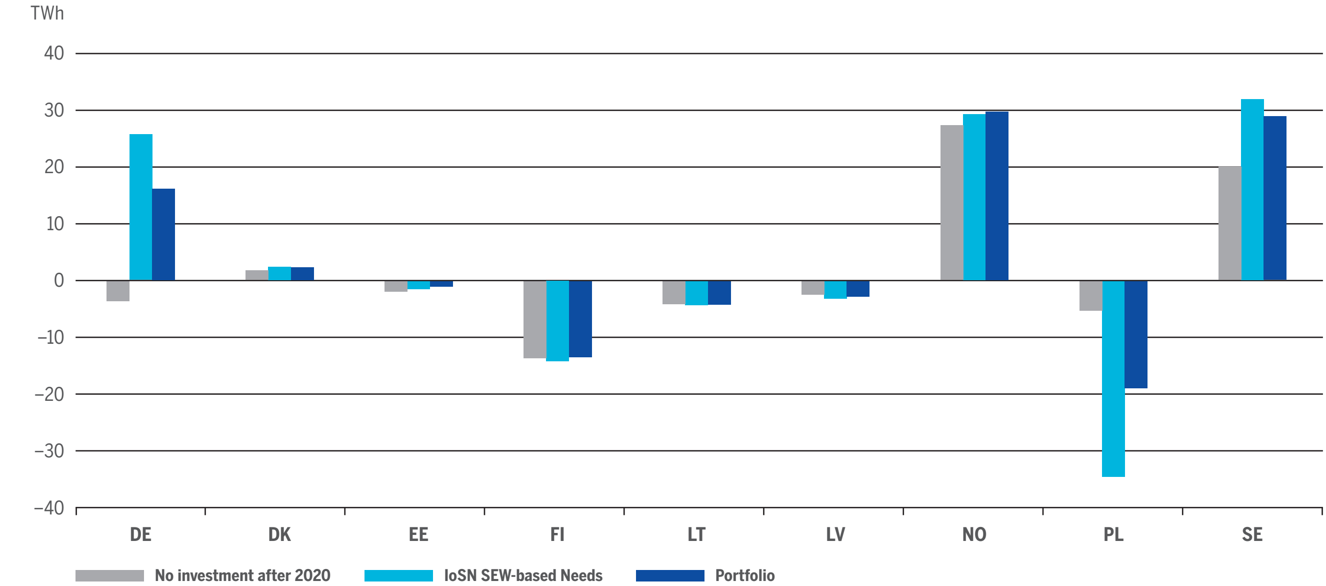

Figure 5 – Net annual balance in TWh

Reduced congestions on borders

Constraint duration refers to the percentage of hours per year where the cross-border flow of energy reaches 100 % of the commercial capacity on the border, meaning it is congested. Reinforcing cross-border capacities reduces congestion and allow European countries to exchange more energy, in total in the BEMIP Corridor an additional 13 TWh/year would be exchanged in 2030 (in SEW-based needs), relative to the situation where Europe would not invest in the grid after 2020.

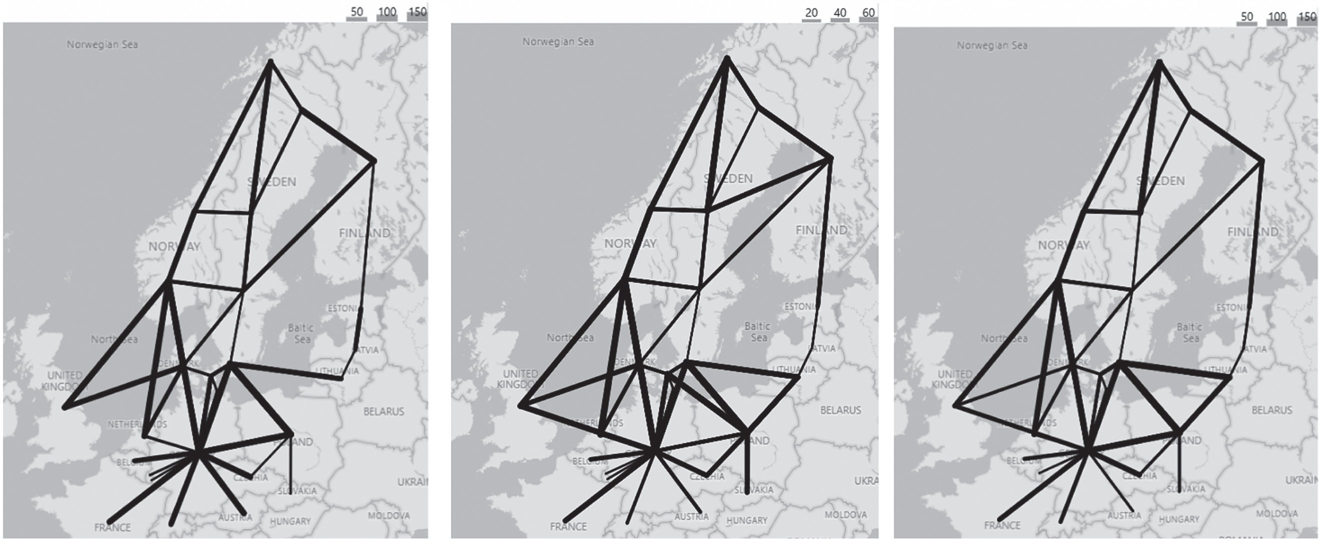

Figure 6 – Percentage of hours per year where the flow of electricity reaches 100 % of the Net Transfer Capacity on the border (constraint duration), in No investment after 2020 (left), SEW-based needs (middle) and Portfolio 2030 (right)

For the exact values of constraint duration

tyndp.entsoe.eu/system-needs

Unlocking 2030 barriers

ENTSO-E has identified in the European power system a set of main boundaries (Figure 7). Figure 8 represents the overall diminution of wholesale market volume (gains in socio-economic welfare) when the total transmission capacity across the boundary increases from the current situation (first point of the curve). Steep curves indicate high needs for further integration of the markets across the boundaries. A boundary is defined as a major barrier preventing optimal power exchanges between countries or market nodes which, if no action is undertaken, leads to high price differences between countries, RES spillage and risk to security of supply. The changes to the generation portfolio – a significant RES increase driving higher power flows across the region – are the main drivers of these boundaries. Using a methodology established within the framework of the interconnection targets 2030, the consequences of not resolving the issues at these boundaries are highlighted. High price differences are also an issue at boundaries, and these are also discussed.

Three major European boundaries were identified in the TYNDP 2016 and 2018 in the BEMIP region, highlighted in Figure 7. These boundaries are: — Nordics to Continental West Europe — Nordics/Baltic to Continental West Europe and — Baltic integration. Analysis shows that these boundaries are still valid in TYNDP 2020. In addition to these three main boundaries, there exist a number of regionally important boundaries related to the long-term needs. One of the most important one is in the north-south direction of Germany. This is however only covered in the German Grid Development Plan.

The boundary Baltic integration is also important regarding to the synchronisation of the Baltic States' electricity networks with the continental European network.

Figure 8 demonstrates that the three major boundaries of BEMIP all show rather high potential for positive benefits regarding increased capacity. The figure only shows benefits regarding market-integration (SEW). In addition, projects of the region in general show positive values regarding decreased CO_2-emissions, increased RES-generation and increased security of supply.

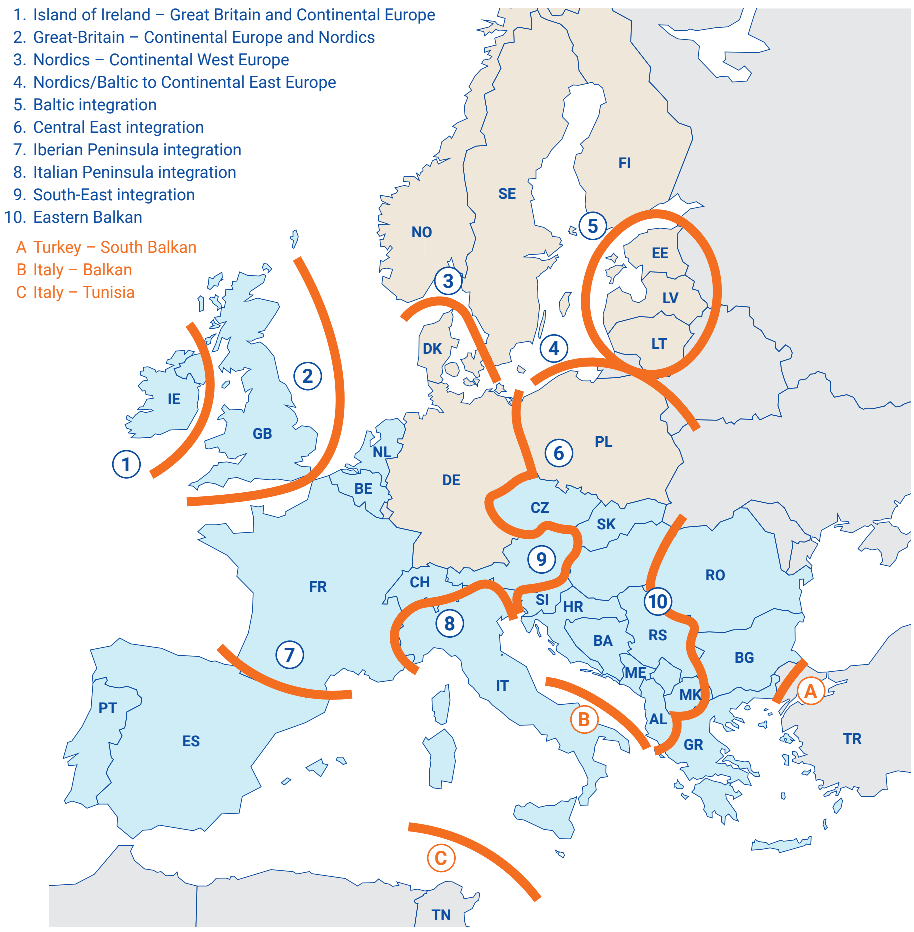

Figure 7 – TYNDP 2020 10 main boundaries

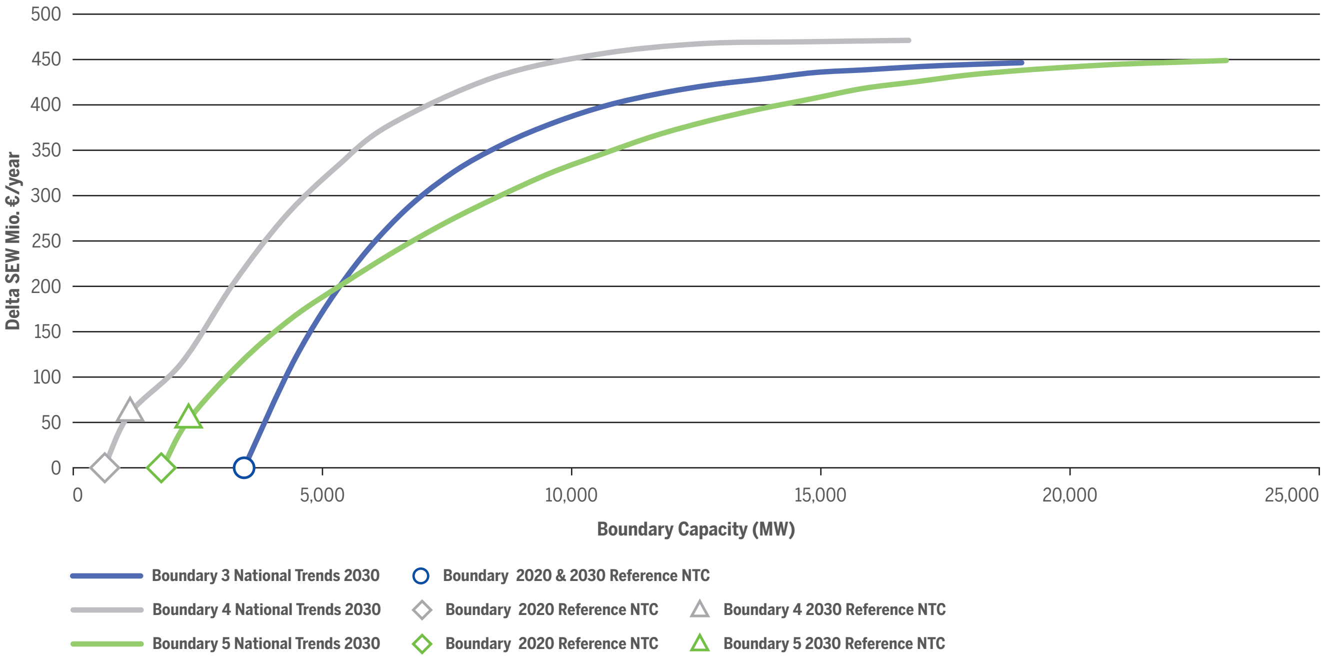

Figure 8 – Increase in socio-economic welfare (SEW) when the transmission capacity increases from the current situation, on main boundaries located in the BEMIP PCI Corridor, in the NT2030 scenario

Sustainability

Investing in electricity transmission infrastructure will be key to enable Europe to achieve the the Green Deal and the Paris Agreement. By allowing electricity from RES to be exported across borders, addressing system needs allows Europe to save 47 TWh of curtailed energy and avoid over 41 Mtons of CO_2 emissions each year until 2030 (compared to a future where Europe would stop investing in the grid after 2020).

A drop in curtailed energy

Increasing the exchange capacity in Europe helps the integration of renewable energy by offering more opportunities to RES power plants to be used. By taking advantage of the different energy mix over Europe and the different RES peaking period between countries, the SEW-based needs and the TYNDP portfolio decrease significantly the curtailed energy.

To ease comparison between countries, curtailed energy is presented both in absolute value (in TWh per year) (Figure 9) and as a share of RES generation (Figure 10).

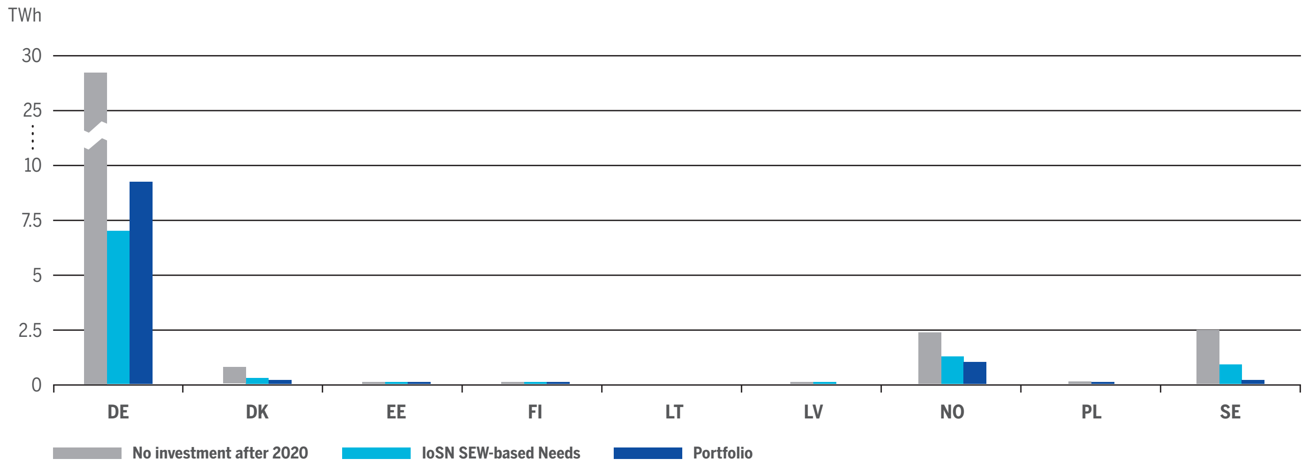

Figure 9 – Curtailed energy per country in TWh

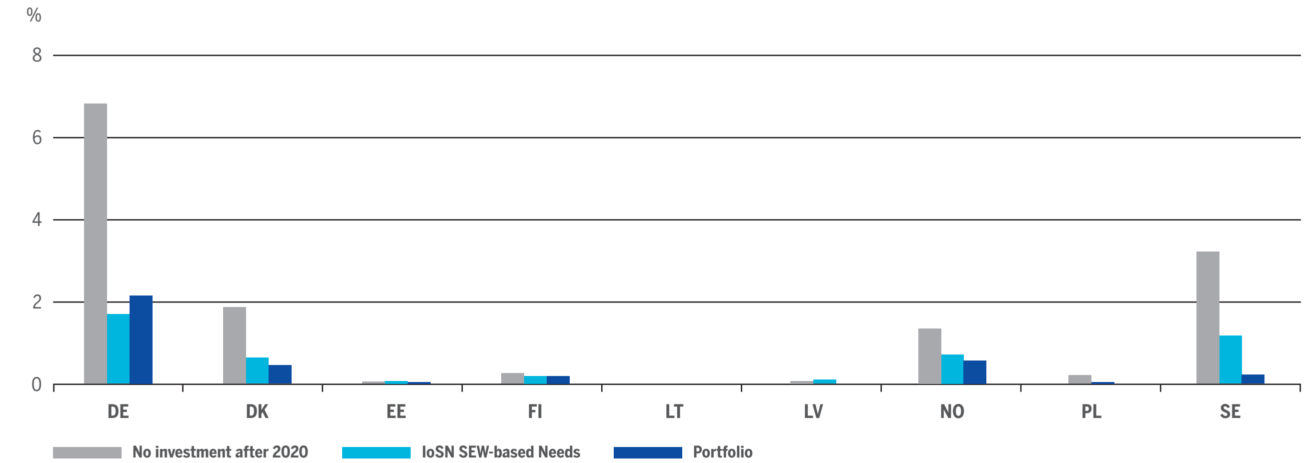

Figure 10 – Curtailed energy per country as a share of RES generation

In addition to RES, some thermal power plants emit very low CO_2 volume while generating electricity. This is the case of nuclear and biofuel power plants. New exchange capacities can increase the use of these generation when they are not used at full load. Indeed, these generation capacities have in general a low marginal cost and can replace other more expensive and CO_2 emitting thermal power plants in other countries. Figure 11 and 12 show the remaining energy available from nuclear and biofuel power plants in different grid configurations.

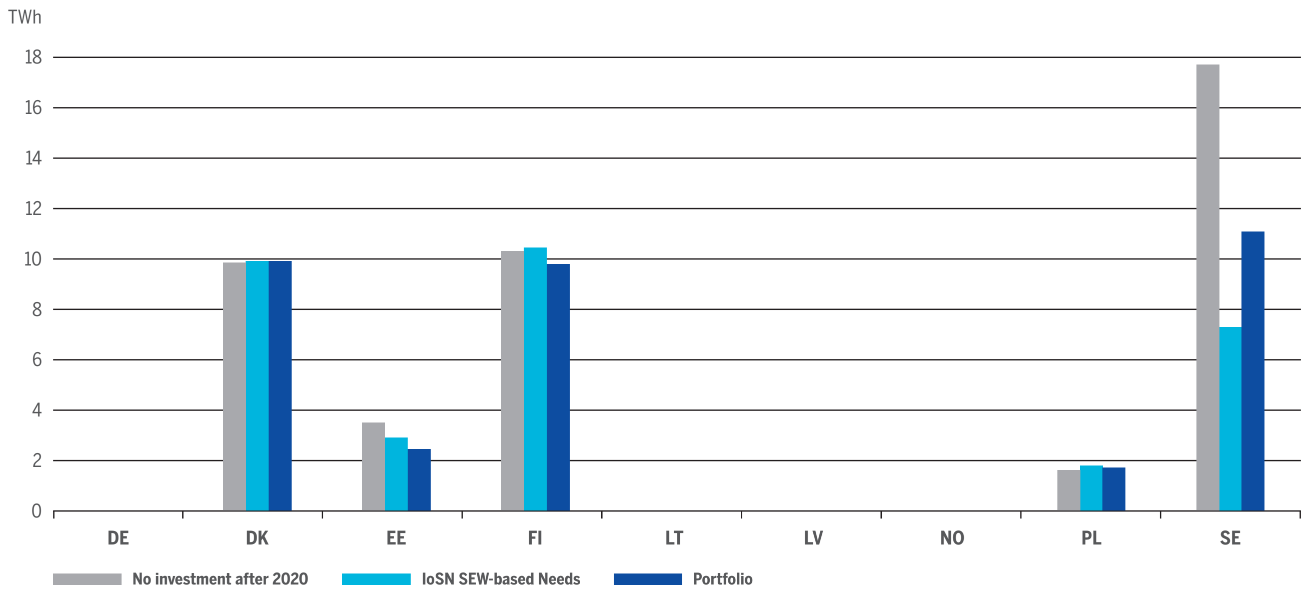

Figure 11 – CO_2 free dispatchable available energy from nuclear and green gas generation, in TWh

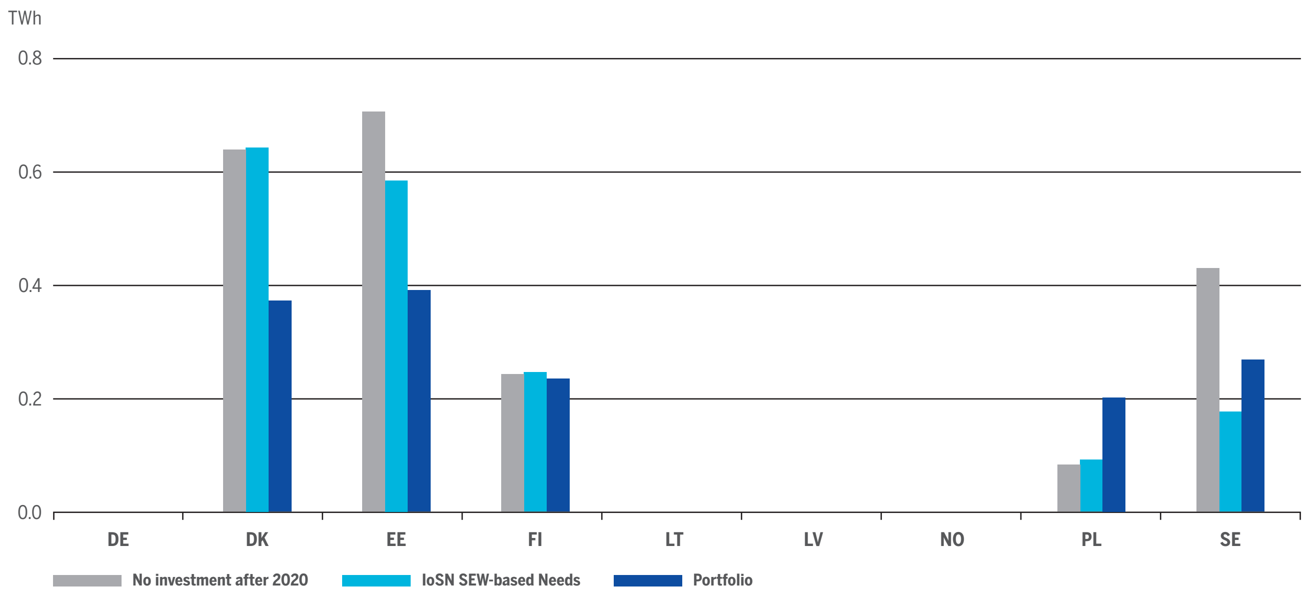

Figure 12 – CO_2-free dispatchable available energy from nuclear and green gas generation as a share of the total CO_2-free dispatchable generation

Reduced CO_2 emissions

By allowing a better integration of non-CO_2 emitting generation, increased cross-border network capacity leads to a reduction of CO_2 emissions, of 41 Mton per year in 2030 in the SEW-based needs case compared to the case without grid expansion after mid-2020. This highlights the important role of the network in the path toward carbon neutrality.

The methodology used to identify the SEW-based needs take CO_2 emissions into account in socio-economic welfare only partially, via the ETS CO_2 price which producers have to pay when they emit CO_2. However, the ETS CO_2 prices of 28 EUR/ton of CO_2 in 2030 is not sufficient to properly decrease CO_2 emissions to an extent consistent with EU climate ambitions. This explains the relatively reduced impact of the SEW-based Needs.

CO_2 emissions per country are strongly affected by the assumptions made in the scenarios, view the Country factsheets for more details.

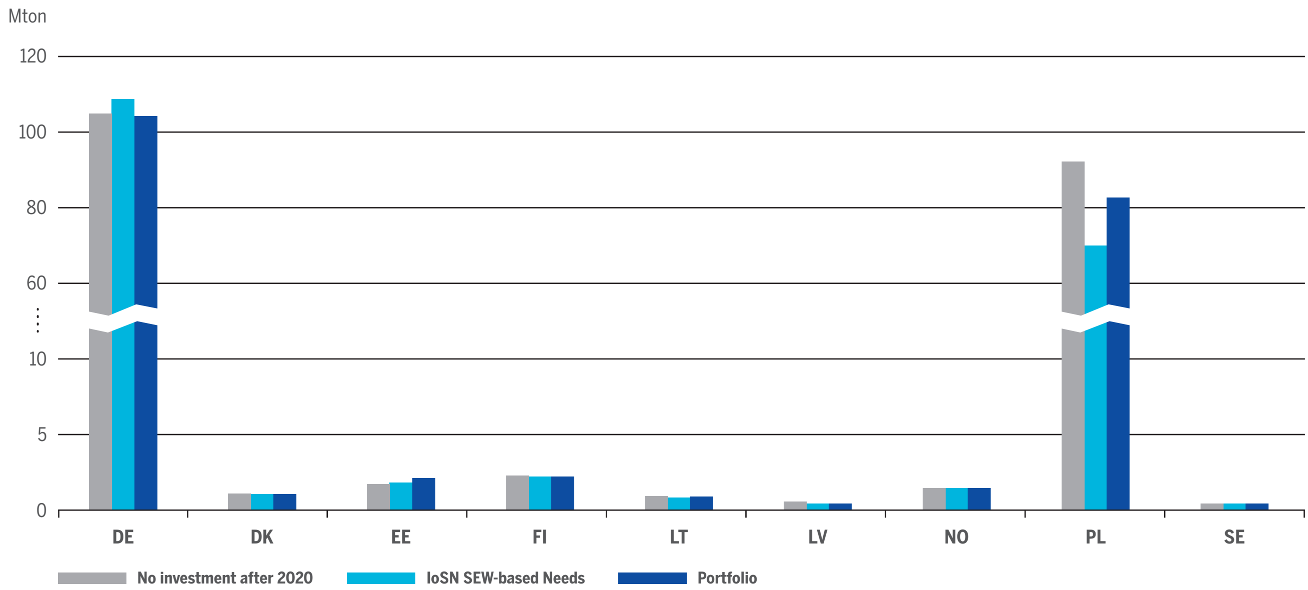

Figure 13 – CO_2 emissions in Mton/year

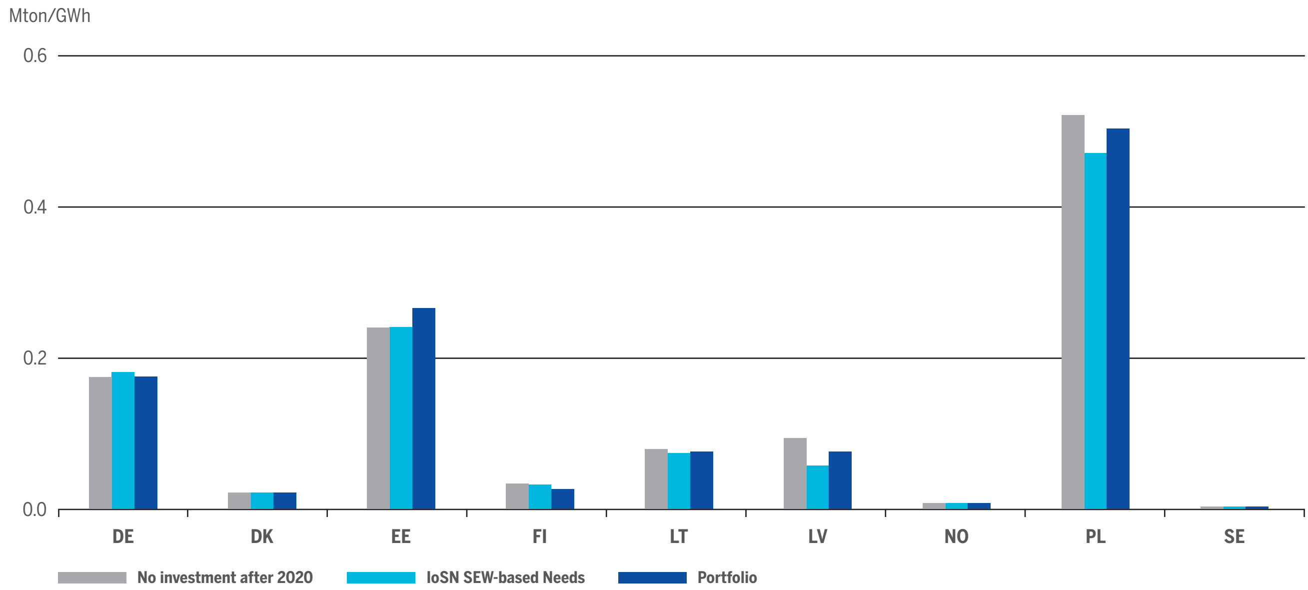

Figure 14 – Ratio of CO_2 emissions in Mton over total generation in GWh

Further interconnections may be needed in some countries to support RES development

This indicator, part of the Interconnection Target Expert Group (ITEG)'s proposed indicators to assess interconnectivity, aims to reflect the electricity supply and the export potential of each country.

The indicator is expressed through a ratio between the nominal transmission capacity of the interconnection lines (thermal capacity) and the installed RES generation. A low ratio means that the RES installed generation in a country is high compared to the thermal capacity of the interconnection lines.

Figure 15 shows this indicator in 2030 in the case where Europe would stop investing in the transmission grid after 2020 (top) and with the expected grid in 2025 (bottom).

For countries in green the ratio is above 60 %, for countries in yellow it is between 30 % and 60 % while for countries in red it is below 30 %. The recommendations from the ITEG is that a ratio below 30 % indicates a need to investigate options for additional interconnectors. Finland passes over the 30 % threshold in the 2025 grid thanks to a new interconnector with Sweden expected to enter in service in 2025.

The ITEG's proposed methodology considers 3 indicators: the spread in marginal cost between neighboring zones > 2 € (Figure 3), the ratio of the nominal transmission capacity to the installed RES generation <30 % (Figure 15) and the ratio of the nominal transmission capacity to the peak load <30 % (Figure 20). As a condition sine qua non, each new interconnector must be subject to a socioeconomic and environmental cost-benefit analysis and implemented only if the potential benefits outweigh the costs.

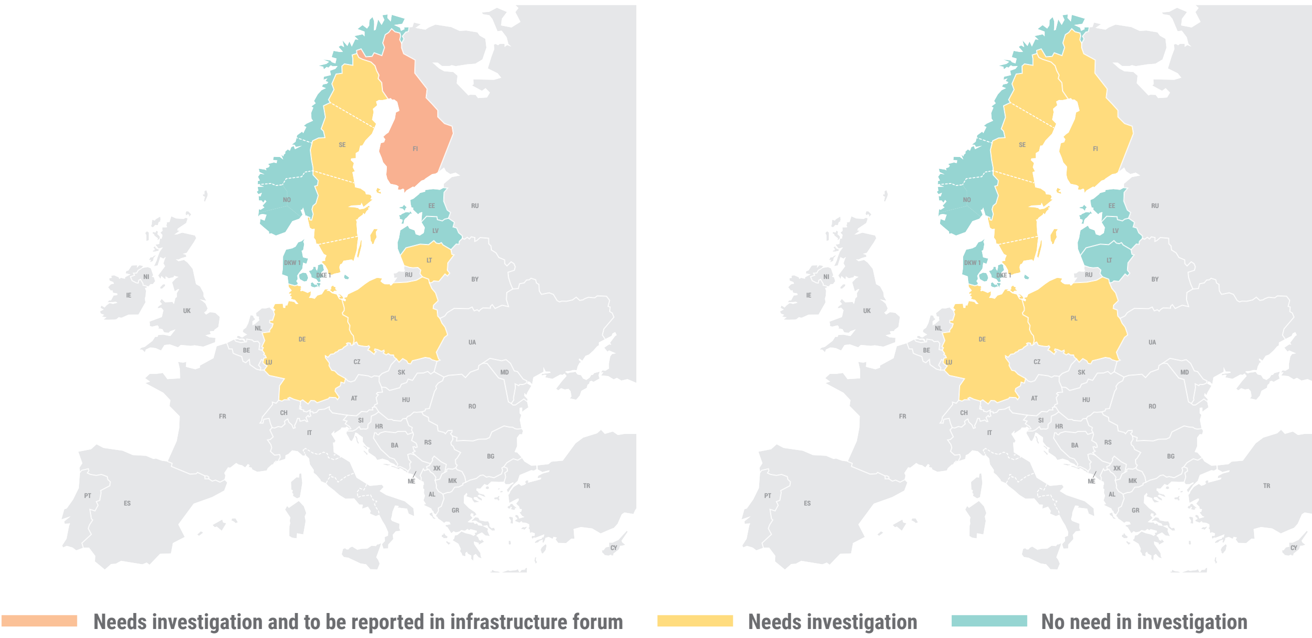

Figure 15 – Ratio of the nominal transmission capacity (thermal capacity) to the installed RES generation in 2030, in the case where Europe would stop all grid reinforcement after 2020 (right) and with the expected grid in 2025 (left)

Security of Supply

The future power system will integrate growing shares of renewable energy sources at all voltage levels, more power electronics either in generation or HVDC connections, a very variable mix of generation as well as large and highly variable power flows. This combination of trends translates into technical challenges including frequency, voltage and congestion management control which, if they are not addressed, may threaten security of supply at European level. Solutions lie partially in new infrastructure.

Increasing share of variable renewable generation

Comparing the installed variable RES generation to the installed conventional thermal generation, in 2025 and in 2030, shows the expected evolution of generation portfolios towards higher share of variable RES (wind, solar) generation.

The ratio increases in almost all countries, and the faster the evolution of this ratio, the harder it is for the power system to adapt.

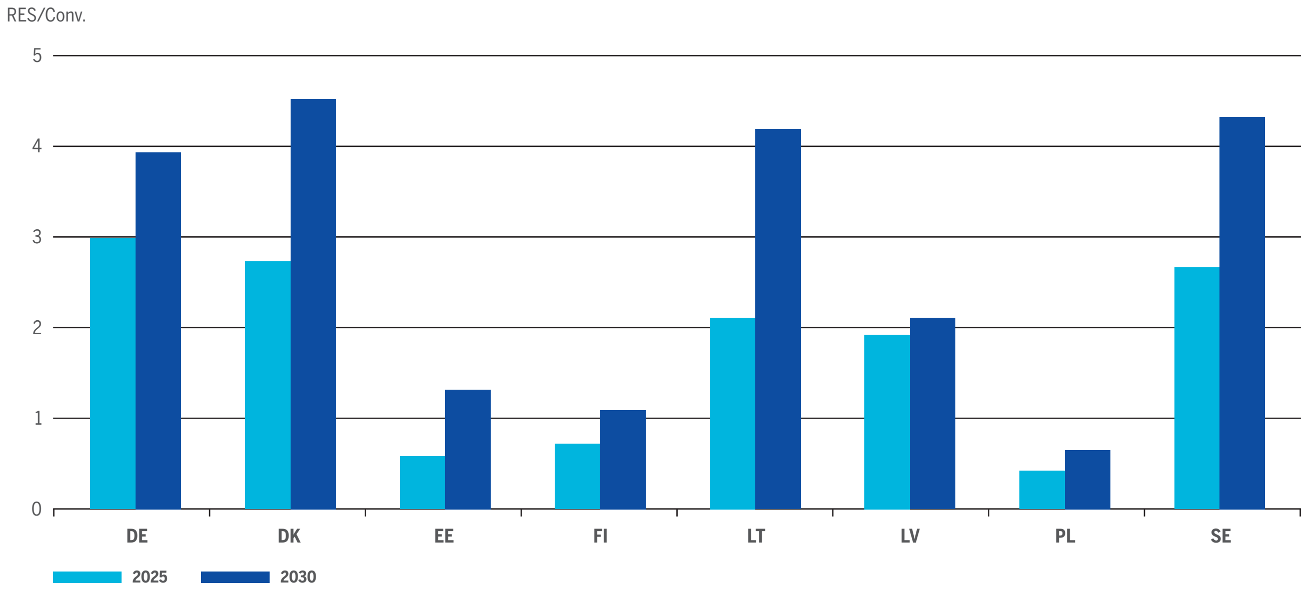

Figure 16 – Ratio of the installed RES generation capacity to the installed conventional generation capacity, in 2025 and 2030. Norway does not appear in this figure because it has very little conventional generation, which renders this indicator meaningless.

Maintaining balance between generation and demand becomes increasingly challenging

The Loss of Load Expectation (LOLE) is the expected number of hours in which the hourly load exceeds the available generating capacity and available imports. This leads to hours wherein the supply cannot be met and load will have to be curtailed.

A non-zero value of LOLE indicates only a resource inadequacy in the market. It does not indicate a risk of blackout or load shedding, because ENTSO-E only observed the day-ahead situation, while TSOs have various tools to resolve situations of scarcity within the day. Zones without circle have LOLE values of less than 0.5 h.

MAF 2019 results do not indicate significant adequacy issues in most countries. As was the case in previous MAF editions, islands are vulnerable to loss of load.

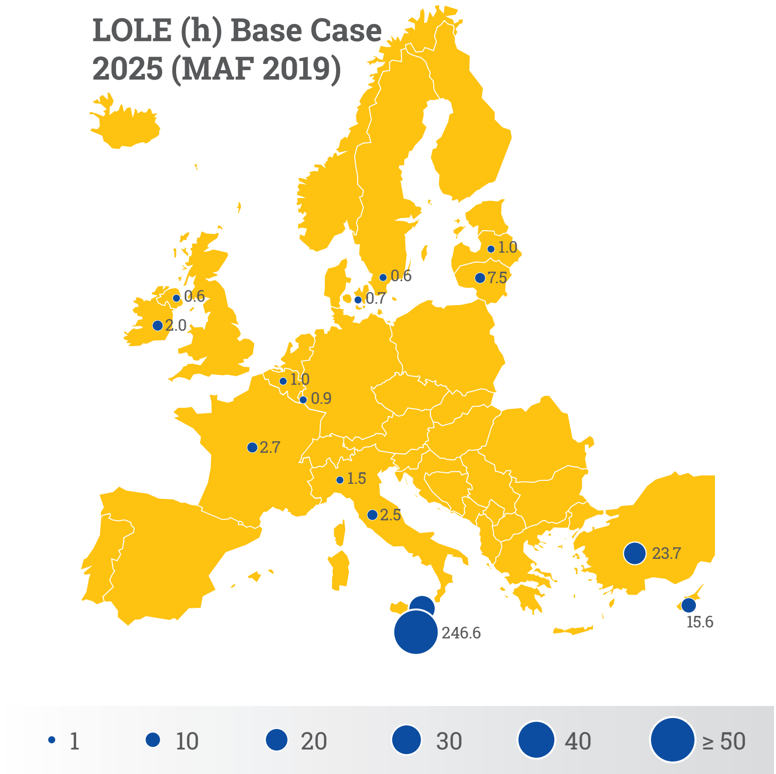

Figure 17 – Loss of Load Expectation in 2025 (Mid-Term Adequacy Forecast 2019)

Hourly residual load ramp is another parameter showing the challenges of operating a system with reduced amount of controllable units, high flexibility needs in normal operation, and a requirement to guarantee the necessary volume of frequency reserves for cases of unforeseen imbalances between active power generation and demand.

The curves show the changes of residual load (demand minus variable RES) from one hour to the following hour. These curves express the response (in MW/hour) that needs to be provided by controllable generating units in order to maintain balance between generation and demand. Steepness of the curve is most affected by the share of RES in the generation mix and by the load, for example Germany's curve is notably different from that of other countries because it has the highest RES and highest demand of all European countries.

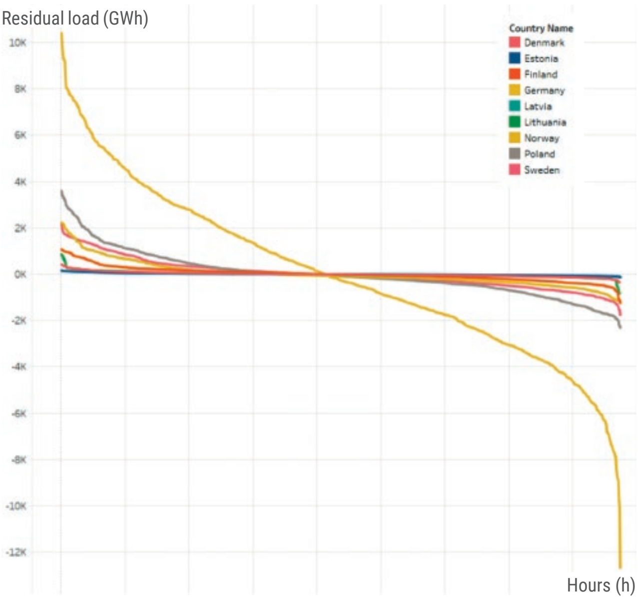

Figure 18 – Hourly residual load ramp of BEMIP countries, in scenario National Trends 2025

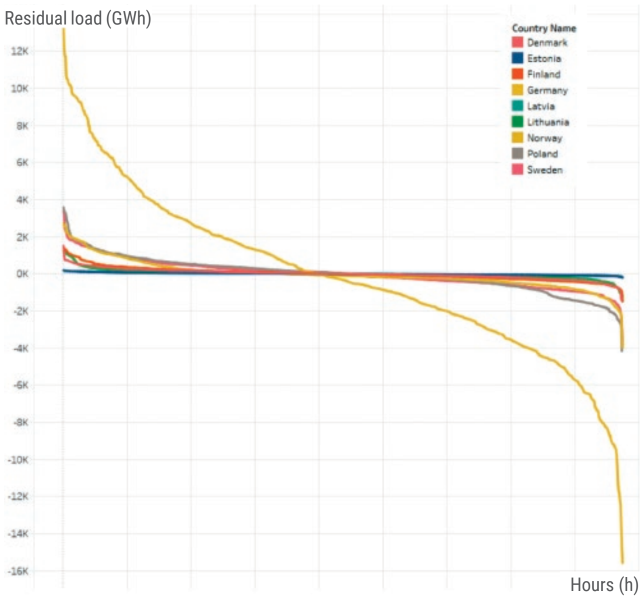

Figure 19 – Hourly residual load ramp of BEMIP countries, in scenario National Trends 2030

To read more on needs triggered by operational challenges and possible solutions

click here or scan the qr-code

TYNDP 2020 Insight report on the inertia challenge

click here or scan the qr-code

Reinforcing interconnections will be needed in some countries for peak load to be served at all times in 2030

According to this indicator of the Interconnection Target Expert Group's proposed methodology to assess interconnectivity, the domestic demand should be served through domestic generation or imports.

The indicator is expressed through a ratio between the nominal transmission capacity of the interconnection lines (thermal capacity) and the peak load. A low ratio means that the peak load in a country is high compared to the thermal capacity of the interconnection lines.

For countries in green the ratio is above 60 %, for countries in yellow it is between 30 % and 60 % while for countries in red it is below 30 %. Where the nominal transmission capacity of interconnectors is below 30 % of their peak load, Member States should investigate options for additional interconnectors.

Figure 20 shows this indicator in 2030, if no investment is made in the cross-border transmission grid after 2020 (left) and with the expected grid in 2025 (right).

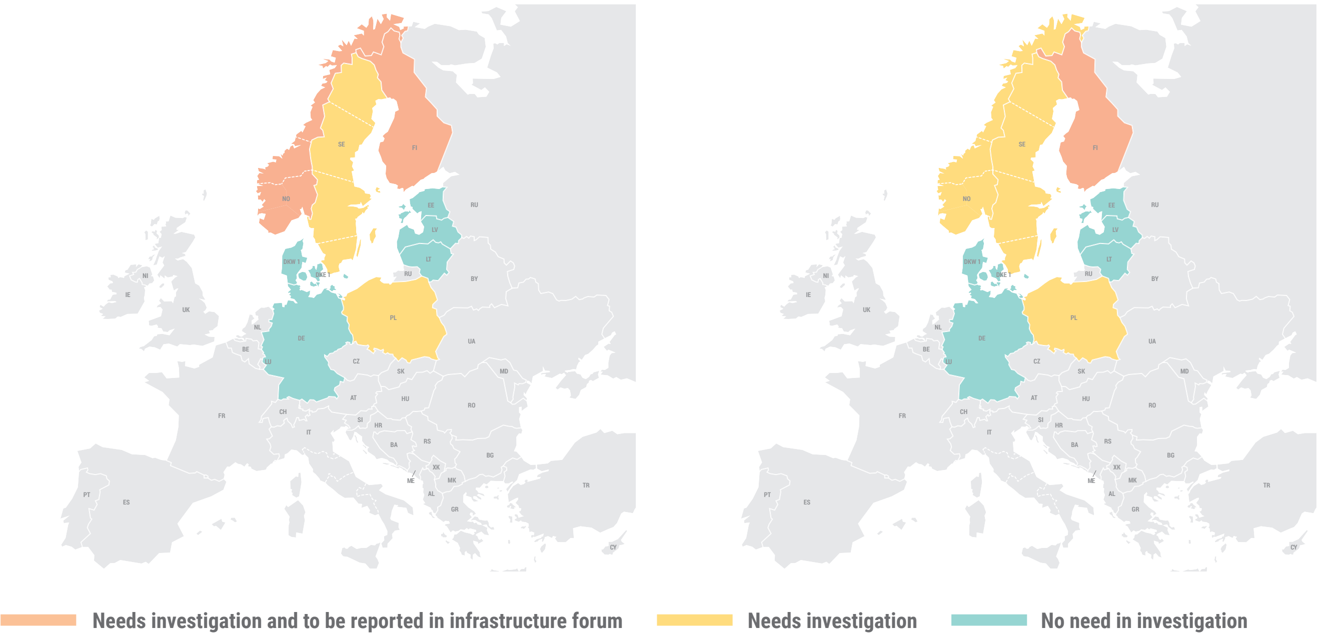

Figure 20 – Ratio of nominal transmission capacity (thermal capacity) to the peak load in 2030, in the case where Europe would stop all investment in the grid after 2020 (left) and with the expected 2025 grid (right)