

Power System Needs 2030

North Seas Offshore Grid

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 NSOG PCI 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 Plans¹:

- › **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 portfolio².
- › **Portfolio 2030:** a hypothetical year 2030 where all projects of the TYNDP 2020 portfolio that project promoters foresee 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

[click here](#) or scan the qr-code

Needs and projects

The TYNDP 2020 addresses two questions:

- › what are power system needs?
- › which infrastructure projects can address those needs?

ENTSO-E's system needs study and the present document answer only the first question. The second question should only be addressed as a second step, by looking at projects cost-benefit analysis results and other information presented in the TYNDP 2020 project sheets.

¹ Northern Ireland is included in UK values in all figures.

² Ireland and Northern Ireland form one wholesale electricity market area known as the Single Electricity Market (SEM). Therefore, the needs identified between the island of Ireland and Great Britain could be satisfied by capacity increases in either Ireland or Northern Ireland

Key messages of the NSOG 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. There is an abundance of renewable energy sources across the Northern Seas Region—onshore and offshore wind, solar and hydro power—that can be utilised.
2. Rapid expansion of offshore wind triggers related offshore- and onshore infrastructure needs. The installed offshore wind capacity in the Northern Seas is expected to be around 70 GW in 2030 and 112 GW in 2040 in ENTSO-E's National Trends scenario, while the Green Deal indicates a potential need for an installed offshore wind capacity of more than 200 GW in 2050.
3. Flexibility is challenged, however Smart Sector Integration will be part of the solution. Activities started already in the region to prepare optimized decarbonization.
4. The above requires new interconnectors, especially between the four synchronous areas of the PCI Corridor and will as well support market integration, security of supply and RES integration.

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 spreads in marginal cost are significantly reduced compared to the situation where Europe would stop all investments after 2020.

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 less reduced in the SEW-based needs case, because identified needs included few offshore links due to the methodology employed. The reduction in spread is higher in the Portfolio 2030 case because of the many offshore links proposed in the TYNDP 2020, with over 15 offshore interconnectors (some of them in competition with each other) proposed in the North Sea, Channel and Irish Sea and foreseen to commissioning between 2020 and 2030.

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

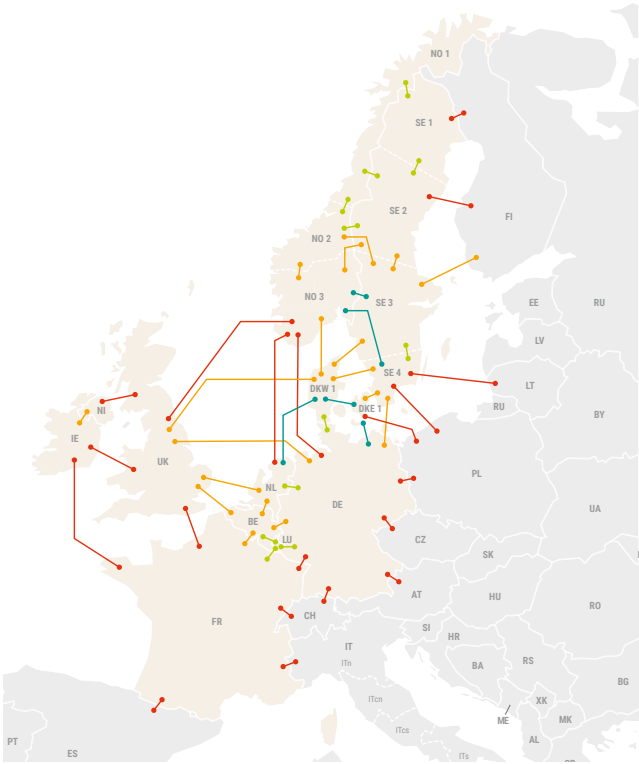


Figure 3a – No investment after 2020

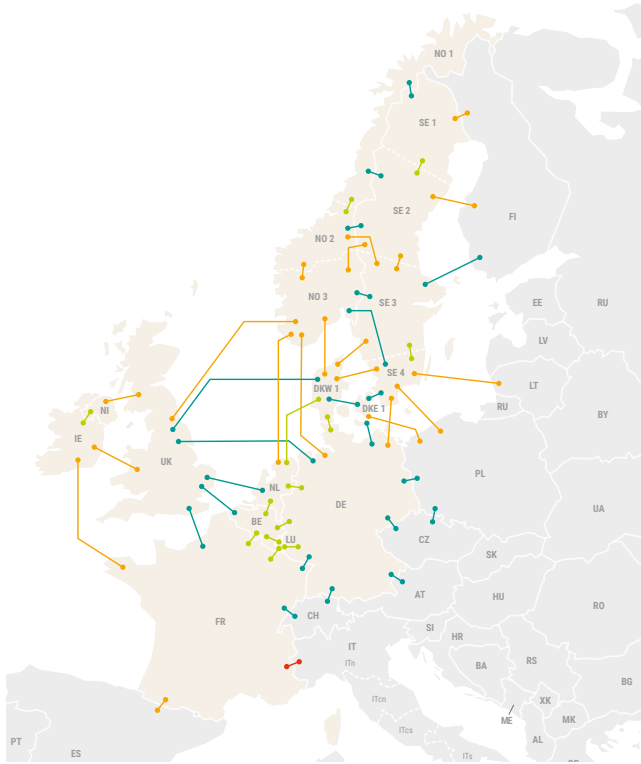


Figure 3b – SEW-based needs 2030

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

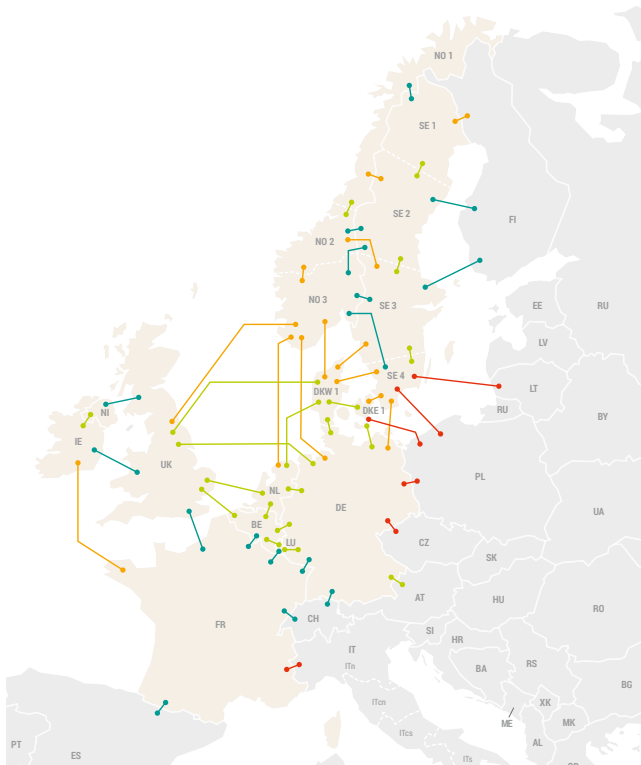


Figure 3c – Portfolio 2030

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 (Figure 5) shows that, for most countries, reinforcing the cross-border grid will reinforce the existing tendency to import or export.

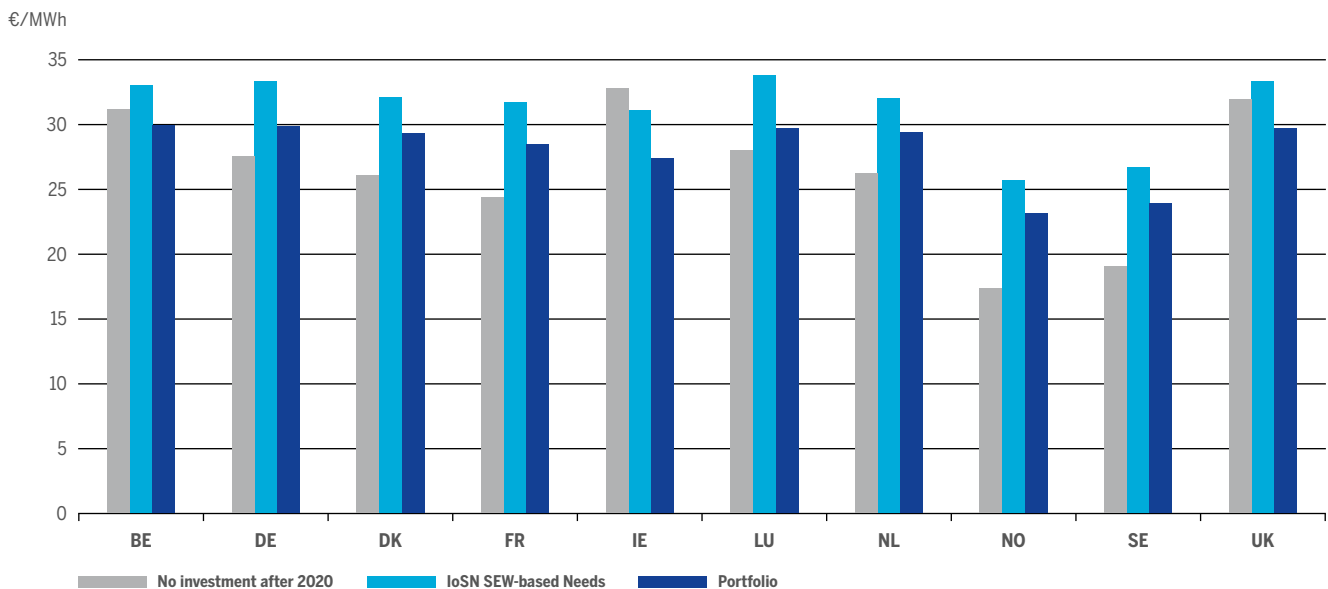


Figure 4 – Average marginal cost per country, in euro/MWh

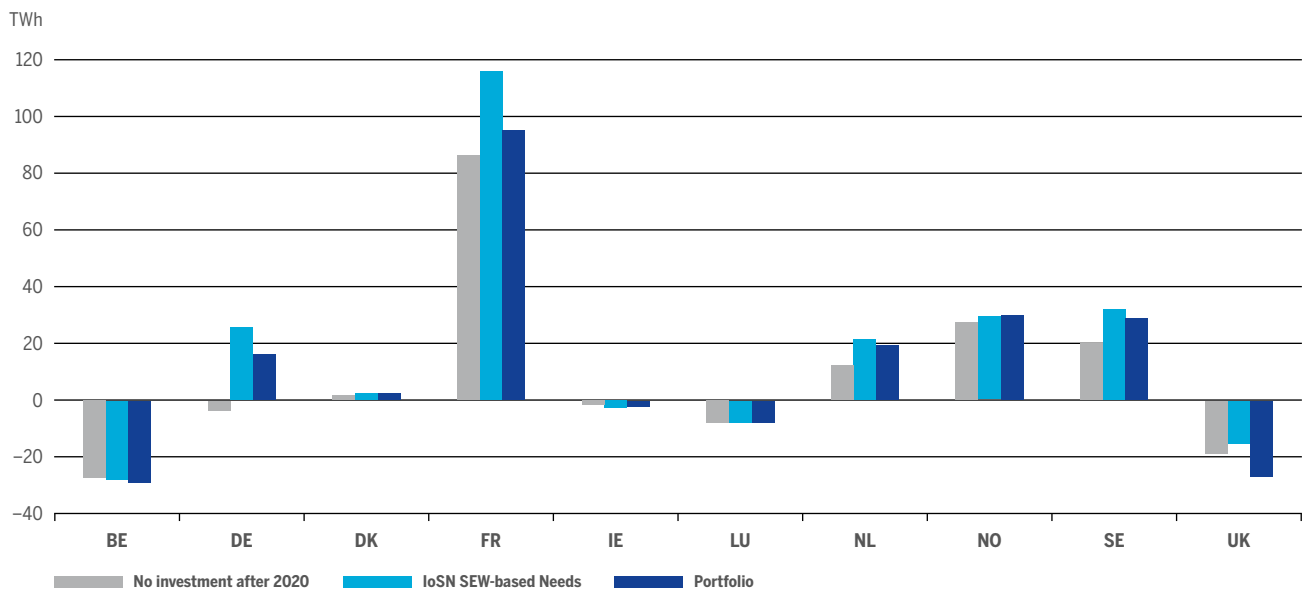


Figure 5 – Net annual balance in TWh

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 allows European countries to exchange more energy, in total

in the NSOG PCI Corridor an additional 85 TWh/year would be exchanged in 2030 (in SEW-based needs), relative to the situation where Europe would not invest in the cross-border grid after.

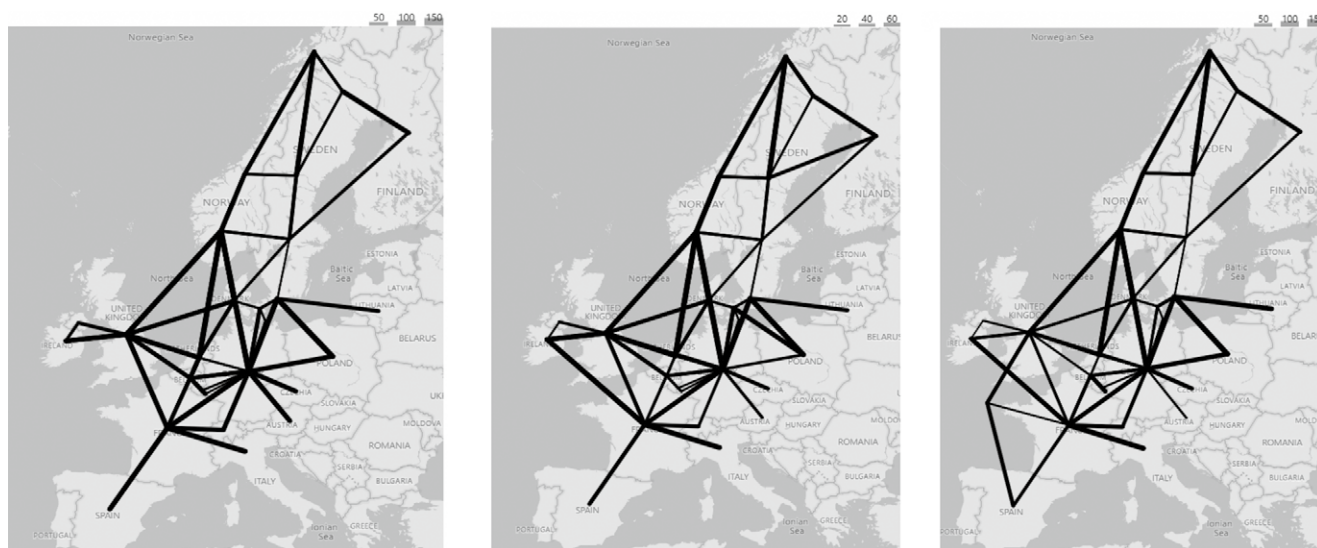


Figure 6 – Percentage of hours per year where the flow of electricity reaches 100 % of the Net Transfer Capacity on the border (constraint duration), in No investment after 2020 (left), SEW-based needs (middle) and Portfolio 2030 (right)



**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. This section covers the main boundaries in the NSOG region. 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 NSOG region, highlighted in Figure 7. These boundaries are: – Ireland to Great Britain and Continental Europe; – Great Britain to Continental Europe and Nordics; and – Nordics to Continental Europe West. 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.

Figure 8 demonstrates that the three major boundaries of NSOG 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 CO₂-emissions, increased RES-generation and increased security of supply.

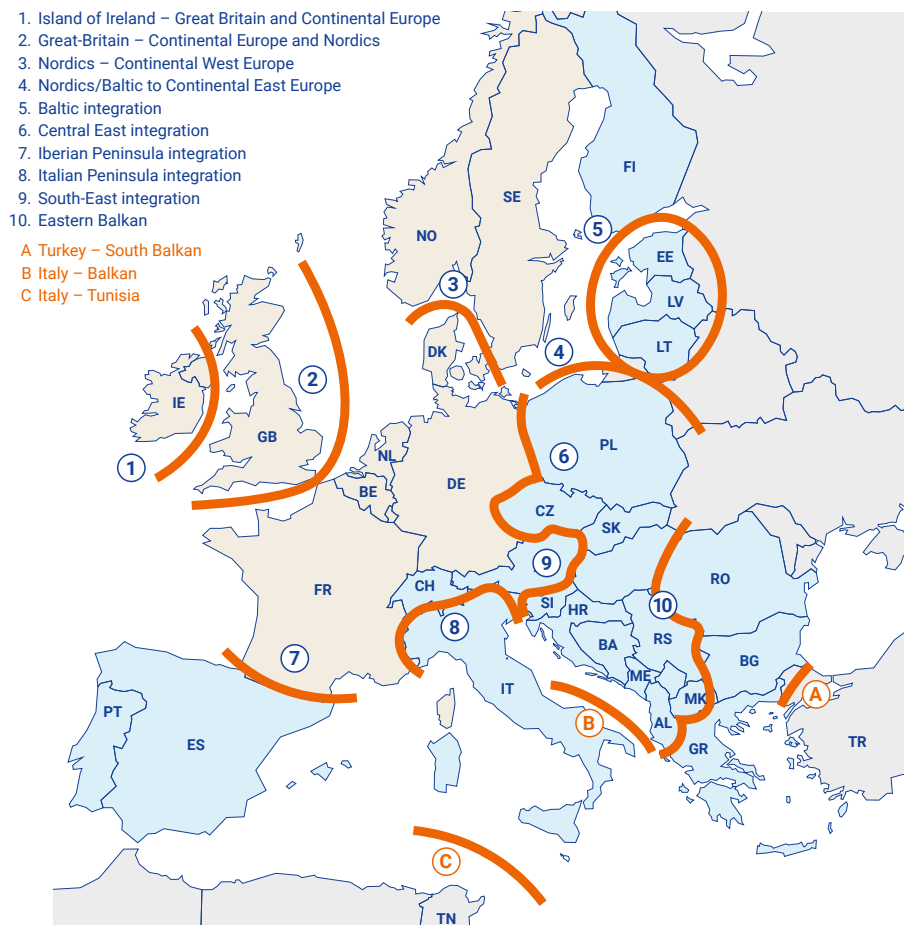


Figure 7 – TYNDP 2020 10 main boundaries

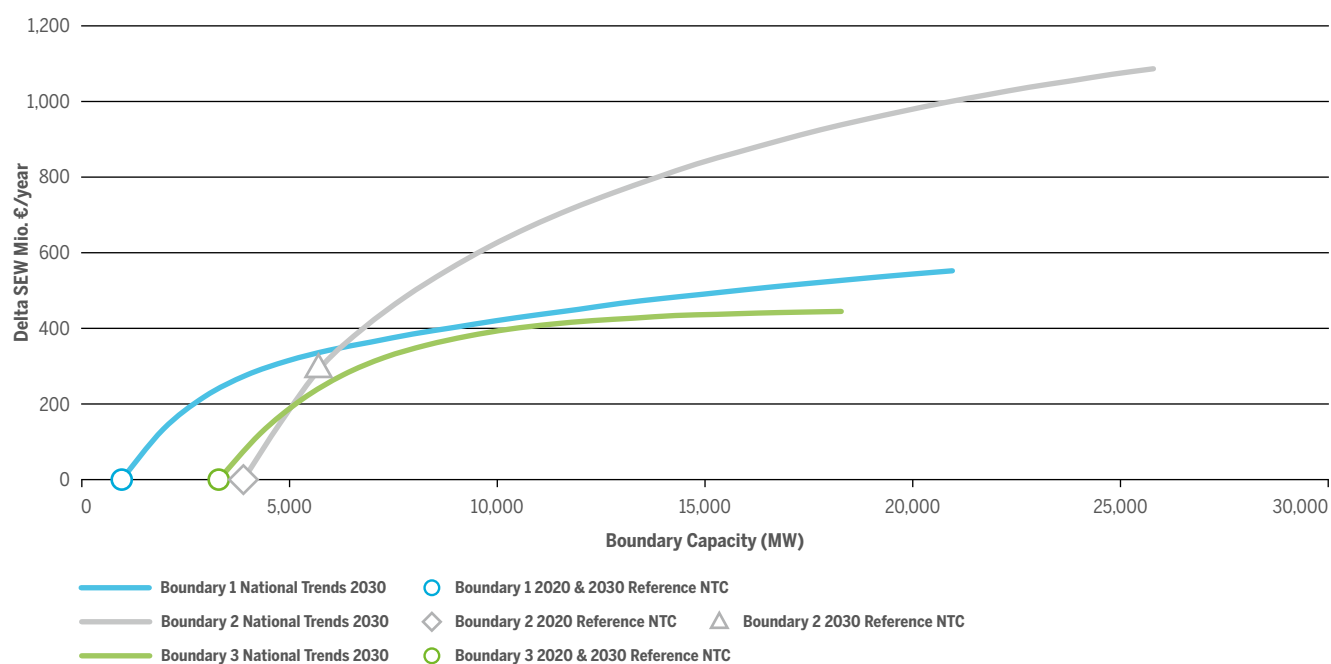


Figure 8 – Increase in socio-economic welfare (SEW) when the transmission capacity increases from the current situation, on main boundaries located in the NSOG PCI Corridor, in the NT2030 scenario

Sustainability

Investing in electricity transmission infrastructure will be key to enable Europe to achieve the Green Deal. 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 CO₂ 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).

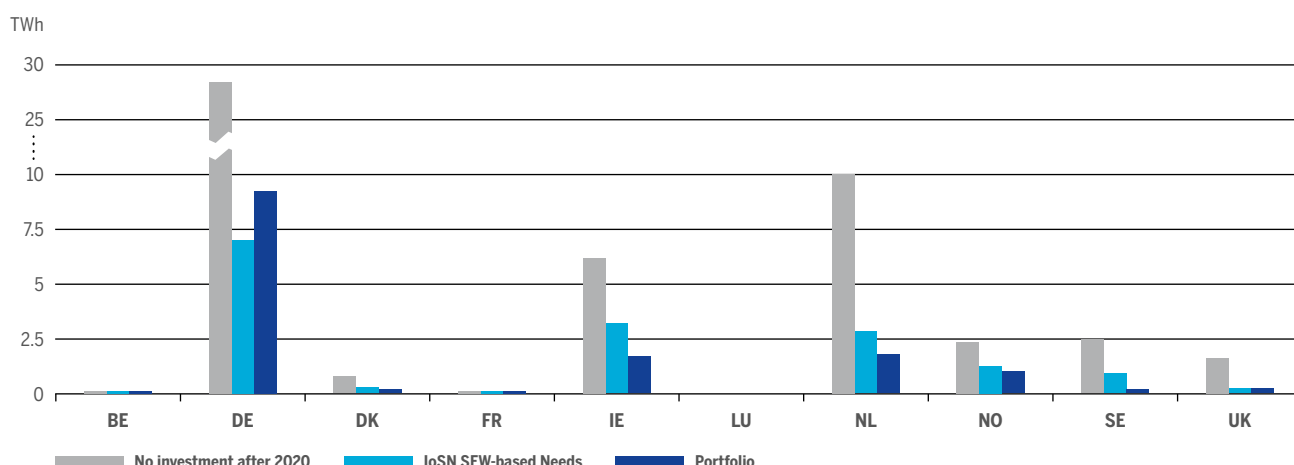


Figure 9 – Curtailed energy per country in TWh

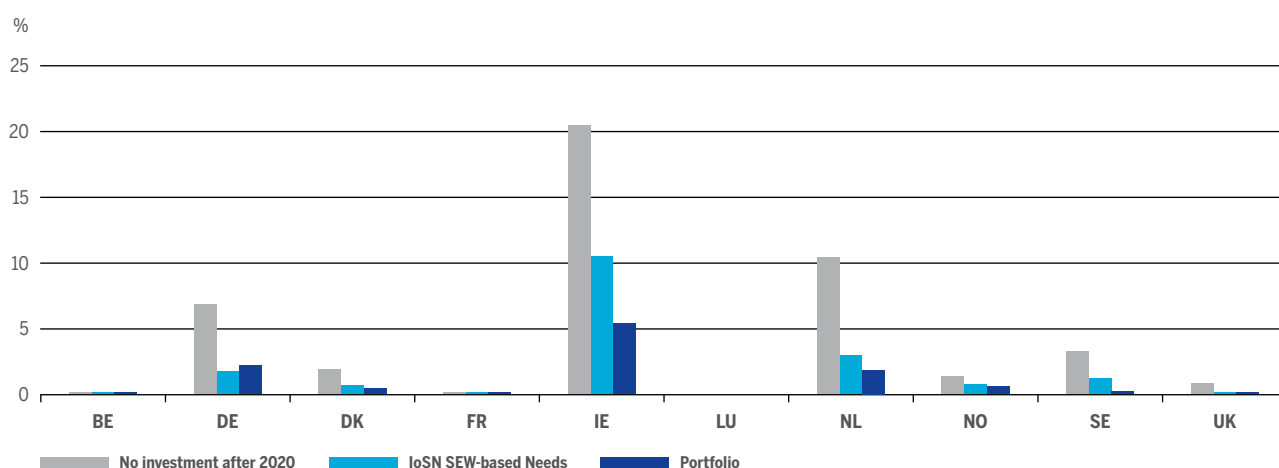


Figure 10 – Curtailed energy per country as a share of RES generation

In addition to RES, some thermal power plants emit very low CO₂ 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 CO₂ 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.

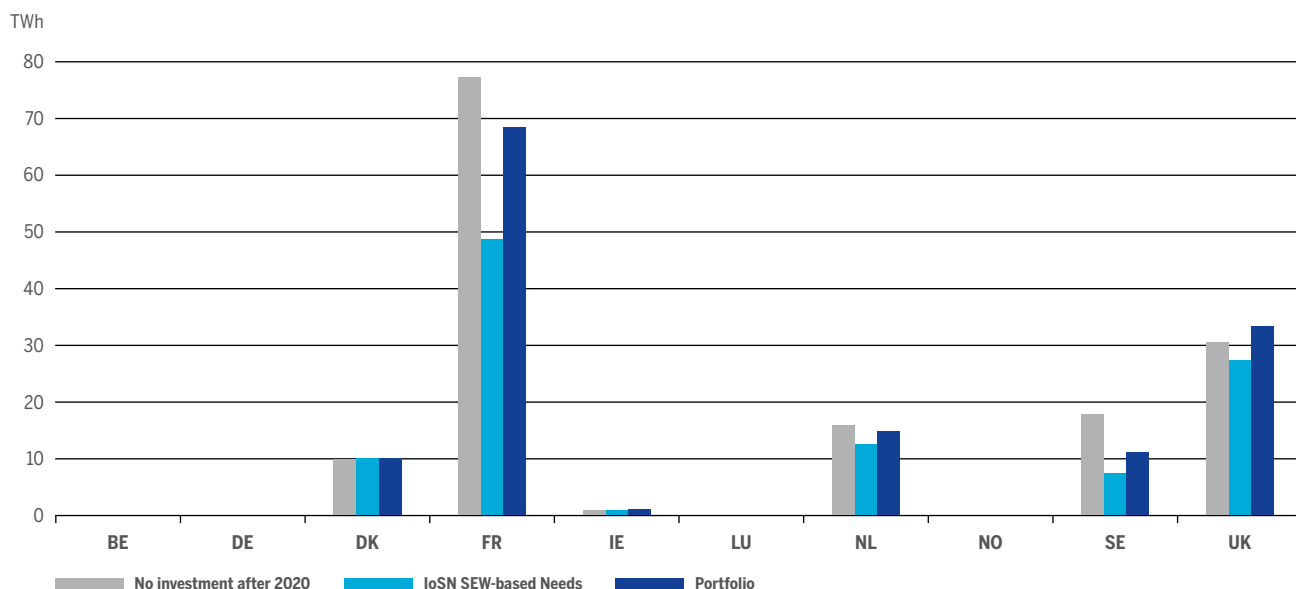


Figure 11 – CO₂ free dispatchable available energy from nuclear and green gas generation, in TWh. Where there is no value it means that the country at hand does not have nuclear or green gas in its generation portfolio.

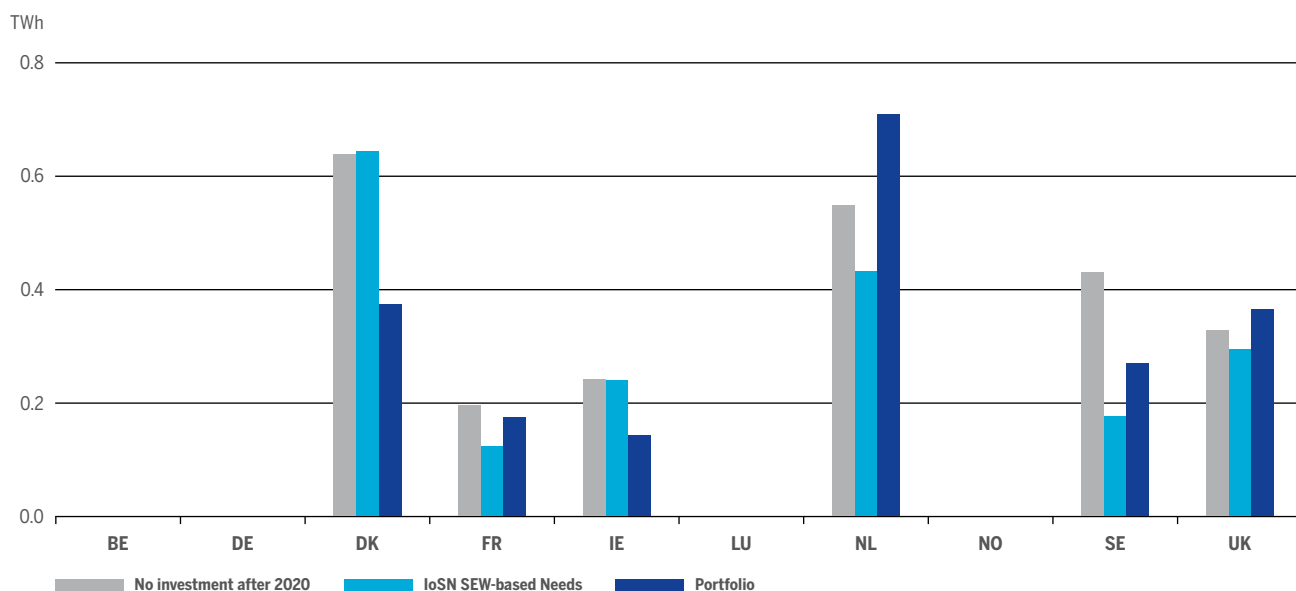


Figure 12 – CO₂-free dispatchable available energy from nuclear and green gas generation as a share of the total CO₂-free dispatchable generation

Reduced CO₂ emissions

By allowing a better integration of non-CO₂ emitting generation, increased cross-border network capacity leads to a reduction of CO₂ 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 takes CO₂ emissions into account in socio-economic welfare only partially, via the ETS CO₂ price which producers have to pay

when they emit CO₂. However, the ETS CO₂ prices of 28 EUR/ton of CO₂ in 2030 is not sufficient to properly decrease CO₂ emissions to an extent consistent with EU climate ambitions. This explains the relatively reduced impact of the SEW-based Needs.

CO₂ emissions per country are strongly impacted by the assumptions made in the scenarios, view the Country fact-sheets for more details.

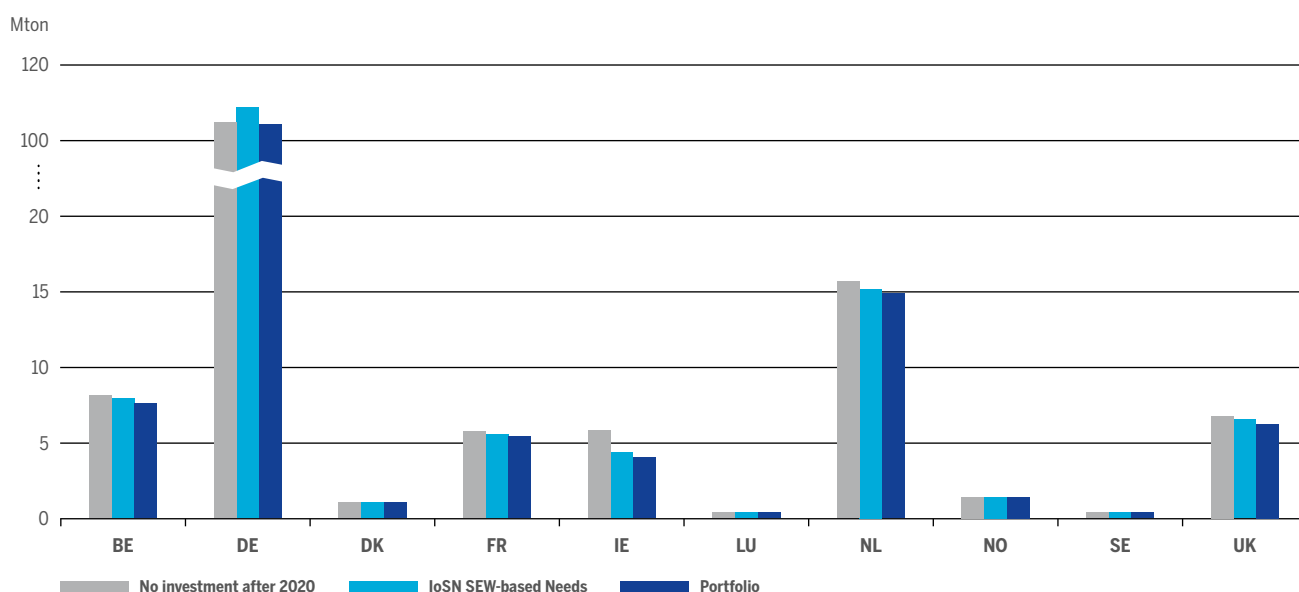


Figure 13 – CO₂ emissions in Mton/year

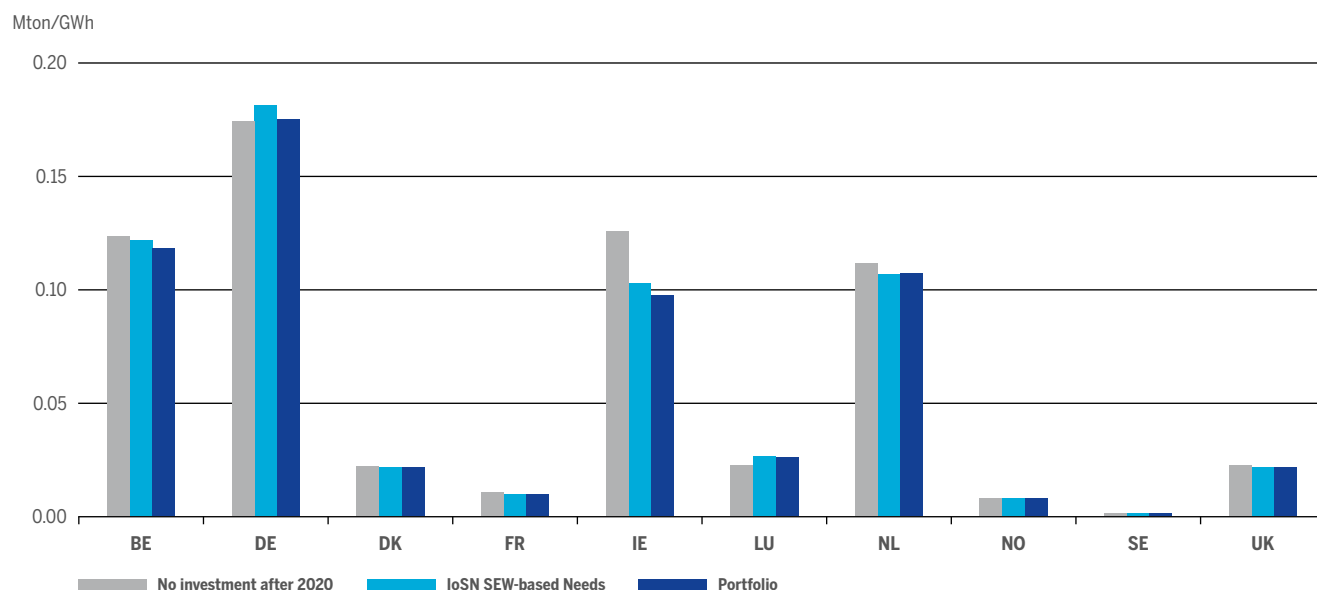


Figure 14 – Ratio of CO₂ emissions in Mton over total generation in GWh

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

This indicator, part of the Interconnection Target Expert Group (ITEG) 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 (left) and with the expected grid in 2025 (right).

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 %, such as for the UK and Ireland, indicates a need to investigate options for additional interconnectors.

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.

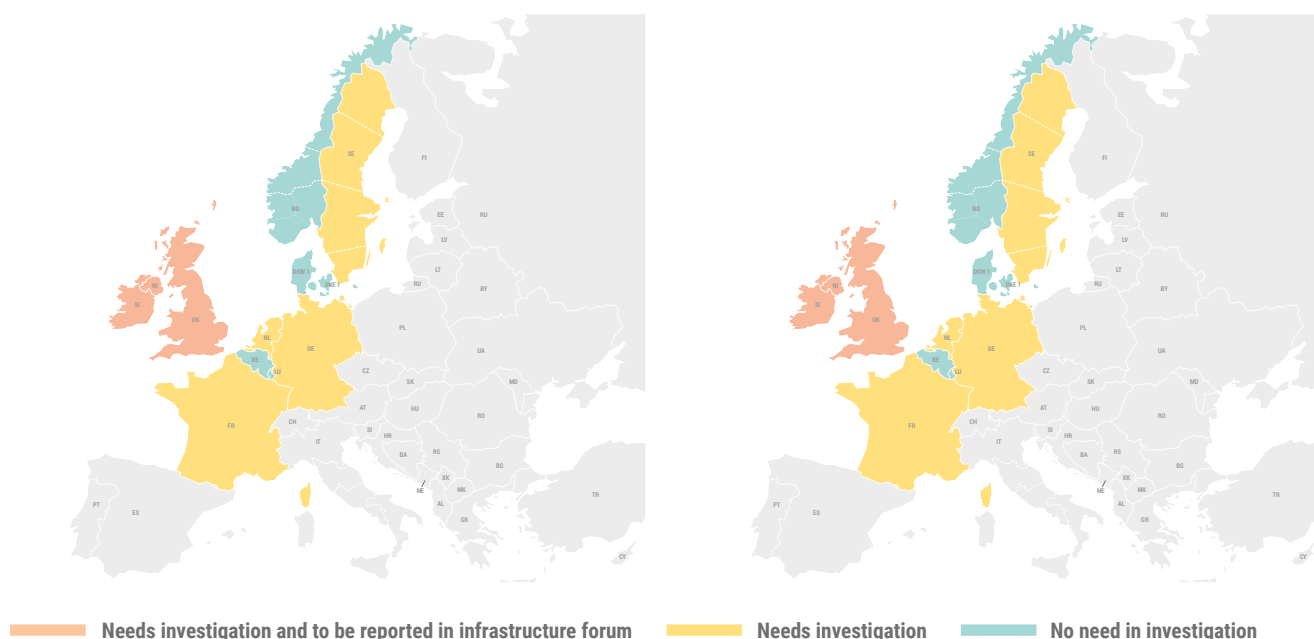


Figure 15 – Ratio of the nominal transmission capacity (thermal capacity) to the installed RES generation in 2030 with the 2020 grid (left) and with the 2025 grid (right)

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 RES (solar, wind) 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 generation (solar, wind). The ratio increases in almost all countries, and the faster its evolution, the harder it is for the power system to adapt.

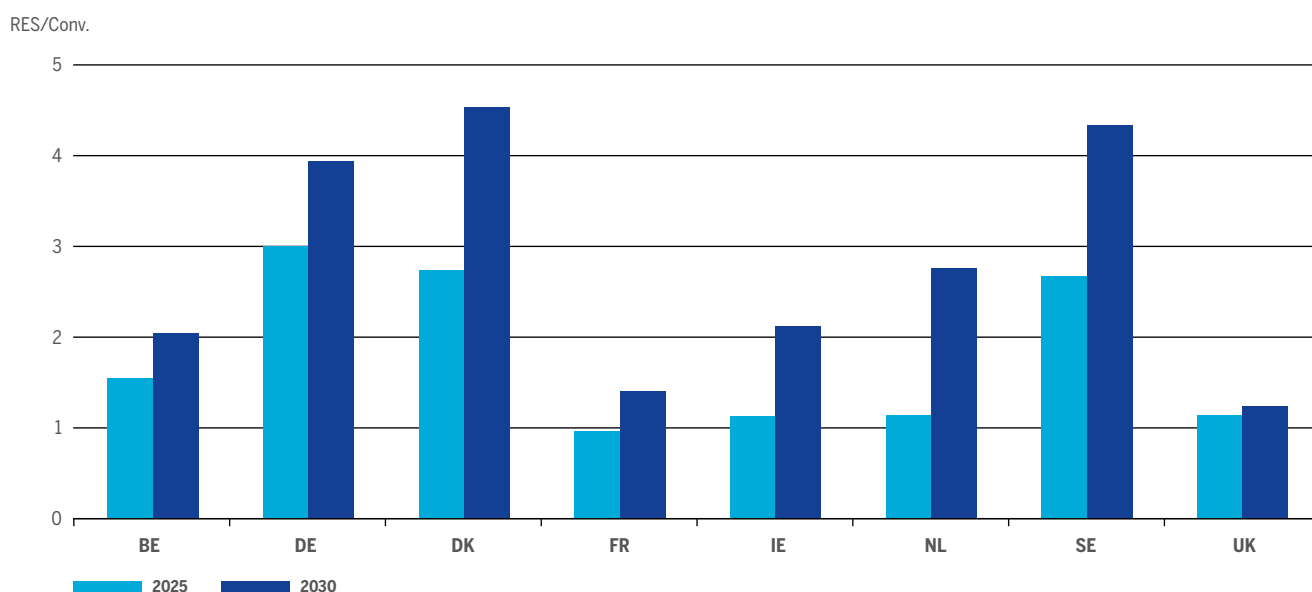


Figure 16 – Ratio of the installed RES generation capacity to the installed conventional generation capacity, in 2025 and 2030. Norway and Luxemburg do not appear in the figure because they have very little conventional generation, which renders this indicator meaningless.

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.

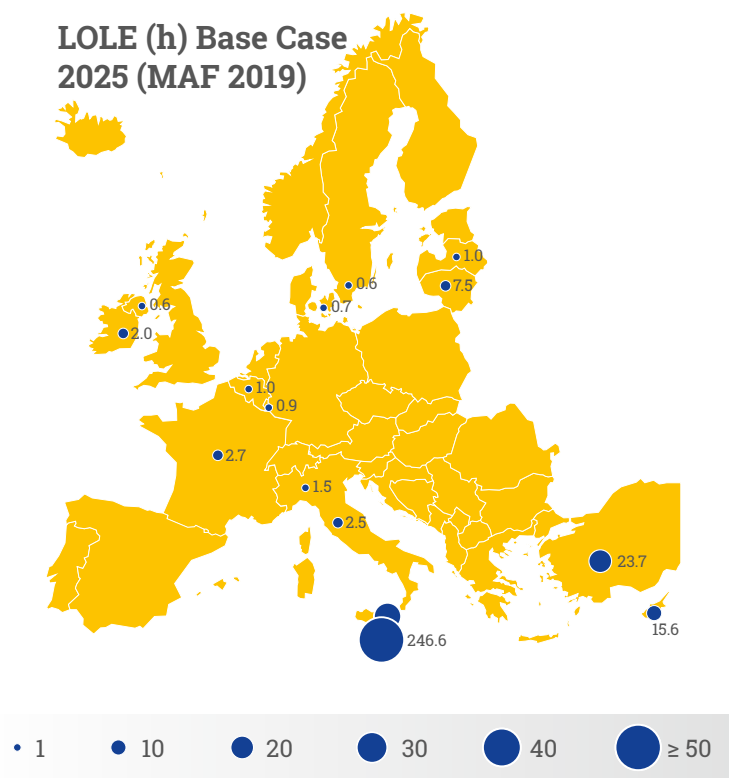


Figure 17 – Loss of Load Expectation in 2025 (Mid-Term Adequacy Forecast 2019)

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.

Figure 18 shows 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.

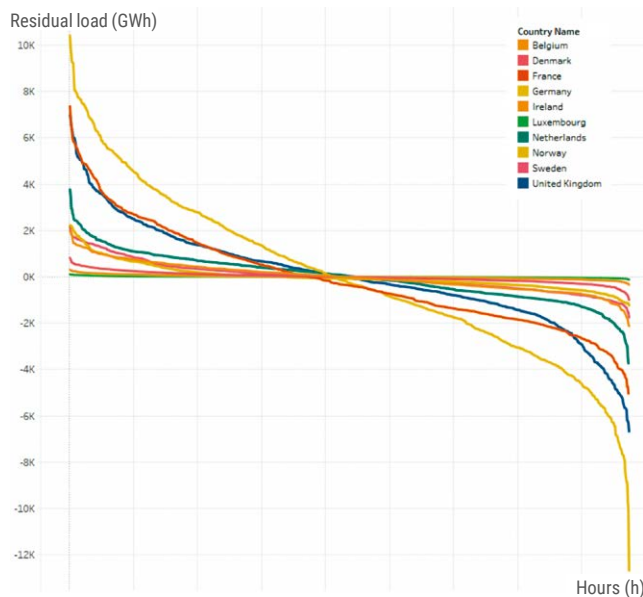


Figure 18 – Hourly residual load ramp of NSOG countries, in scenario National Trends 2025

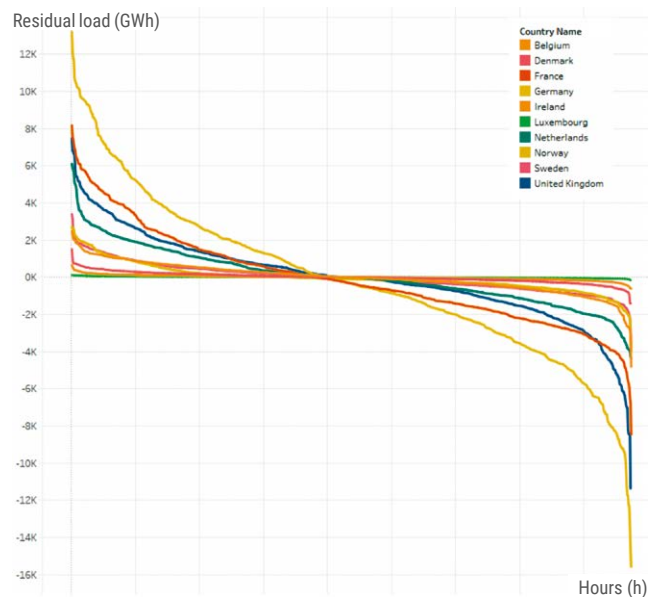


Figure 19 – Hourly residual load ramp of NSOG countries, in scenario National Trends 2030



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 ITEG proposed methodology to assess interconnection needs, the domestic demand should be served through domestic generation or imports. This 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.

When the nominal transmission capacity of interconnectors is below 30 % of their peak load, Member States should investigate options for additional interconnectors.

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 %.

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 2025 grid (right).

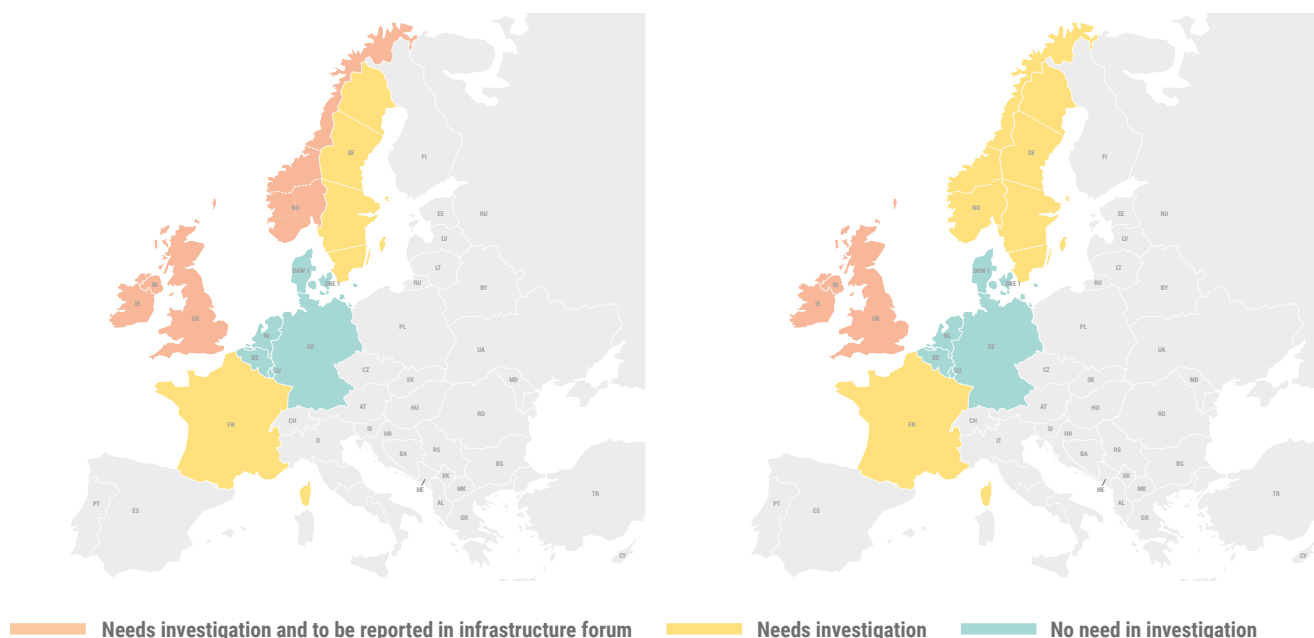


Figure 20 – Ratio of nominal transmission capacity (thermal capacity) to the peak load in 2030 in the case where Europe would stop all grid development after 2020 (left), and with the expected grid in 2025 (right).