TYNDP 2018 Regional Insight Report

North-South Interconnections West

Final version after public consultation and ACER opinion - October 2019

entsoe

Reliable Sustainable Connected

Contents

ENTSO-E Reports 2018

As an improvement to the TYNDP 2018 package, the Insight Reports have been categorised in order to help readers navigate through the document and focus on what readers might find of interest. The category of reports are:

— Executive Report – Contains the key insights of the whole TYNDP package through its two-year cycle.

— Regional Reports – Based on the four projects of common interest (PCI) regions, the reports focus on the regional challenges of the energy transition.

— Communication – These reports communicate how we have interacted with our stakeholders and improved the TYNDP package from 2016 to 2018.

— Technical – These reports give a deeper insight into the technical subjects, including how we use our data, and the technical challenges of energy transition.

We hope this guide is of benefit to all stakeholders.

Main Report

Regional Reports
- North-South Interconnections East
- North-South Interconnections West
- Northern Seas Offshore Grid
- Nordic & Baltics

Communication
- Stakeholder Engagement
- Improvements to TYNDP 2018

Technical
- Data and Expertise
- Technologies for
- Transmission
- Viability of the Energy Mix
- CBA Technical

Adequacy
- Mid-Term Adequacy Forecast

Executive summary

This document addresses grid development issues in the geographical area covered by the North-South Interconnections in Western Europe ('NSI West') established by Regulation (EU) No. 347/2013 on guidelines for Trans-European energy infrastructure ('The Energy Infrastructure Regulation').

The geographical area of the NSI West Corridor is covered by the ENTSO-E Regional Groups (RGs) Continental South West (CSW), Continental Central South (CCS) and North Sea (NS). Each RG published an Investment Plan at the beginning of 2018, and these plans provided in depth information beyond that presented in this Insight Report.

The countries involved in NSI West are:
Austria, Belgium, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Malta, Portugal, Spain, and the United Kingdom.

Considering long-term horizons, it is expected there will be an abundance of renewable generation in the NSI West Corridor, particularly due to wind generation in the north of the region, and solar generation in the south. Additionally, the Alpine region offers an opportunity for large-scale pumped storage projects.

The TYNDP 2018 highlights five main boundaries in the NSI West Corridor where additional reinforcement will be particularly beneficial. These boundaries result from high price differences between areas and large installed capacities of RES generation. They are:
— between Iberian Peninsula (Portugal and Spain) and France
— between Italy and France, Switzerland and Austria
— between Great Britain and Continental Europe
— Ireland to Great Britain and Continental Europe.

In addition to these main boundaries, there are a number of other significant boundaries throughout the region where development is required. This development is required to enable the efficient integration of the expected future generation portfolio and to enable the potential benefit of the main boundaries.

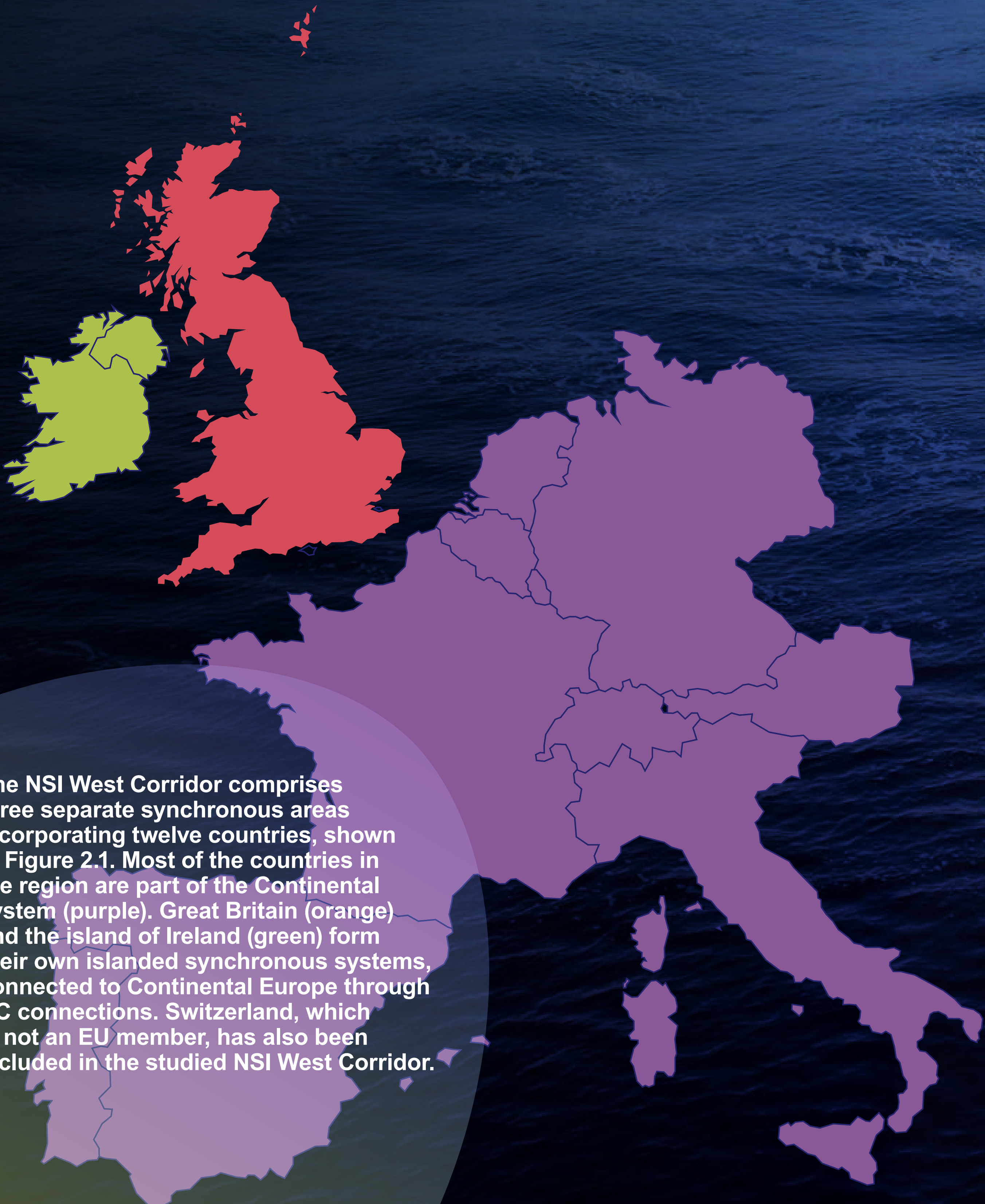
In the TYNDP 2018, three separate scenarios for the year 2030 were analysed, which reflect different possible pathways to meet future EU decarbonisation targets. Each of these have common themes with regard to renewable generation, whether it be onshore, offshore wind, or solar.

As an outcome of this analysis, the long-term (2030 or 2040) needs study has identified a need for significantly more cross-border capacity Europe-wide. This finding must be remembered when examining the current project portfolio and the results of the project assessments:
— The number of projects is quite stable compared to TYNDP 2016; most of them are to be delivered by 2025 or before and look on track; the project portfolio is smaller beyond 2025
— The overall effect of these projects in terms of market convergence, improvement of security of supply and helping the energy transition is widely positive; the Social Economic Welfare (SEW) of projects is however generally lower than for TYNDP 2016. The reasons for this are mainly due to:
    — A general reduction in the assumed fuel prices used for the Cost Benefit Analysis (CBA)
    — A lower price spread between differing thermal plant types, and
    — An increase in losses attributable to these projects, although the assessment of losses requires further investigation as it shows a very high sensitivity to assumptions regarding detailed location of dispatched generation.

Section 2

Key messages of the region

Figure 2.1: Synchronous areas of the NSI West Corridor



The NSI West Corridor comprises three separate synchronous areas incorporating twelve countries, shown in Figure 2.1. Most of the countries in the region are part of the Continental system (purple). Great Britain (orange) and the island of Ireland (green) form their own islanded synchronous systems, connected to Continental Europe through DC connections. Switzerland, which is not an EU member, has also been included in the studied NSI West Corridor.

The NSI West Corridor faces many challenges over the coming decades. The large increase in renewable generation across the region needed to meet European targets, coupled with the requirement to integrate the European electricity market, create a number of challenges for the 2030 horizon summarised below.

2.1
Changes in the generation portfolio

Climate change mitigation will require energy efficiency measures such as migration from fossil-fuel based end-users to CO_2-free energy sources. There will be substantial changes to the generation fleet across the NSI West Corridor over the coming decades, with the significant changes being:

— A shift from thermal to renewable generation. As abundant renewable sources across the corridor (wind, both onshore and offshore, and solar) are increasingly exploited, there is a reduction in thermal plants usage. Solar energy is more developed in this TYNDP edition than in TYNDP 2016.

— A reduction in nuclear generation. The overall trend across the NSI West Corridor is for a reduction in nuclear capacity, with nuclear planned to be phased out in Belgium and Germany, and a partial phase-out in France. In Great Britain, the level of nuclear generation varies depending on the scenario.

— A shift from coal to gas generation. Existing coal-fired power plants are being phased out due to a combination of reaching the end of their life and policies being put in place to enable a reduction in the carbon emissions of the generation portfolio.

2.2
Power flows across the region

The future generation portfolio will drive new and large power flows across the NSI West Corridor for which the grid was not originally designed. The diverse nature of the generation is a major factor. Renewable energy output in Great Britain and Ireland is dominated by wind generation, while in Continental Europe there is a mix of both wind and solar generation. In particular, there is a large increase in solar generation in the CSW region (in the range 55 TWh to 140 TWh a year by 2030 in TYNDP 2016 and in the range 120 TWh to 160 TWh a year by 2030 in TYNDP 2018). Pumped storage power plants in the Swiss and Austrian Alps are also expected to see a large increase. These technologies are subject to variable hourly output.

While the primary thermal generation in the region is gas, nuclear generation makes up a significant majority of thermal generation in France.

This generation diversity across the region drives market exchange opportunities and consequently power flows between the three synchronous areas and also between the Member States. These power flows increase in volume from current values, and become more international as the distance between the consumer and the location where the cheapest available energy is being produced increases, highlighting a series of congested boundaries in the region that are to be alleviated through the development of a proper electricity grid infrastructure.

2.3
Requirements for new interconnection

Additional interconnection capacity is required across the region, between synchronous areas and Member States. This increased capacity will allow improved market integration which will reduce energy price differentials. It will also allow for improved cross-border trade, enabling the integration of renewable generation, which will minimise its curtailment and aid decarbonisation of generation production. The 2030 objectives show the need for interconnection development in the region.

However, there is a need to integrate some areas that are still isolated to improve the functioning of the European electricity market. This is especially the case for Great Britain (and Ireland), Italy, and Spain (and Portugal, that is the Iberian Peninsula), which will be far from the 10% interconnection ratio objective set by the European Council to be reached by 2020.

This additional cross-border capacity will drive larger power flows across Member States' internal grids in the future. As a result, existing transmission corridors will have to be reinforced, or new corridors developed, to upgrade the internal grids to accommodate these developments.

2.4
Ensuring security of supply

The expected changes in the generation fleet across the NSI West Corridor will pose challenges for the security of supply in all the synchronous areas of the region. The increased reliance on renewable generation means the weather will have a greater impact on the future energy system; there will be instances where there is low RES production in multiple adjacent countries.

Additional interconnection allows the sharing of resources, ensuring security of supply in a more cost-effective manner compared to an isolated approach, which would require additional installed generation capacity at an individual country level.

In addition to the network development, new flexible thermal generation has been assumed in the scenarios. This generation is not necessarily economically viable in an energy-only market, hence (partially) relying upon capacity remuneration mechanisms.

Moreover, the increased complexity of the future energy system will present many operational challenges, and coordination of market rules and network codes will be important.

2.5
Ensuring flexibility in the region

Power production from renewable energy is reliant on an intermittent energy source (i.e. wind or solar) which means significant changes in output power will occur within countries. These resulting fast changes to variable generation output can occur at the same time as changes to the load profile. TSOs will subsequently face challenges in maintaining system balance, driving a need for flexibility across the region. This could be provided by various sources, including additional interconnection, storage, fast acting peaking generation and demand side response.

The planned development of interconnection in the NSI West Corridor will aid flexibility, by strengthening connections between areas with diverse generation portfolios. In addition, storage projects in the region will enable a more efficient use of renewable generation. This TYNDP assessed a number of pump storage and hydro plants in the Alps region; additionally, several storage projects are also assessed in the periphery of the region, such as in Ireland and Spain.

2.6
Changes since last Insight Report

For TYNDP 2016, projects were assessed against four scenarios in 2030, referred to as Visions 1 to 4. For TYNDP 2018, the scenarios have changed in their definition and for the first time were built together with ENTSO-G. For 2030, there are now three scenarios. One of them is bottom-up, built on information provided by TSOs, another one is top-down, looking for a pan-European view. The third scenario is provided by an external party, the European Commission (EC). This is the first time an external scenario has been included in the TYNDP.

All scenarios represent different pathways to meeting 2030 decarbonisation targets in the EU. For TYNDP 2018, each scenario has been assessed multiple times, each time using climate data from different years. As renewable generation develops, the weather will play a bigger role in determining when and where generation is dispatched.

Other improvements apart from the scenarios themselves are:

- Improvements implemented on both the pan-European Market Modelling Database and the pan-European Climate Database
- A more centralised assessment with a new improved CBA methodology (CBA 2.0)
- New methodology for the interconnection target computations based on the recommendations of the Expert Group established by the EC
- An improved management of the project sheets via a standalone project platform.

Nevertheless, details regarding improvements in the current TYNDP can be consulted in the dedicated Insight Report “Improvements of TYNDP 2018”.

2.7 Confirmation of 2030 system needs

An analysis with the 2030 scenarios and a no grid development beyond 2020 has been performed that helps to identify and confirm the needs for 2030, and the drivers for grid development in the region.

The results of this analysis highlight the issues that further development of the network in the region might allow: reducing CO_2 emissions across the region, particularly for the EUCO scenario, maximising the integration of renewable generation by reducing the RES spillage observed in many countries for the ST and DG scenarios, sharing resources to reduce the impact of unserved energy in countries across the region, particularly in France, Great Britain, Italy, Ireland and Northern Ireland, and reduce the marginal cost differences in many borders in the region.

The main needs in the region for 2030 are in line with those identified in the pan-European Investigation of System Needs process for the 2040 horizon, and are also coherent with the boundaries identified in TYNDP 2016: Ireland to Great Britain and Continental Europe; Great Britain to Continental Europe (and Nordics); the Iberian Peninsula integration and the Italian Peninsula integration.

In these main boundaries, a set of Social Economic Welfare vs Grid Transfer Capacity (SEW/GTC) curves can be used to get an idea of the socio-economic welfare of increasing capacities beyond 2020 values, and these results are compared to the capacities provided by the planned projects in the boundary considered in the TYNDP 2018 portfolio, explaining the special characteristics in each boundary. SEW is considered in the CBA as the savings in variable generation cost, but it is important to mention that it is not the only benefit considered in the CBA. In addition, these curves do not consider the cost of potential projects beyond 2020. In cases where the SEW compensates the cost of a project that provides certain capacity increase, the profitability of the project is ensured for the scenario at stake. Otherwise, the other CBA indicators or potential additional benefits of the projects should be carefully analysed to check the profitability of a new project.

2.8 Project portfolio and outcome of the project assessment

The number of projects is quite stable compared to TYNDP 2016; most of them are to be delivered by 2025 or before and look on track (but with an increase of reference capacity involving competing projects, which in turn raises the question of the level of economically viable Net Transfer Capacity (NTC) on the border, see 4.5; furthermore, some projects are currently delayed due to regulatory issues especially on the France – GB border); in addition, the project portfolio is thinner for the time horizons beyond 2025.

Although AC is still the main technology with 78% of the project portfolio, it is clear that HVDC is becoming the more prominent technology type in the region for TYNDP projects, mainly because long-term relevant European projects result in long route or submarine projects.

The overall effect of these projects in terms of market convergence, improvement of security of supply and helping the energy transition is widely positive; the SEW of projects is however generally lower than for TYNDP 2016 (this being mainly due to a general reduction in the assumed fuel prices used for the CBA analysis and a lower price spread between differing thermal plant types), and the level of losses induced by these projects is higher (nevertheless the assessment of losses requires further investigation as it shows a very high sensitivity to assumptions regarding detailed location of dispatched generation).

The cost benefit analysis of existing projects has to be deepened over time, taking account of the materialisation of energy scenarios, and not focus only on SEW analysis, but also in other CBA benefits and especially in their potential additional benefits.

2.9

2030 transmission adequacy

In the same way as in 2020, Great Britain, Spain, Italy, Poland and Cyprus won't fulfil the objective of the 10% interconnection ratio due to not having enough transmission capacity available by that date with their neighbours and a significant growth in their installed generation capacities, it is also detected in 2030 that some countries and some borders require additional assessments to be able to fulfil the recommendations established for 2030 by the Interconnection Target Expert Group, especially those areas already identified as main boundaries in the region. These recommendations have been recently transposed in article 4 and Annex 1 part 1, Section A, Part 2.4.1 of the final compromise text with a view to agreement, adopted on 19 June 2018.

Section 3

Regional scenario overview – Future perspectives

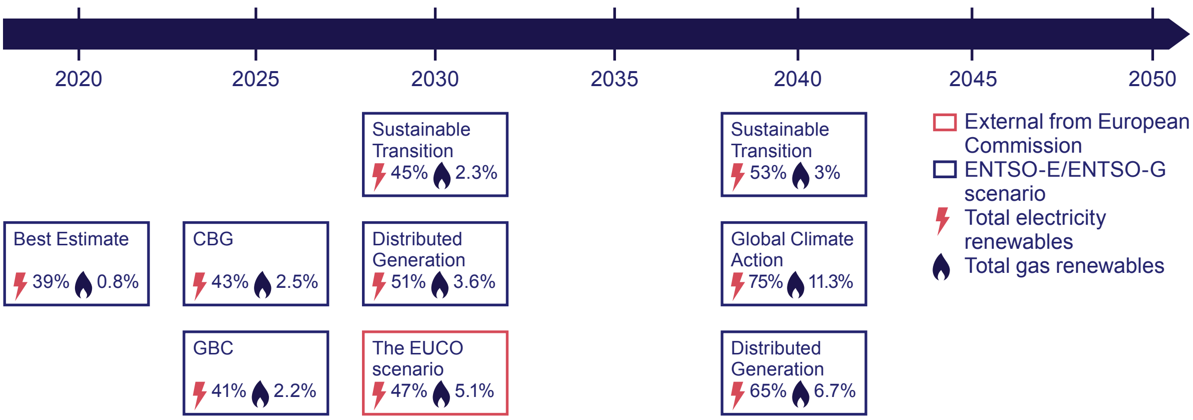
This section provides a summary of the scenarios considered in the CBA analysis of the projects considered in the NSI West Corridor. The full storylines, parameters and price assumptions supporting these possible futures and the methodology for building the scenarios are explained in detail in the TYNDP 2018 Scenario Report.

3.1
Scenario overview and main storyline

The respective TYNDP 2018 scenarios include a Best Estimate scenario for short-term (2020) and medium-term (2025) time horizons, and three different storylines for the long-term (2030 and 2040) time horizons to reflect increasing uncertainty.

All of the scenarios are on track by 2030 to meet the decarbonisation targets set out by the EU. The scenario pathways from 2020 to 2030 are shown in Figure 3.1.

Figure 3.1: 2020 to 2030 scenario building framework for TYNDP 2018



All scenarios detail electrical load and generation along with gas demand and supply, within a framework of EU targets and commodity prices. The Best Estimate scenarios for 2020 and 2025 are based on a TSO perspective. While they reflect all national and European regulations in place, they do not conflict with any of the other scenarios.

The present study analysed the three following main scenarios for the 2030:

Sustainable Transition (ST)
This scenario will be achieved by replacing coal and lignite by gas in the power sector, leading to a quick and economically sustainable CO_2 reduction. The targets are reached through national regulation, emission trading schemes and subsidies, steady RES growth, moderate economic growth, and moderate development of electrification of heating and transport. The scenario is in line with the EU 2030 target, but slightly behind the EU 2050 target.

Distributed Generation (DG)
In this scenario, prosumers are centrally placed. The scenario DG represents a more decentralised development with focus on end user technologies. Smart technology, electric vehicles, battery storage systems and dual fuel appliances, such as hybrid heat pumps, allow consumers to switch energy depending on market conditions. An efficient usage of renewable energy resources is enabled at the EU level as a whole. The 2030 and 2050 EU emission targets are reached.

Scenario "EUCO 2030"
In addition, for the year 2030 there is a third scenario based on the European Commission's (EC) EUCO scenario for 2030 (EUCO 30). The EUCO scenario is designed to reach the 2030 targets for RES, CO_2 and energy savings, taking into account current national policies, like German nuclear phase-out. The EUCO 30 already models the achievement of the 2030 climate and energy targets as agreed by the European Council in 2014, but includes an energy efficiency target of 30%.

Global Climate Action (GCA)
In the 2040 scenarios, an additional scenario is provided. Global Climate Action is characterised by full speed global decarbonisation and large-scale renewables development in both electricity and gas sectors. The 2030 and 2050 EU emission targets are reached.

[1] https://tyndp.entsoe.eu/tyndp2018/scenario-report/

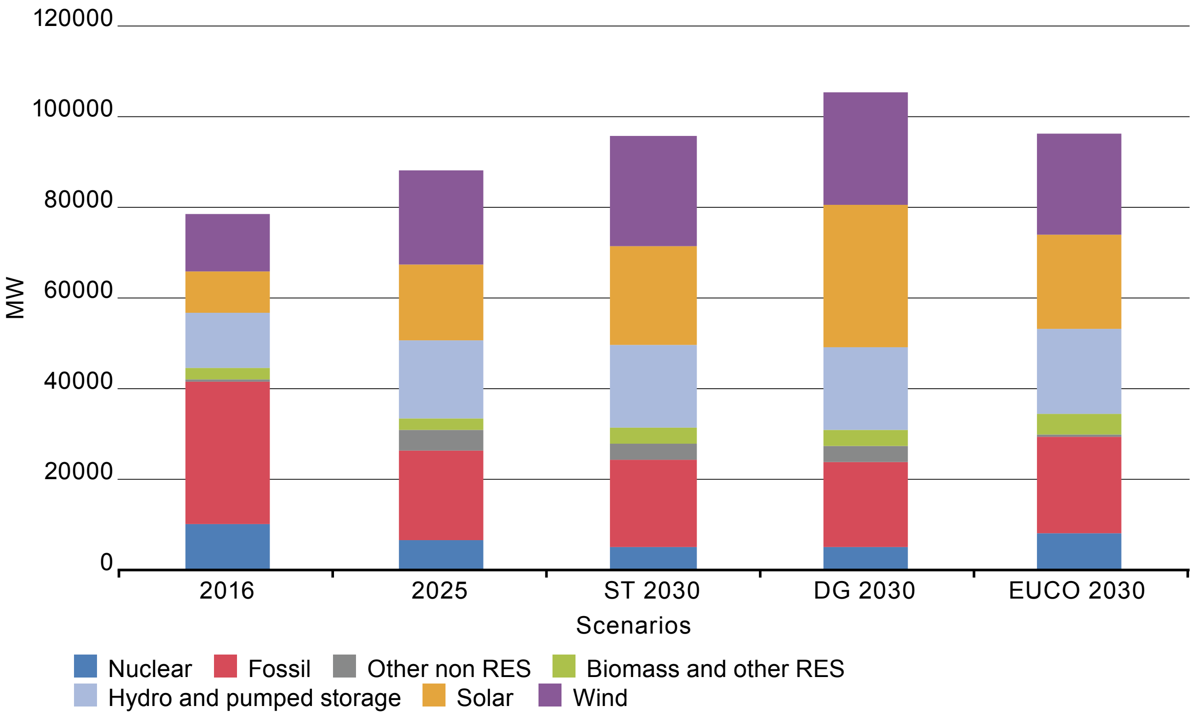
3.2
Scenario results

Summarised below are the results of the scenario process, covering the electricity sector in terms of installed capacities, generation (mix) demand, the evolution of CO_2 emissions and renewable energy sources. These results are displayed at the level of the region as explained in this document. Related figures per country can be found in the Annex. Figure 3.2 shows the installed generation capacities, and Figure 3.3 shows the generation production versus demand for the region.

In all cases, the information presented uses the weighted average of the three climate years for each scenario. The general trends that the generation portfolio of the NSI West Corridor will experience out to 2030 include:

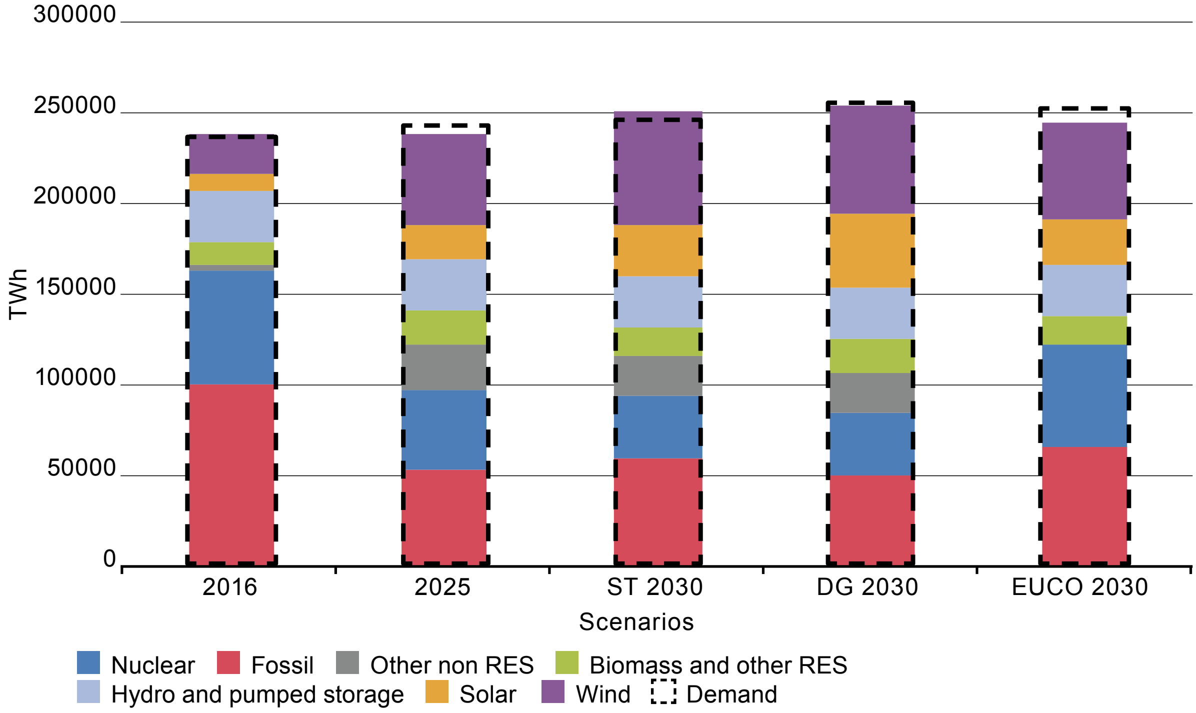
- A stabilisation of the demand between 2016 and 2030, except in EUCO scenario;
- From 2016, a reduction in nuclear generation capacity in all 2030 scenarios; the rate of closure is slower in the EUCO scenario;
- Large increases in wind and solar generation from 2016 to 2025 and on to 2030, with the DG scenario seeing the highest installed capacity;
- A significant decrease in fossil fuel capacity between 2016 and 2030, mostly driven by the closure of coal plants;
- An increase in biomass generation in all 2030 scenarios, most pronounced in the EUCO scenario; and
- An increase in hydro and pumped storage capacity by 2030 in all scenarios.

Figure 3.2: Regional installed capacities for 2016, 2025 and the 2030 scenarios



Reflecting the changes in installed generation capacities, Figure 3.3 shows a significant reduction in thermal generation production and a corresponding increase in wind generation production from 2016 to the 2025 and 2030 scenarios. Solar generation production also increases, but at a more moderate growth compared to production from wind generation (details about installed generation capacity per country can be seen in Annex 7.1), in spite of the large increase in installed solar capacity; this reflects the lower load factor associated with solar generation.
The EUCO scenario shows nuclear generation production comparable to that of 2016, while in the other scenarios there is a notable reduction in output.

Figure 3.3: Regional generation and demand for 2016, 2025 and the 2030 scenarios



As demonstrated in Figure 3.3, for 2030 the NSI West Corridor is a net importer of power in the EUCO scenario, slight exporter in the ST scenario, and almost neutral in the DG scenario (details about generation vs demand per country can be seen in Annex 7.2).
At a more detailed level, Figure 3.4 shows the energy balance for each country in the region for 2025 and the three 2030 scenarios.
Again, these are determined using the weighted average of the three climate years for each scenario. The energy balance represents whether a country is a net importer or exporter of energy for a particular scenario. The trends are:

- France, with its large nuclear capacity, is a significant exporter in all scenarios, also Spain is a net exporter in all scenarios due to its high RES potential. However, their highest export cases happen in different scenarios (EUCO in the case of France and ST in the case of Spain)
- Great Britain is an exporter in 2030 ST scenario only, being almost neutral in DG and a net importer in the EUCO scenario. Ireland is almost neutral in all scenarios and Northern Ireland is generally a net importer, but is almost neutral in the EUCO scenario
- Germany is a significant energy exporter in ST and DG, however a significant importer in the EUCO scenario due to the slower growth of RES generation
- In the Benelux countries, Belgium and Luxembourg are net importers in all scenarios, however, the Netherlands is an exporter in both ST and DG, with higher RES generation capacity
- Austria is net importer for ST and DG and exporter in EUCO scenario
- Both Italy and Portugal are importers in all three scenarios, Italy significantly so.

Figure 3.4: Import/Export balances

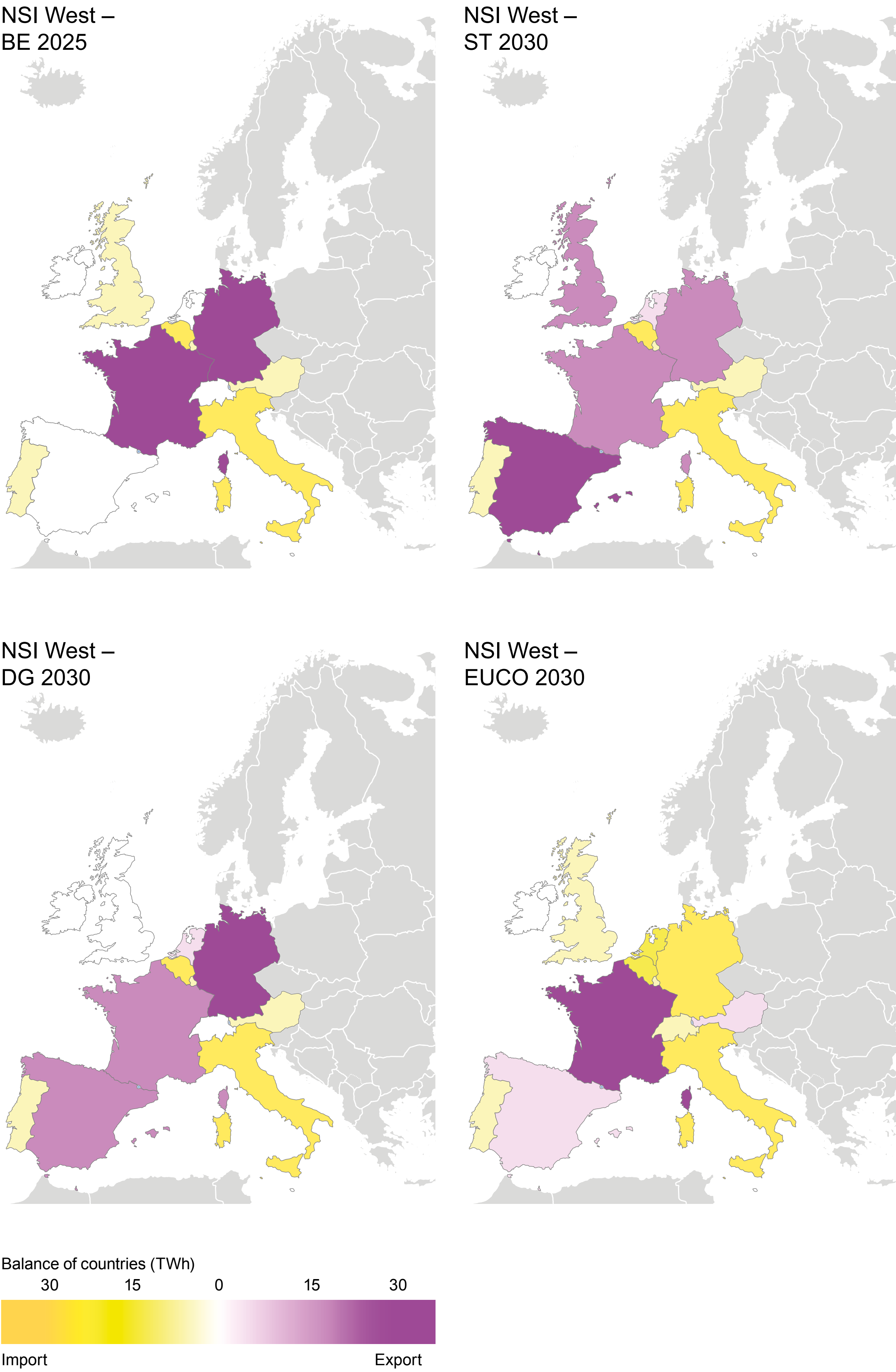
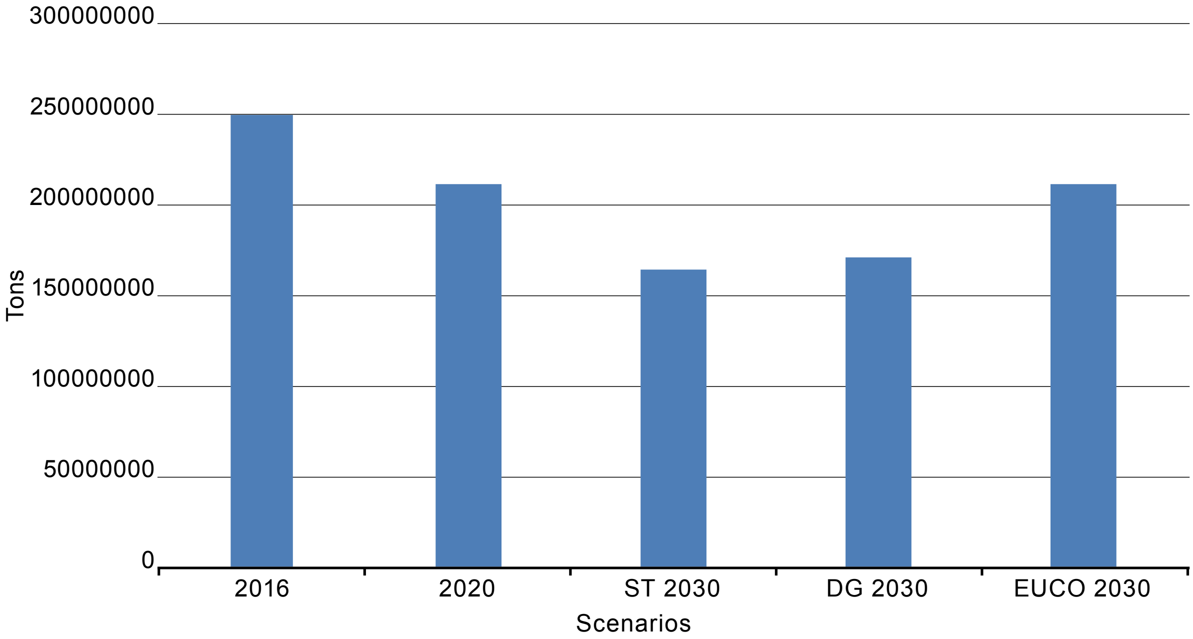
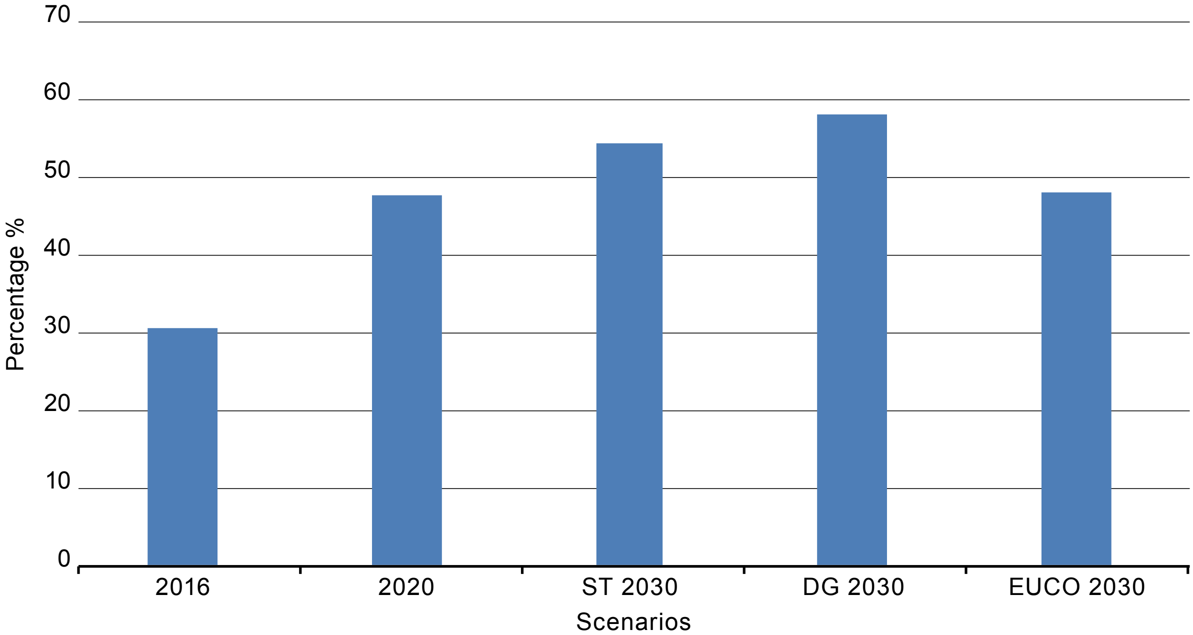


Figure 3.5 shows the CO_2 emissions and RES penetration for the region for 2020 and the three 2030 scenarios (2020 and 2016 years have been considered for CO_2 emissions and RES penetration respectively as a near today reference). Unsurprisingly, as the contribution from renewable generation, as part of the overall generation production, increases from 2016 to 2025 and on to 2030, CO_2 emissions in the region decrease. In particular, the DG scenario sees 60% of all demand being supplied by renewable generation, highlighting the prominent role of the 'prosumer' in this scenario; this scenario also has the lowest CO_2 emissions across the region.

The only exception is the EUCO scenario, with its lower levels of RES generation requiring greater running of thermal generation, resulting in larger CO_2 emissions than in the 2025, ST and DG scenarios (details about RES penetration per country are shown in Annex 7.3).

Figure 3.5: CO_2 emissions (top) and RES contribution as a percentage of demand (bottom) for 2016, 2020 and the three 2030 scenarios





Section 4

Regional needs, main boundaries and mid-term targets

This section bridges the regional long-term needs 2040 (identified in the Regional Investment Plan 2017), via the interconnection targets for 2030 to the list and description of European and regionally significant boundaries. The storyline of this section is schematically depicted in Figure 4.1.

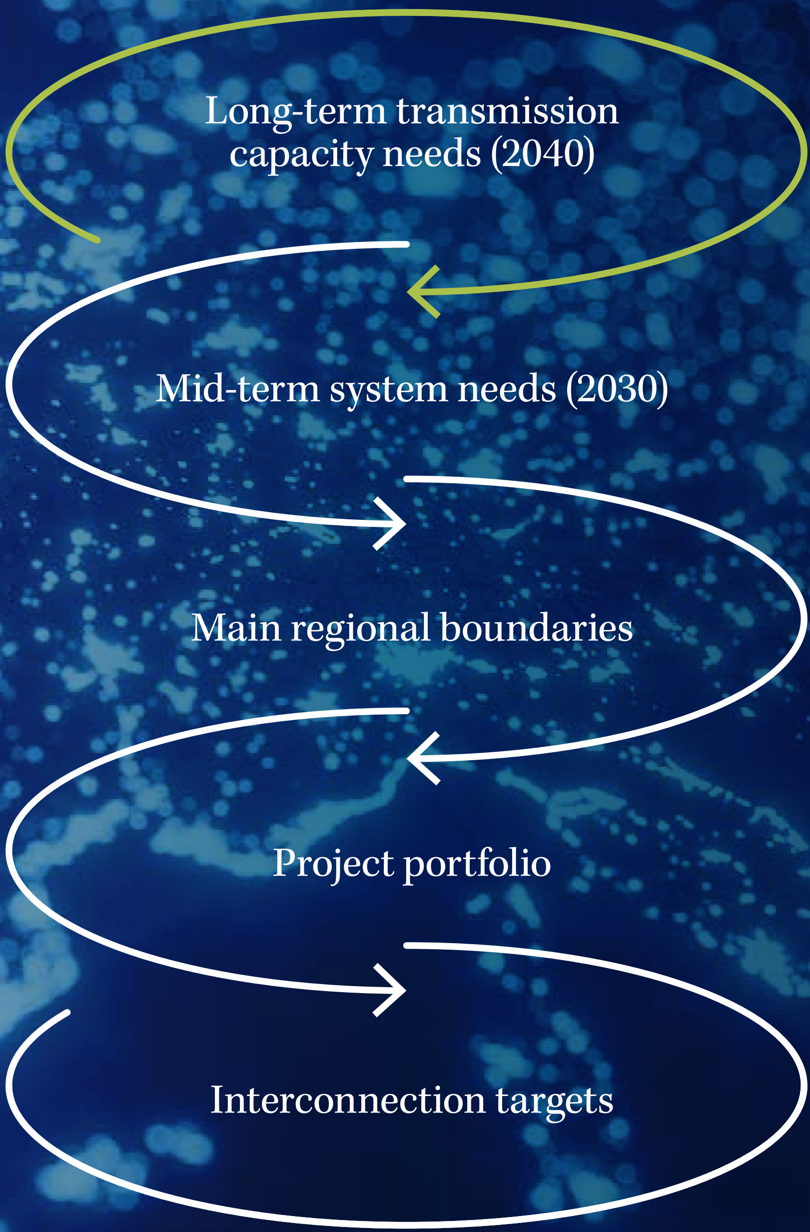


Figure 4.1: Study overview, needs targets and projects

4.1

Main needs in the region

4.1.1 Long-term transmission capacity needs (2040)

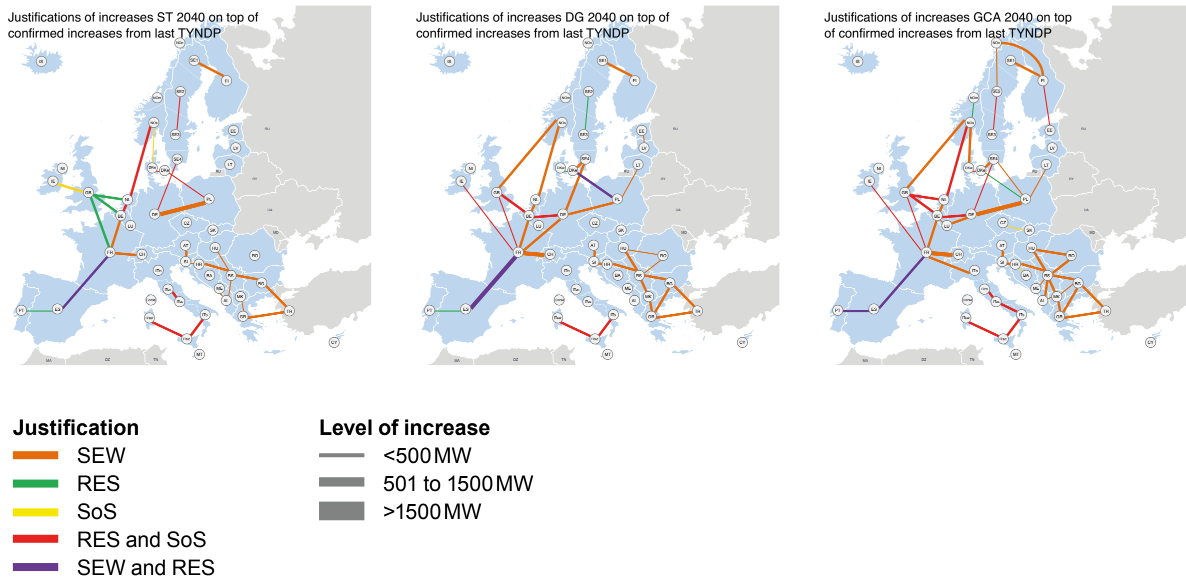
The 2017 Regional Investment Plan showed system needs for the long-term 2040 horizon. These needs were evaluated with respect to market integration/socio-economic welfare, integration of renewables and security of supply.

Following the pan-European Investigation of System Needs process, the main needs identified in the NSI West Corridor were:

- Further integration between Great Britain and the Continental system, due to i) price differences, ii) better optimisation of RES generation and iii) challenged security of supply in high demand/low variable RES (wind and solar) periods.
- Further integration between Germany and France, Belgium, Netherlands (east-west and north-south) due to i) optimisation of the production system and ii) potential to optimise the sharing of resources to ensure challenged security of supply in high demand and low-variable RES (wind and solar) periods.
- Further integration between Ireland and Great Britain/France due to i) price differences, ii) optimisation of RES generation and iii) challenged security of supply in high demand and low RES (wind and solar) periods.
- Further integration of the Iberian Peninsula (Portugal and Spain) due to i) price differences, ii) optimisation of RES generation.
- Further integration between Italian Peninsula and all neighbouring countries in order to: i) integrate Italian market, ensure security of supply and full integration of RES capacities by improving flexibility, also through the exploitation of the hydro-pumped storage plants in the Alps and to connect the Italian system with main islands and Corsica.

The dependency of the needs to the respective scenario assumptions needs to be taken into account. Only by considering a variety of studies (e.g. several TYNDPs) can a robust assessment of the needs be made.

Figure 4.2: Identified capacity increase needs from 2020 to the three 2040 scenario grids[1]



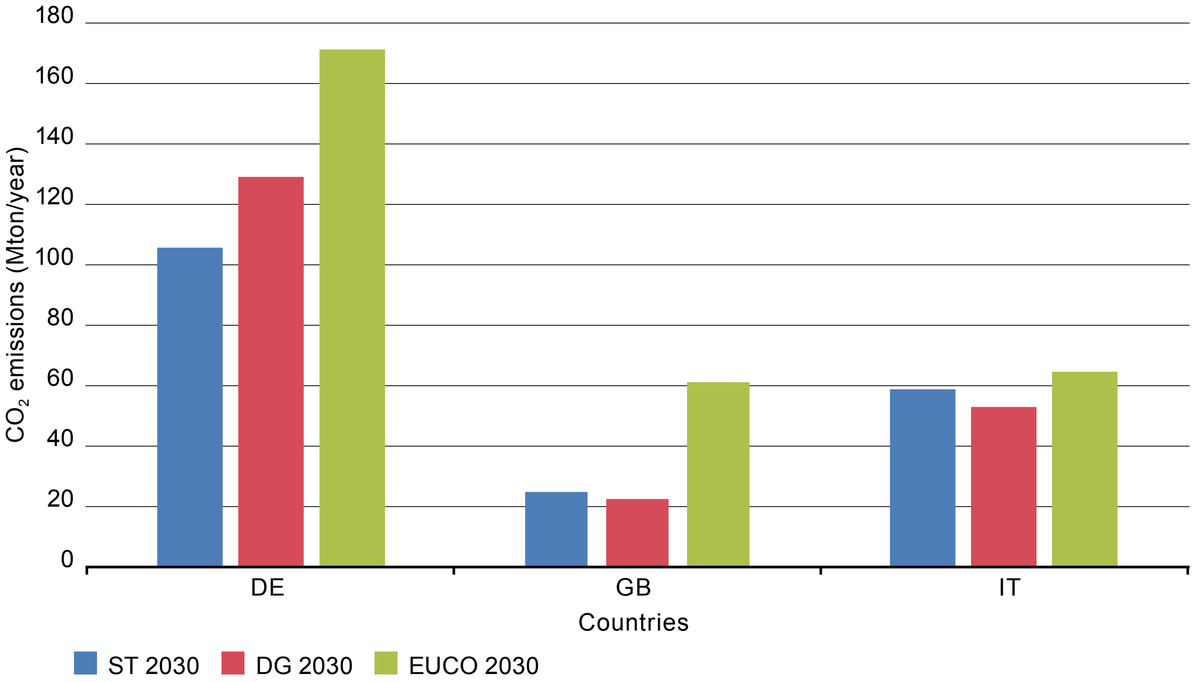
[1] "Confirmed Increases from last TYNDP" refers to the reference capacities of TYNDP 2016 for 2030 which for some borders had been adjusted for the TYNDP 2018 purpose. Projects commissioned in 2020 are not included as increases.

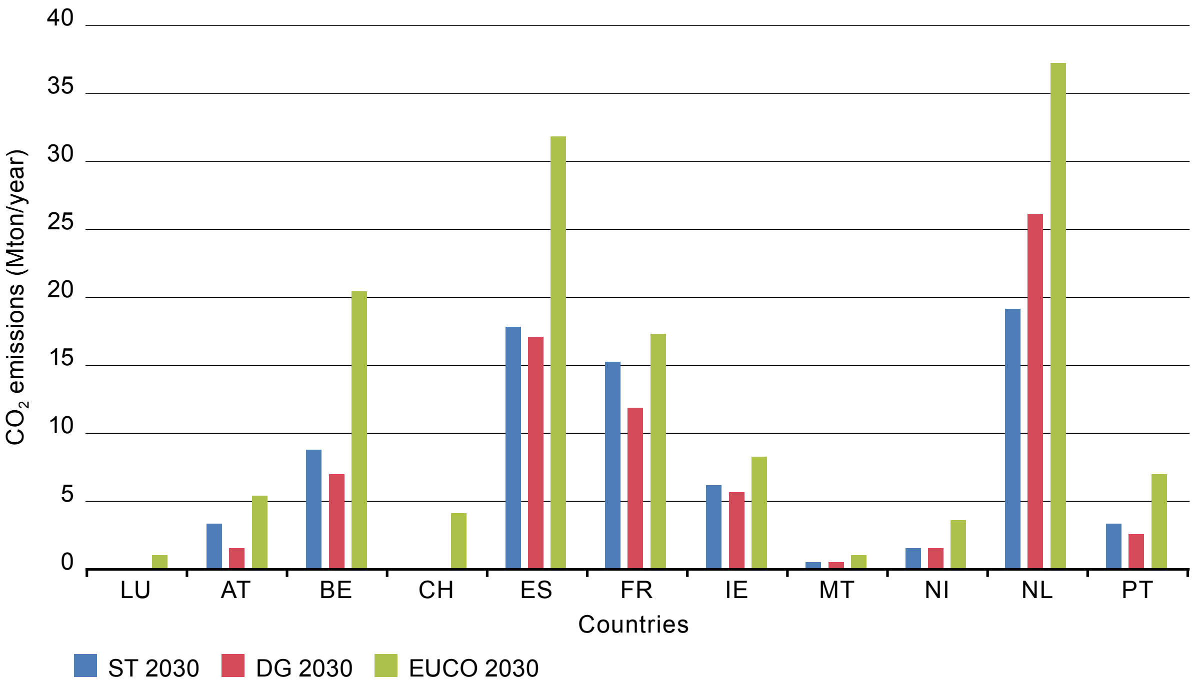
4.1.2 Mid-term transmission capacity needs (2030)

Considering the 2030 scenarios, Figure 4.3 presents the CO_2 emissions, RES curtailment and unserved energy for all countries in the region in the case of a no action situation, in other words they show how the system would behave with the 2020 grid[2] (no grid development beyond 2020) and with the 2030 scenarios.

The results help to identify and confirm the drivers for development in the region.

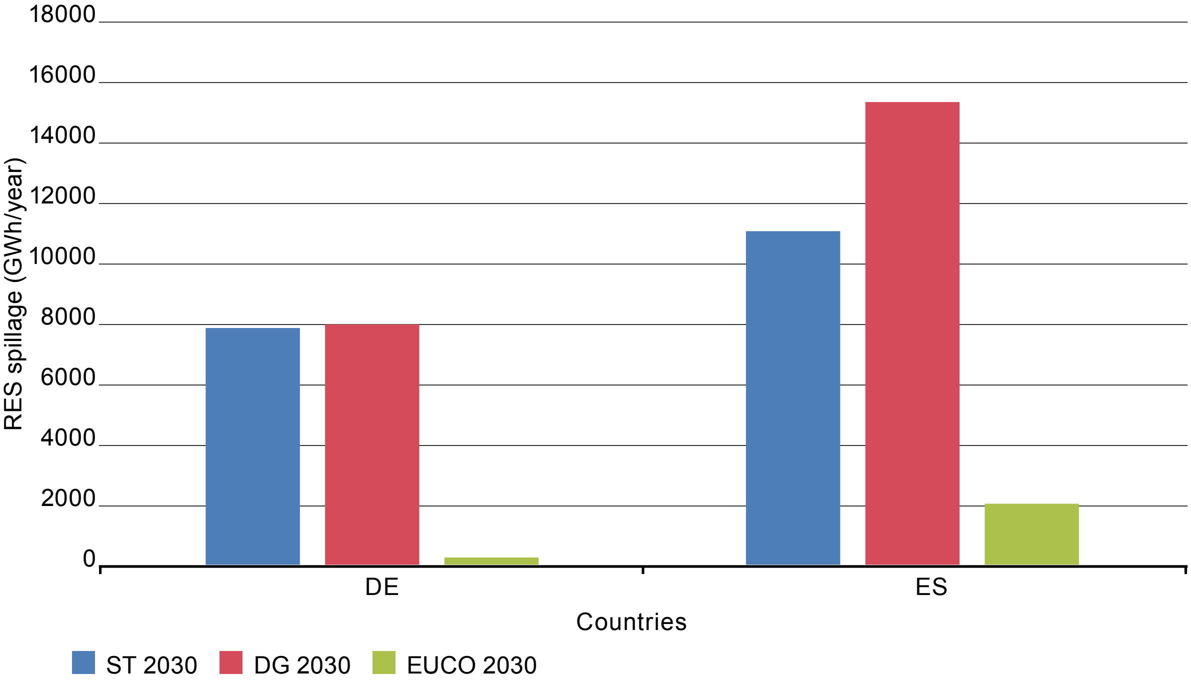
Figure 4.3: 2030 scenarios on the 2020 grid





[2] In this analysis, 2030 scenarios with 2020 grid, the reinforcement of the interconnection between Portugal and Spain was considered already in service, although currently the commissioning of the project is expected only for 2021.

Figure 4.3 continued: 2030 scenarios on the 2020 grid



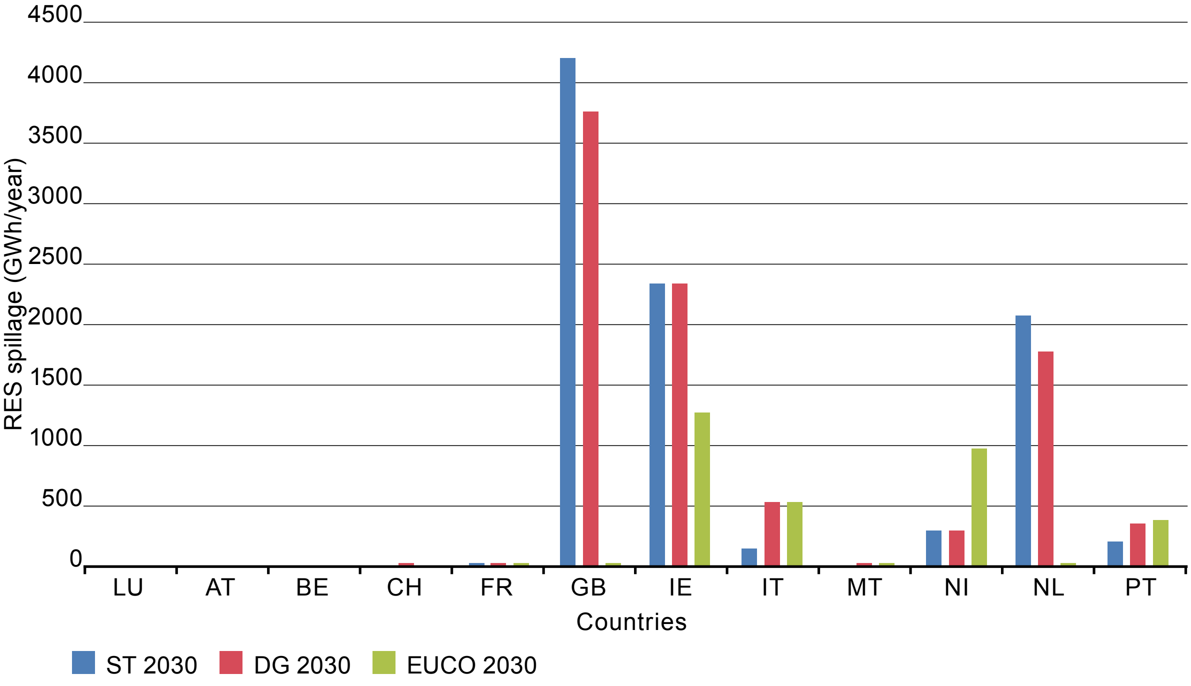
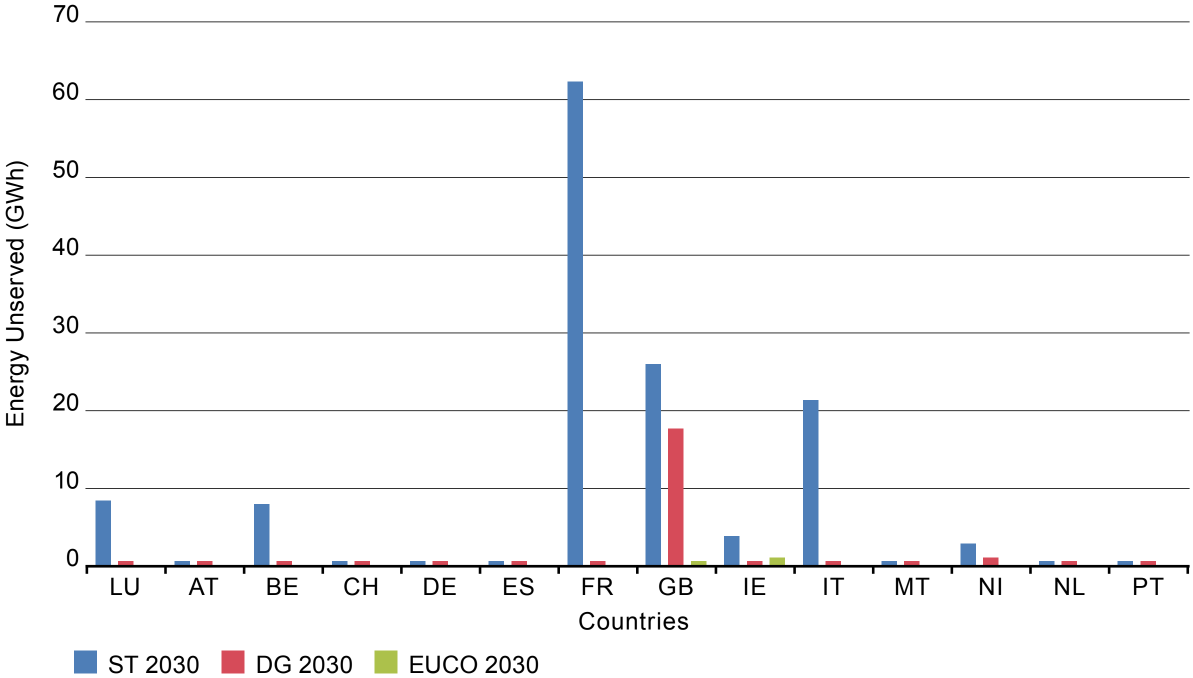


Figure 4.3 continued: 2030 scenarios on the 2020 grid



The results highlight the issues that further development of the network in the region might help solve:

— Reduce CO_2 emissions across the region, particularly for the EUCO scenario, by the sharing of renewable generation and more efficient thermal generation; CO_2 emissions in 2030 with the 2020 grid are particularly high in Germany and Italy. And the EUCO scenario shows a high difference of CO_2 emissions with the other scenarios, especially in Germany, Great Britain, Belgium and Spain.

— Maximise the integration of renewable generation by reducing the RES spillage observed in many countries for the ST and DG scenarios in particular (although the EUCO has also relevant values of spillage in Spain, Ireland and Northern Ireland and Italy). The highest value of spillage in 2030 with the 2020 grid is identified in Spain and Germany;

— Share resources to reduce the impact of unserved energy in countries across the region, particularly in France, Great Britain, Italy and Ireland and Northern Ireland. It should be noted that the key reason why there is no significant security of supply issue is the fact that the scenarios are constructed to make sure every country has sufficiently adequate generation mix to cover its demand for the studied climatic years.

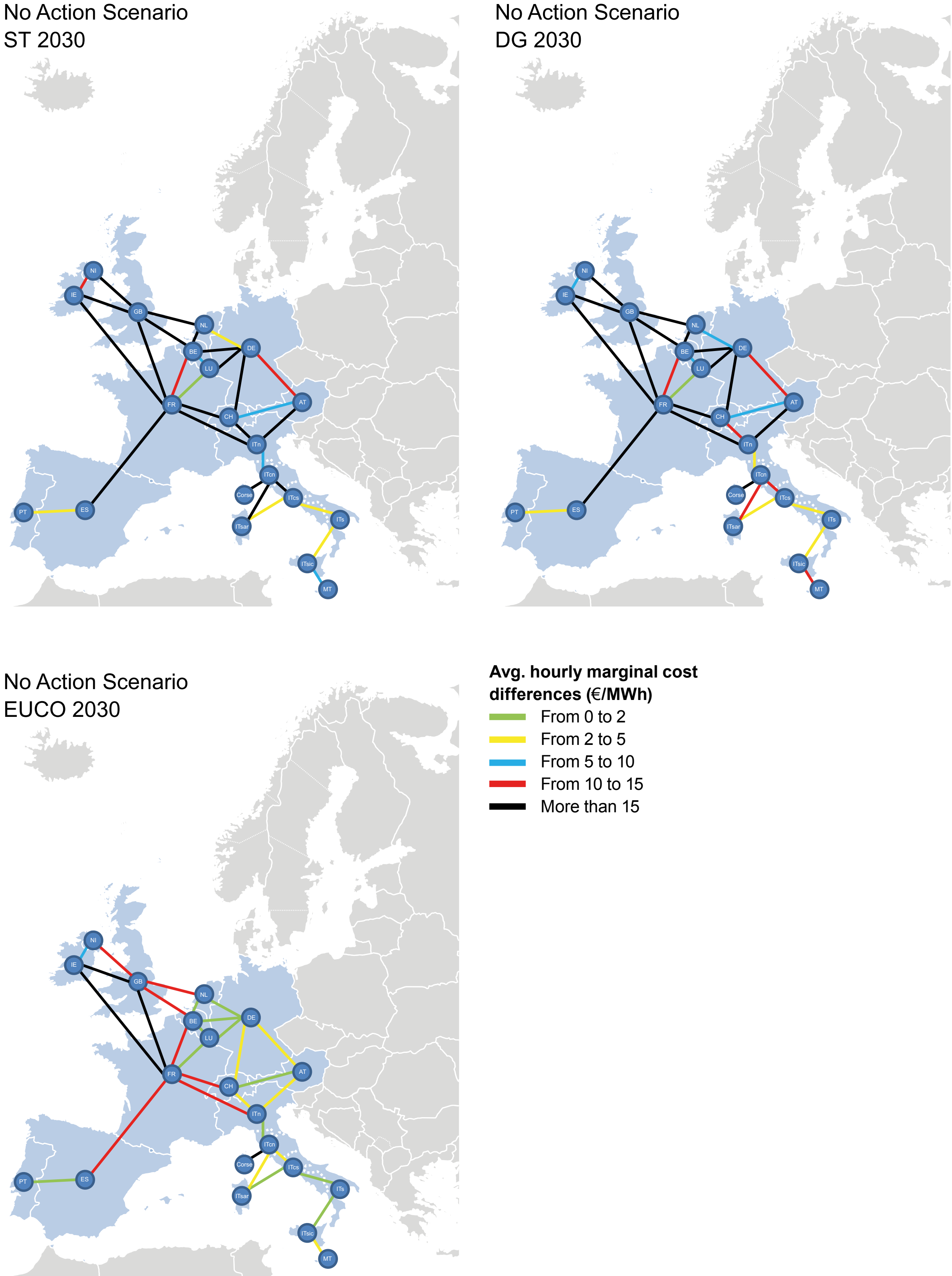
— To be in line with these adequacy standards, additional flexible thermal generation has been introduced in the scenarios during the scenario building phase. This new thermal generation is not necessarily economically viable in an energy-only market, hence, (partially) relying upon capacity remuneration mechanisms.

— Thanks to the sharing of resources, interconnectors ensure security of supply in a more cost-effective manner compared to an isolated approach, which requires greater installed generation capacity at an individual country level.

— Alternatively, if the level of installed generation capacity is maintained, the addition of additional interconnection capacity will reduce the amount of unserved energy. This effect is illustrated in Table 4.2 when comparing the unserved energy between the levels of interconnection capacity assumed in 2020 and in 2030.

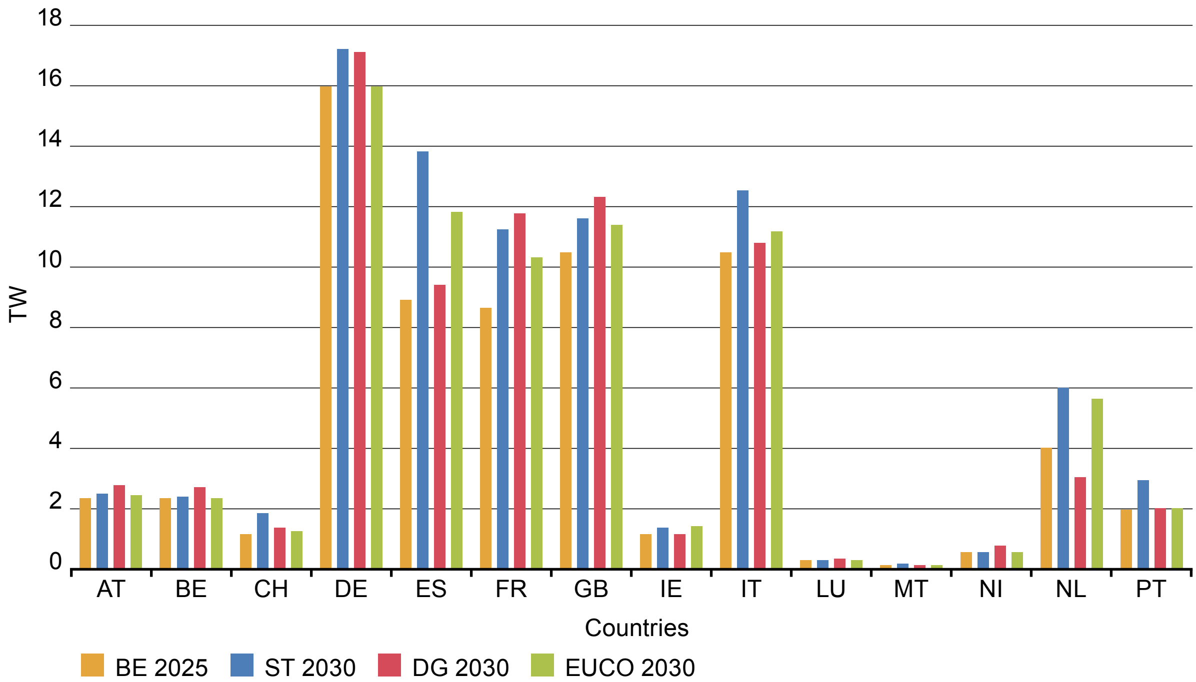
The next figure shows the marginal cost differences in the region in the case of a no action situation, in other words they show how the system would behave with the 2020 and with the 2030 scenarios. The results indicate that development in the region is required as, without grid development beyond 2020, there would be many borders in Europe with differences higher than 15€/MWh especially in the ST and DG scenarios. In the EUCO scenario, differences higher than 15€/MWh only affect the triangle Ireland-Great Britain-France, and Italy-Corsica.

Figure 4.4: Marginal cost differences with 2030 scenarios on the 2020 grid



Unlike conventional generation with costly but controllable sources of primary energy, RES utilise primary energy sources with variable nature, hence the energy produced by RES plants must be balanced in order to maintain the equilibrium of the system. In this regard, in mid/long-term scenarios, the increase of energy produced by RES, and decommissioning of thermal plants, will cause high residual load ramps, defined as the remaining load after subtracting the production of variable renewable energy sources (wind and solar production). Figure 4.5 shows the 99.9 percentile highest hourly ramp of total native load minus non-controllable VRES generation (wind and solar).

Figure 4.5: NSI West Corridor overview of the residual load ramps in 2030 scenarios 2020 grid



In more detail, the figure above reveals a high value of load ramps for some countries. If the power system cannot face such strong ramps, consequences could be load shedding leading in extreme cases to blackouts. Therefore, the strong necessity to improve the flexibility of the system is a strong driver for investments in transmission infrastructure.

According to the above mentioned analyses, investing in transmission infrastructure is essential for guaranteeing satisfying values of security of supply, for increasing the amount of RES integrated and for improving the market integration in the region, thanks to the improvement in sharing resources between different areas that interconnection makes possible. The above-mentioned needs can be mostly addressed in the mid term thanks to the confirmed planned projects of TYNDP 2016 even if, according to additional analyses and the expert view of the TSOs of the region, these projects are not completely sufficient to reach an adequate security of supply in the long-term scenarios.

PCI projects are of particular primary importance in this path toward a more secure, sustainable and integrated transmission system, such as planned interconnections on the northern Italian boundary, and the integration of the Iberian Peninsula to the European Continental system, through the development of the France – Spain interconnection.

Internal lines in each of the concerned countries and links between mainland and major islands (like Corsica and Sardinia) are important as well to overcome problems due to scarcely meshed grid and isolation. The PCI projects of the NSI West Corridor that are of primary importance to integrate the Italian Peninsula and to mitigate the needs in the area are: Interconnection between Airolo (CH) and Baggio (IT); Interconnection between Grande Ile (FR) and Piossasco (IT) [currently known as "Savoie- Piemont"]; Interconnection between Codrongianos (IT), Lucciana (Corsica, FR) and Suvereto (IT) [currently known as "SACOI 3"]; Interconnection between Thusis/Sils (CH) and Verderio Inferiore (IT) [currently known as "Greenconnector"].

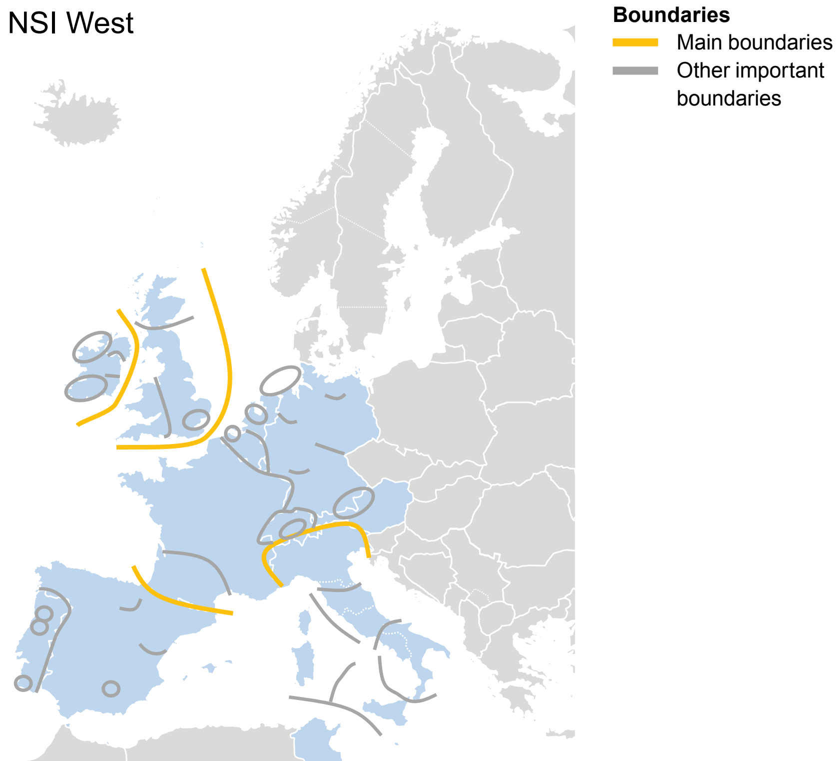
4.2
Boundary impact from a regional focus

A boundary is identified every time a major barrier, preventing optimal power exchanges between countries or market nodes, occurs.

General reasons in this region for these boundaries/barriers include:
— Natural barriers, such as mountains and seas, which have been a geographical difficulty to the grid development;
— High price differences between countries;
— A significant increase in RES generation in a certain region; and
— Increased local variability of power infeeds causing higher regional flows which require stronger integration of power systems.

Four European boundaries were identified in TYNDP 2016 in the NSI West Corridor, and they are highlighted in yellow in Figure 4.6.

Figure 4.6: Investment needs and main boundaries in the NSI West Corridor (TYNDP 2016)



The priority European boundaries in the NSI West Corridor in this TYNDP 2018 are:

- **Ireland to Great Britain and Continental Europe**
- **Great Britain to Continental Europe (and Nordics)**
- **The Iberian Peninsula** – between France and the Iberian Peninsula (Spain and Portugal)
- **Italian Peninsula integration** – between Italy and its neighbours Slovenia, Switzerland, Austria and France (including Corsica).

Figure 4.4 shows the cross-border marginal cost differences in the NSI West Corridor for the three 2030 scenarios with the 2020 grid. With that information, the main boundaries identified in TYNDP 2016 are therefore still valid for TYNDP 2018.

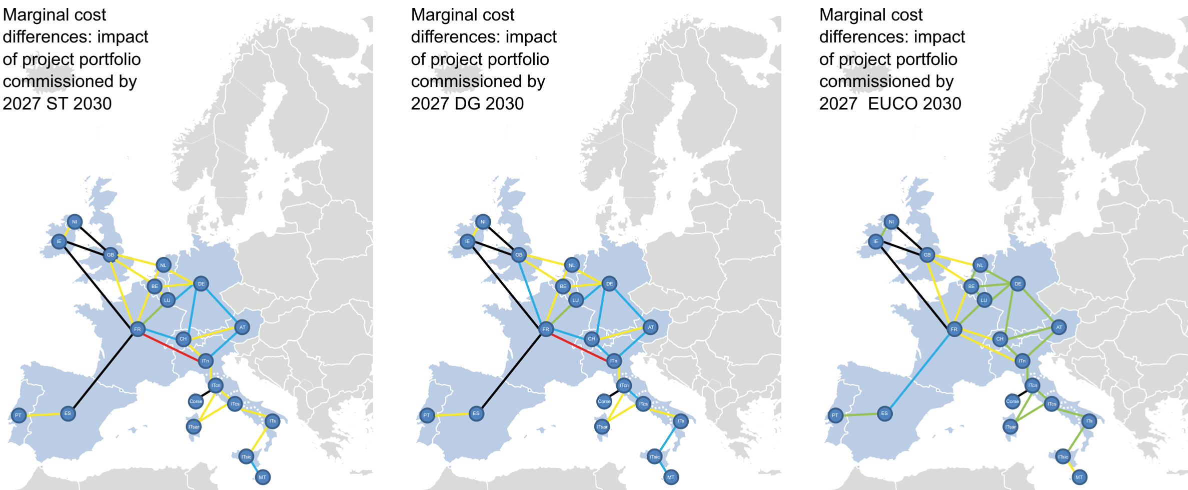
As well as the five main European boundaries, there exist a number of regionally important boundaries. These boundaries are related to the long-term needs as described in Section 4.1.1 and reflected in the regional key messages of Section 2. In particular, as highlighted in the system needs report, the grid is heavily congested in the Central West Europe area (Benelux, Germany and France). This is due to its central location in facilitating both north-south and west-east power flows. Also, the border between Portugal and Spain presents some congestions due to price differences between both countries.

These regionally important boundaries are also shown in Figure 4.6, and are highlighted in grey.

Figure 4.7 shows the cross-border marginal cost differences in the NSI West Corridor for the three 2030 scenarios with the reference grid (projects to be commissioned by 2027 that have already started the permitting in 2018). There is an important improvement from values shown in Figure 4.4 with the 2020 grid, which reflects that the projects in the reference grid are needed to help the Internal Energy Market (IEM) functioning.

However, there are still some borders with cost differences higher than 15€/MWh such as from Ireland to both Great Britain and Continental Europe. Additionally, large price differences exist from both the Iberian Peninsula and Great Britain to Continental Europe, and from Italy to Corsica in every scenario. Also, cost differences higher than 15€/MWh still occur between Iberian Peninsula and France. In addition, high prices differences are detected between France and Italy.

Figure 4.7: Marginal cost differences for the three 2030 scenarios with reference grid (2027)



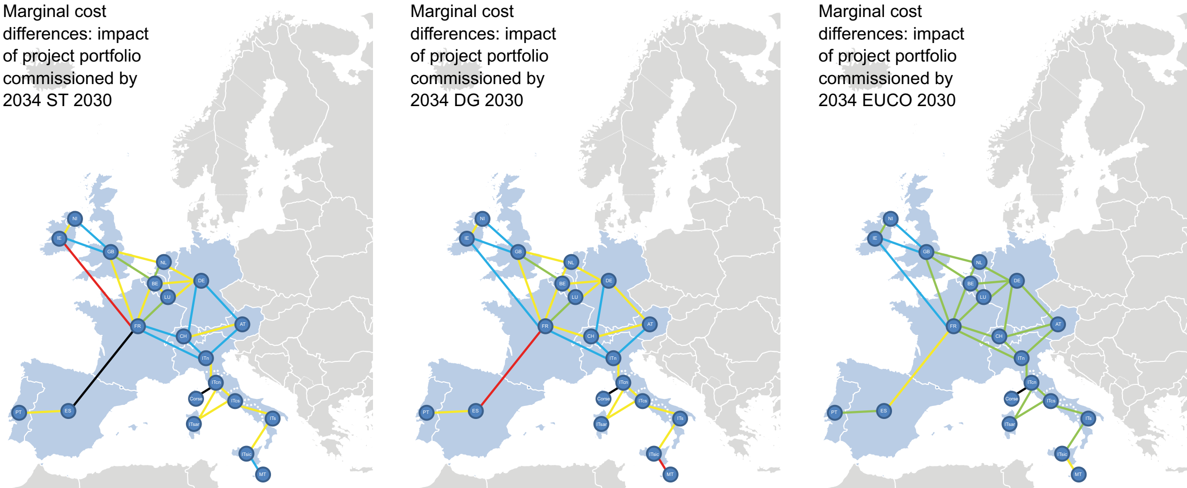
Avg. hourly marginal cost differences (€/MWh)

- From 0 to 2
- From 2 to 5
- From 5 to 10
- From 10 to 15
- More than 15

Figure 4.8 shows the cross-border marginal cost differences in the NSI West Corridor for the three 2030 scenarios with the PINT projects (projects to be commissioned by 2034 beyond the reference grid). There is an important improvement from values shown in Figure 4.5 with the reference grid, which reflects that the PINT projects might contribute to improve the IEM functioning.

There are still some high marginal cost differences especially in ST and DG scenarios, in the main regional boundaries defined previously. Further explanation can be found in the next section.

Figure 4.8: Marginal cost differences for the three 2030 scenarios with grid by 2030



Avg. hourly marginal cost differences (€/MWh)

- From 0 to 2
- From 2 to 5
- From 5 to 10
- From 10 to 15
- More than 15

These boundaries cause tensions in the transmission grid between particular areas of Europe, where potential for RES is high – hydro and wind mainly in the north and solar in Mediterranean countries – and in densely populated areas with large power consuming areas. These barriers appear mostly where geography has set natural barriers: seas and mountain ranges, more difficult to cross.

In order to provide a quick overview of one of the main development needs affecting the region, the figures below show the aggregated price differences on the main boundaries. These figures highlight the very high values of price spreads expected if the grid wasn't to evolve beyond 2020, and the mitigation that the planned projects will introduce. It must be underlined that even considering all the projects commissioned by 2034 the price differences present remarkable values on the main boundaries of the region (in Annex 7.4 the aggregated price differences on the main boundaries for the reference grid are shown).

4.3
Socio-economic benefits and capacity changes on boundaries

All the scenarios studied include a large increase in renewable generation and decrease in CO_2 emissions. Without additional grid development beyond 2020, however, the full range of benefits will not be realised.

On the other hand, Figures 4.8 to 4.11 show the development of the SEW in the case of uniform capacity increases across the five main boundaries in the NSI West Corridor.

The following figures show the variation of the socio-economic welfare due to commercial flows in the energy-only market, when transmission capacity across the four main boundaries of the NSI West Corridor is developed. The benefits depicted in the figures are not exhaustive (they do not include all the other benefits provided by the transmission projects like increase of security of supply, RES integration, increase of flexibility and operational security, reduction of ancillary services cost, reduction of emissions, etc.) and are significantly dependent on the scenario. In addition, it is worth noting that the variation of the socio-economic welfare on one boundary – due to the variation of the transmission capacity across that boundary – is strongly related to the grid considered in the entire pan-European perimeter. For the analyses reported in this section, the reference grid at year 2027 has been considered, and the results depend on the real commissioning of the planned projects outside the boundary under evaluation. In fact, despite the fact that the SEW/GTC curves are not very steep, the 2030 scenarios with 2020 grid analyses show considerably high price differences, highlighting the strong need to improve market integration.

These SEW/GTC curves can be used to get an idea of the socio-economic welfare of increasing capacities beyond 2020 values. SEW is considered in the CBA as the savings in variable generation cost, but it is important to mention that it is not the only benefit considered in the CBA. These curves do not consider the cost of potential projects beyond 2020. In cases where the SEW compensates the cost of a project that provides certain capacity increase, the profitability of the project is ensured. Otherwise, the other CBA indicators or potential additional benefits of the projects should be carefully analysed to check the profitability of a new project.

4.3.1 Ireland to Great Britain and Continental Europe

Figure 4.8 shows the price differences after having implemented the projects up to the end of 2030. These additional projects decrease price differences even further.

The degree to which the prices reduce varies according to the scenario. Due to how it was constructed, the EUCO scenario shows the greatest degree of cross-border price reduction on all but a few boundaries within northern areas of the Nordics.

Figures 4.9 to 4.12 show the development of the SEW in the case of uniform capacity increases across the three main boundaries in the NSI West Corridor. The benefits depend on the scenario and on the number of projects already having crossed the boundary before the investigated project is built.

The SEW/boundary capacity curves provide an indication of the value of increasing capacities across boundaries beyond the reference capacity, which is an isolated view on the development of regional variable generation cost, called "SEW" indicator in the CBA. However, it is important to note it is not the only benefit considered in the CBA, but other benefits such as RES integration or CO_2 savings are also part of the multi-criteria CBA. Additionally, it is important to note that the curves consider neither the cost of potential projects beyond 2020 nor the losses, potentially introducing further costs.

Thus, the SEW value in the graphs below should not be confused with the "socio-economic welfare" project promoters may have in mind when using the same terminology to describe the aforementioned (or more) components being combined and depreciated.

Where the SEW benefits compensate the cost of a project providing a certain capacity increase, the profitability of the project is ensured. Otherwise, the other CBA indicators and/or potential additional benefits of the projects may be the trigger for a project; on the other hand, it may indicate the need for an alternative asset, such as a storage project.

Figure 4.9: SEW vs. boundary capacity – Ireland to Great Britain and Continental Europe

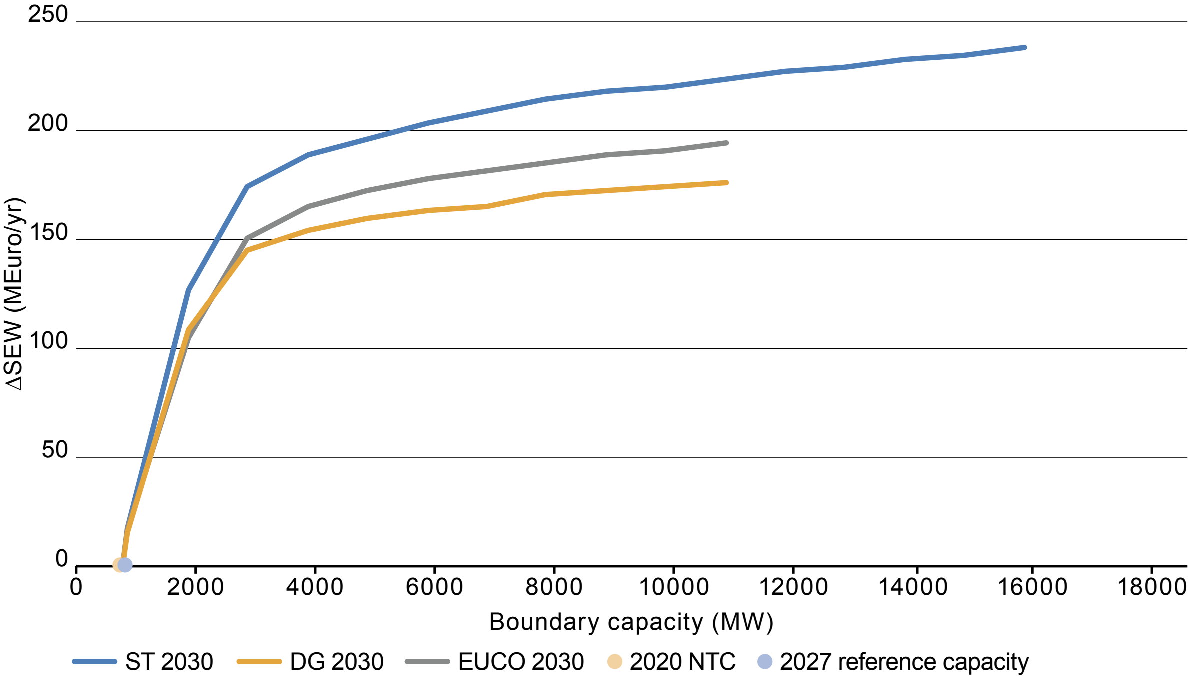


Table 4.1 : TYNDP 2018 projects for Ireland to GB and Continental Europe boundary

Project ID	Name	Commissioning	NTC increase (MW)
107	Celtic Interconnector	2026	700
286	Greenlink	2023	500

4.3.2 Great Britain to Continental Europe (and Nordics)

The transition from thermal to RES generation, alongside the replacement of coal with gas generation, will require stronger interconnection of Great Britain with both the Nordics countries and Continental Europe. Additional capacity across this boundary will allow the integration of RES generation, and security of supply by linking together three areas of differing generation portfolios.

Investments across the boundary will play a key role in delivering European market integration, as well as developing the Northern Seas Offshore Grid infrastructure.

The analysis shows that projects between the Nordic and Great Britain systems have high benefits, however, there are also high costs due to the long distances involved. Substantial price differences remain between the Nordics and British system in all scenarios.

As demonstrated in Figure 4.8, the reference grid capacity for this boundary has changed since TYNDP 2016. Previously it was 10.2 GW. For the TYNDP 2018 analysis, it is 14.4 GW. This significant increase results in a corresponding decrease in SEW benefits for all projects assessed as part of this border. The reference capacity now aligns with the flatter, saturated area of the curve in Figure 4.8. As a project is assessed against this capacity, there is less of a SEW benefit available to the project.

Figure 4.10: SEW vs. boundary capacity – Great Britain to Continental Europe and Nordics

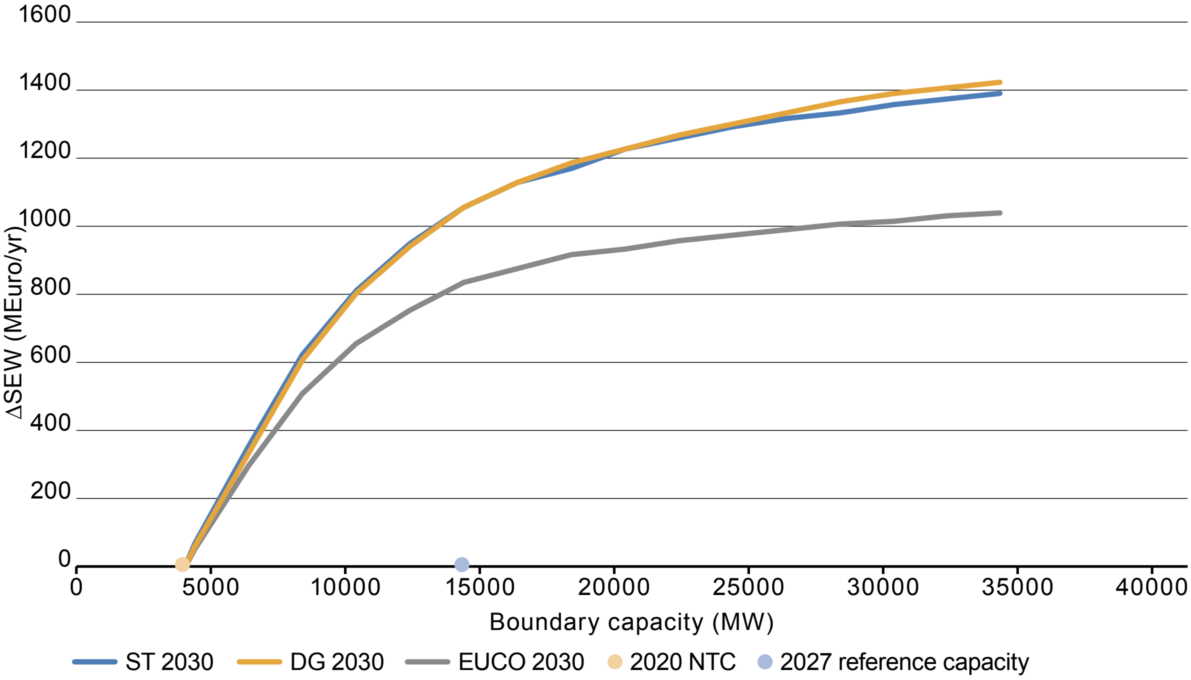


Table 4.2: TYNDP 2018 projects for Ireland to GB and Continental Europe boundary

Project ID	Name	Commissioning	NTC increase (MW)
25	IFA2	2020	1000
74	Thames Energy Cluster	2019	1000
110	Norway-GB NSN	2021	1400
121	Nautilus (2nd interconnector Belgium-UK)	Earliest 2028	1400
153	France-Alderney-Britain	2022	1400
167	Viking DKW-GB	2022	1400
172	ElecLink	2020	1000
190	NorthConnect	2022	1400
247	AQUIND Interconnector	2022	1800
260	New GB-NL Interconnector	2030	1000
271	Conceptual Northern Seas Offshore Grid Infrastructure		
285	GridLink	2022	1400
286	Greenlink	2023	500
286	Greenlink	2023	500

4.3.3 Iberian Peninsula

The following SEW/GTC curve shows that projects between the Iberian Peninsula and France have high benefits (in the range of 50-150 M€/y for 1 GW capacity increase up to 10 GW in the ST and DG scenarios). Values are higher in ST and DG scenario than in the EUCO at every boundary, as in the ST and DG scenarios the main trend is that the high RES potential in the Iberian Peninsula is exported to central Europe.

Although the curves start to be flat beyond the 15 GW of exchange capacity, the reference capacity is 5 GW (considering the Biscay Gulf project) and the full TYNDP 2018 project portfolio aims at reaching 8 GW of NTC between France and Spain with two additional trans-pyrenean projects, the target capacity can not be clearly defined.

In spite of proven evidence of benefits in the increase of cross-border capacity through this boundary, the corresponding projects that could address these capacity increases might be of special complexity, and their added value might be limited by internal congestions. Their costs (as they should cross the Pyrenees or be submarine in the Atlantic or the Mediterranean sea, and solve internal bottlenecks) are rather high, especially when projects are envisaged in HVDC technology in order to comply with social requirements.

Figure 4.11: SEW vs. boundary capacity – Iberian Peninsula

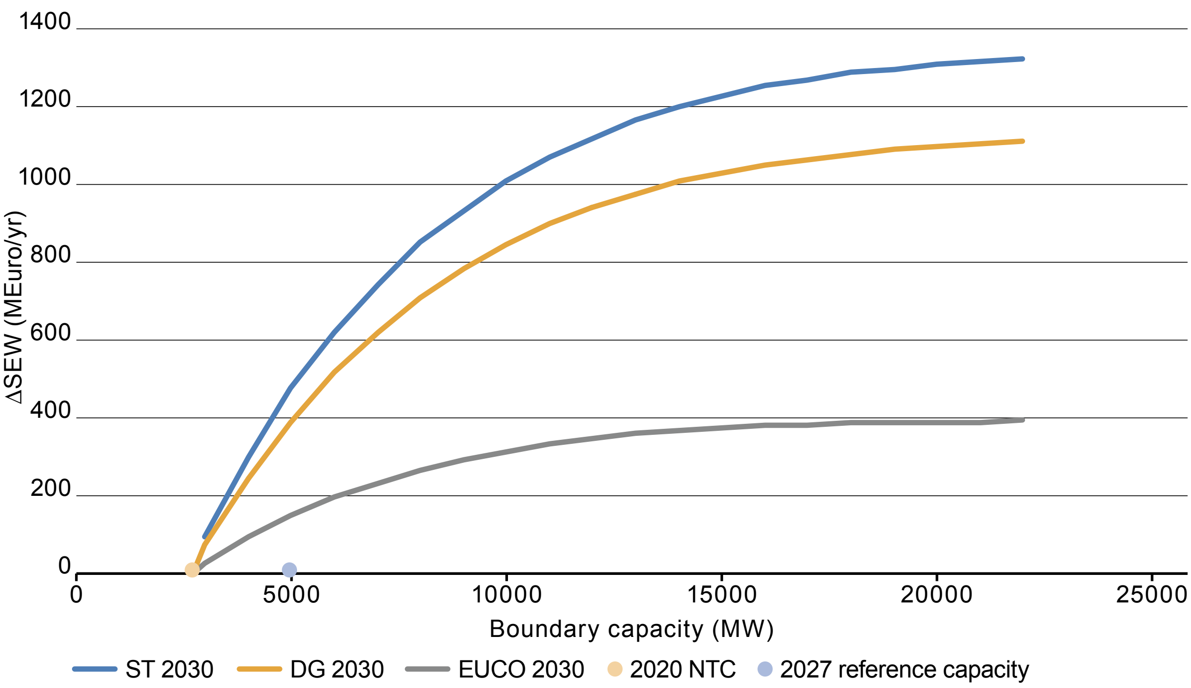


Table 4.3 shows the TYNDP projects to be commissioned in this border in order to increase 2020 exchange capacity values (NTC) of 2,800 MW.

Table 4.3 TYNDP 2018 projects for Iberian Peninsula boundary

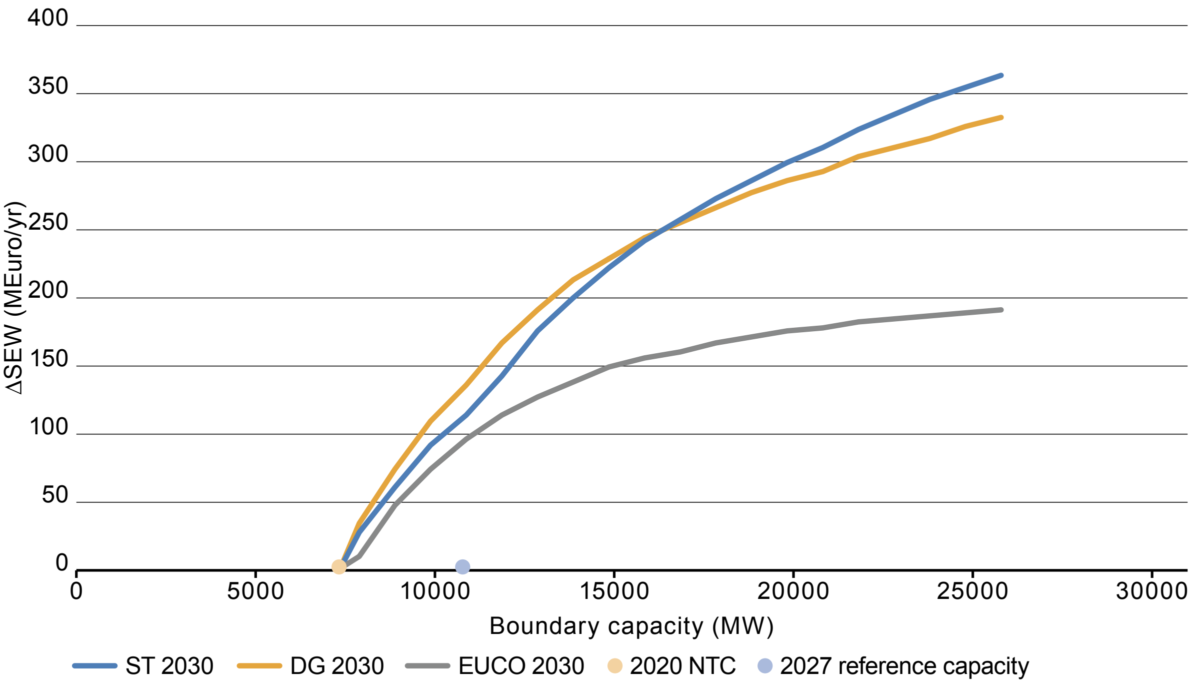
Project ID	Name	Commissioning	Overall boundary NTC (MW)
16+378+379	Biscay Gulf + uprates Gatica + Gatica transformer	2025	2200
276	Navarra – Landes	2027	1500*
270	Aragón – Atlantic Pyrenees	2027	1500**

* Value of the capacity increase reached under the assumption that previous projects have been commissioned.
** Value of the capacity increase reached by 2030 under the assumption that previous projects have been commissioned.

4.3.4 Italian Peninsula integration

The integration of the Italian Peninsula, one of the main barriers for the power exchange in this pan-European perimeter, is related to the connection of the Italian system and main islands to the heart of the European market, including Corsica.

Figure 4.12: SEW vs. boundary capacity – Northern Italy



The following projects are planned on the "Italian Peninsula integration" boundary

Table 4.4 TYNDP 2018 projects for Italian Peninsula boundary

Project ID	Name	Commissioning	NTC increase (MW)
21	Italy – France IT-FR	2019	1000 (IT>FR) – 1200 (FR>IT)
26	Austria – Italy IT-AT	2021	300
31	Italy – Switzerland IT-CH	2025	750
150	Italy – Slovenia SI-IT	2025	1000
174	Greenconnector IT-CH	2022	850
210	Wurmlach (AT) – Somplago (IT) Interconnection IT-AT	2021	150
250	Merchant line "Castasegna (CH) – Mese (IT)" IT-CH		100

Table 4.5 details the increase in capacity for all scenarios for the five boundaries in the NSI West Corridor. The 2027 capacity describes the reference grid, the 2035 capacities result from the capacity increase through the Identification of System Needs process and the 2040 capacities were identified as scenario capacities for each scenario. Further information on these can be found in the Regional Investment Plan 2017.

Table 4.5 Boundary capacities (NTC) in [GW] in the NSI West Corridor

Scenario	Ireland to Great Britain & Continental Europe (GW)	=> East / <= West Great Britain to Continental Europe and Nordics	=> North / <= South Iberian Peninsula	=> North / <= South Northern Italy
2016	0.95	3	2.4-2.8	8.5/3.6
2020	0.95/0.58	4	2.6-2.8	9.7/3.5
2027 (Ref.cap CBA)	0.95/0.78	14.40	5	13.3/8.4
2035 ST, DG, EUCO	2.15/1.98	19.80	8	13.9/8.9
2040 ST	2.70	16.10	9	13.9/8.9
2040 DG	2.20	14.60	10	13.9/8.9
2040 GCA	2.20	15.10	9	14.9/9.9

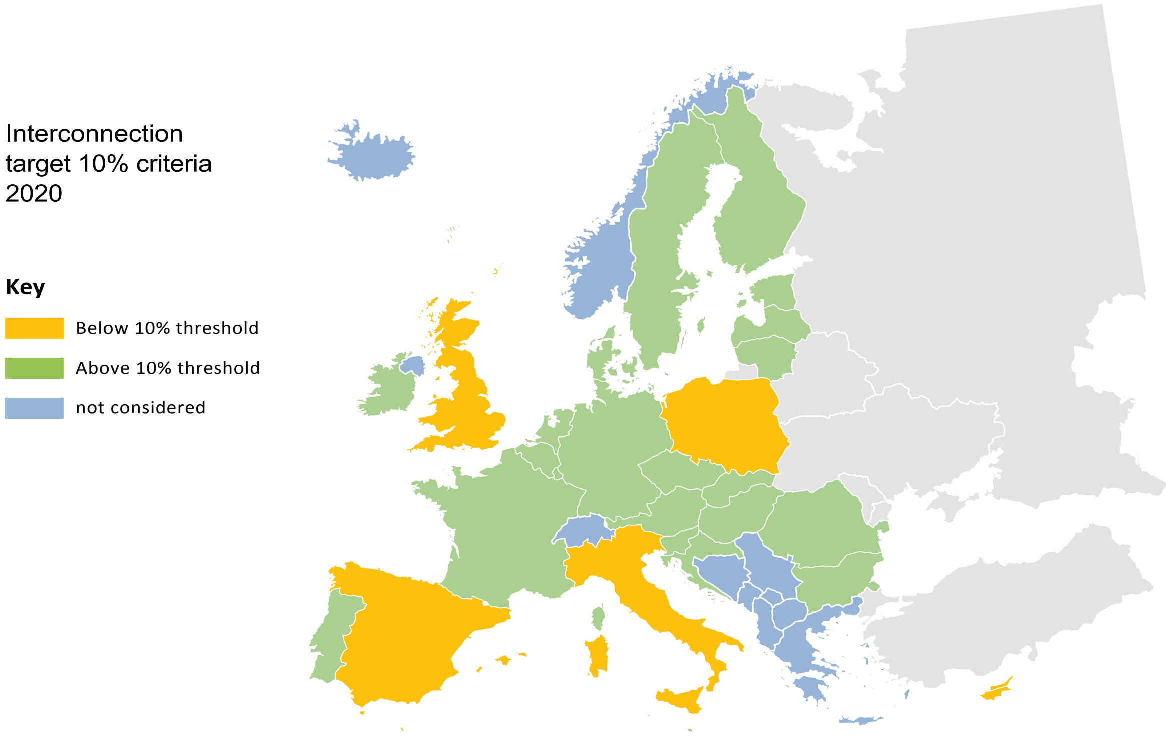
It should be noted that the level of the identified capacities of full project portfolio shown in Table 4.5 is significantly lower than the level of boundary capacity for which the SEW starts to become flat on SEW/capacity diagrams (for example, in the case of Iberian Peninsula, the identified capacities provided by project portfolio amount to 8 GW while the SEW/capacity diagram becomes flat at about 15 GW of exchange capacity. The difference is that the SEW/capacity diagram reflects a need for additional cross-border exchange capacity (around 15 GW on our example) without highlighting whether there exists any potential project addressing this need and at what cost, while Table 4.5 shows the effect of the existing project portfolio in terms of overall NTC (8 GW on the example).

Bridging the gap (from 15 GW to 8 GW on the example) requires identification of new potential projects, their cost, their ability to bring the expected additional cross-border capacity and assessing their cost/benefit ratio. The outcome may be that some potential good value for money projects are missing in the studied scenarios, that some additional benefits beyond SEW are not considered enough, but it may also be that there does not exist any additional project likely to accommodate the extra need on an economical basis. In the specific case of the Iberian Peninsula, where there are three projects in the project portfolio, it is relevant to progress with these projects before defining new ones, as how they evolve could affect the content of potential future projects beyond them.

4.4
Regional mid-term targets

In October 2014[3], the European Council put forward an initial interconnection target of 10% for Member States by 2020 and called for speedy implementation of all the measures to achieve this target. The target is computed as total import capacity divided by installed generation capacity. The EC "communication on strengthening Europe's energy networks" [4] published in November 2017 shows that in 2020 Great Britain, Spain, Italy, Poland and Cyprus won't fulfil that objective.

Figure 4.13: Fulfilment of the 10% interconnection target in 2020 (source EC)



In addition, the European Council also endorsed the proposal by the European Commission of May 2014[5] to extend the current 10% electricity interconnection target to 15% by 2030 "while taking into account the cost aspects and the potential of commercial exchanges in the relevant regions." In November 2017, the EC set up an Expert Group (EG) composed of industry experts, organisations, academia, NGOs, ACER and ENTSO-E/G. The EG presented a report[6] recommending criteria for the assessment of needs to develop interconnection capacity further. Additionally, the EG also proposed a multi-criteria assessment, using the following 3 criteria:

— Minimising price differentials: Recommendation of 2€/MWh for the wholesale price between market areas as the indicative threshold to consider developing additional interconnectors. This trigger focuses on increased market integration and lower prices for the benefit of all.
— Meeting electricity demand, through domestic generation and imports: Recommendation that the sum of all nominal transmission capacity is at least above 30% of the peak load. This trigger contributes to guaranteeing sufficient security of supply.
— Decarbonisation of the EU energy system by enabling export potential of excess renewable production: Recommendation that the sum of all nominal transmission capacity is at least above 30% of all renewable installed generation capacity. This trigger ensures effective renewable integration is maximised.

[3] Council Conclusions of 23 and 24 October 2014 http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf
[4] COM(2017) 718 final https://ec.europa.eu/energy/sites/ener/files/documents/communication_on_infrastructure_17.pdf
[5] COM(2014) 330 final.
[6] https://ec.europa.eu/energy/sites/ener/files/documents/report_of_the_commission_expert_group_on_electricity_interconnection_targets.pdf

A very important precondition for the effective commitment to further development of interconnection capacity remains a positive CBA assessment (socio-economic and environmental on pan-European level) of any projects facilitating cross-border interconnection capacity. The multi-criteria assessment above will help to indicate the urgency with which further developments needs to be analysed. Countries above the 30% target, but below 60%, are also recommended to regularly investigate possible options for future interconnection.

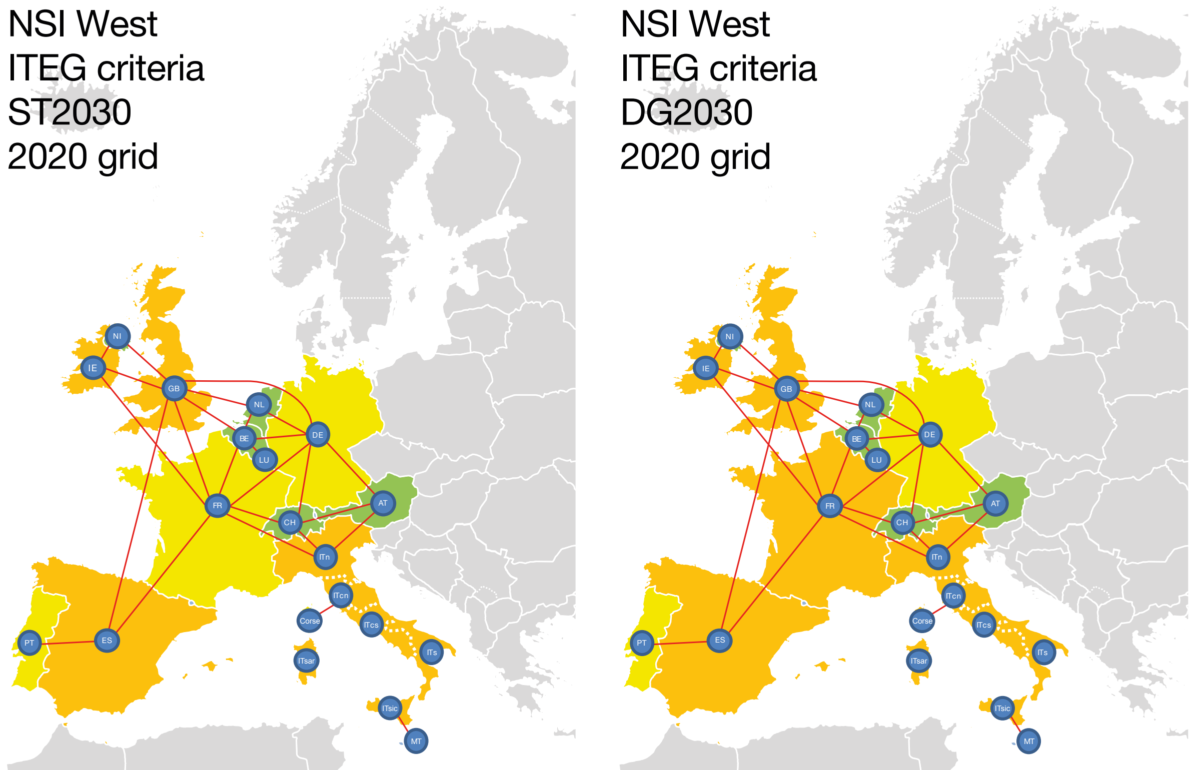
ENTSO-E presents the following maps with the results when these above criteria are utilised on the three 2030 scenarios of TYNDP 2018. The assumptions behind these results are:

— Data of demand and installed generation as in the final TYNDP Scenario Report
— Price (marginal cost) differentials as the average of the three climate years analysed in the TYNDP Scenarios
— Nominal transmission capacities as "today's situation, which includes projects commissioned by 2030

grid of the current CBA assessment, which includes projects commissioned by 2027 that have already started the permitting process in 2018.

The EG report considered TYNDP 2016 scenarios, and 2020 nominal transmission capacity, as this was the information available to them at time of publication.

Figure 4.14: Interconnection targets for the three 2030 scenarios, applied to the 2020 grid[7]

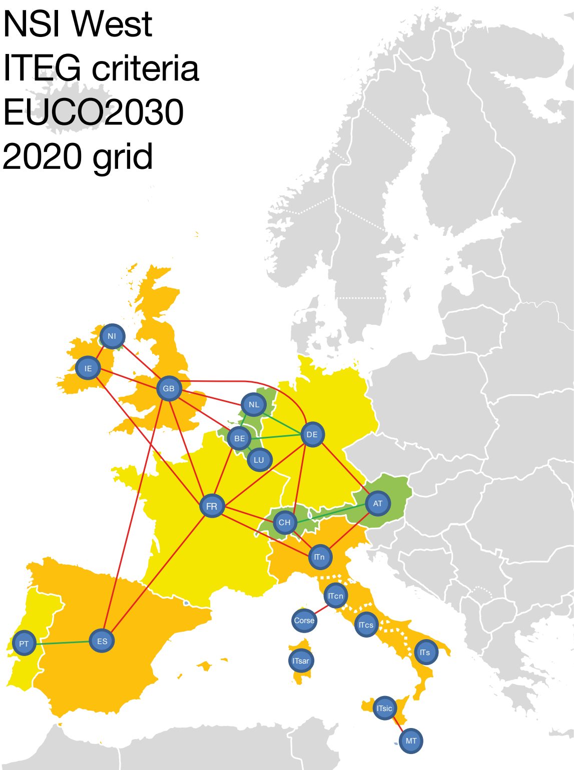


Avg. hourly marginal cost differences (€/MWh)

- Yearly average marginal cost difference <2€MWh
- Yearly average marginal cost difference >2€MWh
- At least one of the 30% criterias show <30%
- At least one of the 30% criterias show >30% but <60%
- Both criterias show >60%

[7] In this analysis, 2030 scenarios with 2020 grid, the reinforcement of the interconnection between Portugal and Spain was considered already in service, although currently the commissioning of the project is expected only for 2021.

Figure 4.14 continued: Interconnection targets for the three 2030 scenarios, applied upon the 2020 grid[7]



The maps in Figure 4.14 show that almost all market areas and cross-country sections in the region might need to be investigated beyond the 2020 grid, with more urgent focus on island or peninsular systems (Great Britain, Ireland and Iberian Peninsula); in particular:

— In all 2030 scenarios, large marginal cost differentials (>2€/MWh) exist between each border showing the need for possible additional interconnection development based on this criterion (except the Netherlands-Germany, Belgium-Germany, Belgium-Luxemburg and Switzerland-Austria borders in EUCO scenario).

—With respect to the security of supply and RES integration criteria, the assessment of interconnection development towards GB, Italy and Iberian Peninsula appears to be most urgent in all scenarios and towards France and Ireland in DG and EUCO scenarios respectively. For Belgium, the Netherlands, Luxemburg, Switzerland, and Austria, the criteria appear to be satisfied with levels >60% in all scenarios, however the development of interconnections with these countries can remain a relevant option for the countries not yet reaching the thresholds.

NSI West Corridor-wide TOOT projects included in the reference grid are clearly not sufficient to satisfy the three criteria at stake, and the additional PINT projects which today are planned or considered but not yet in permitting phase are likely to help improve the situation by 2030-2035.

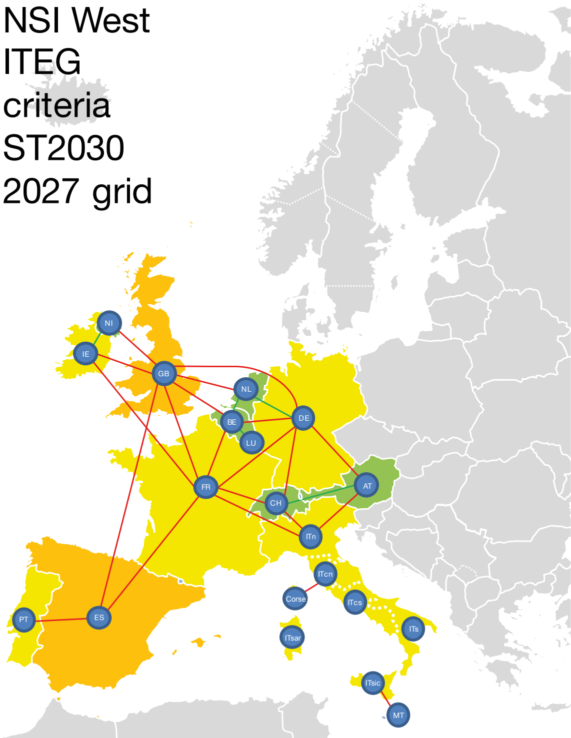
Figure 4.15 displays the indicators for the 2030 interconnection target when adding all projects commissioned by 2027 that have already started the permitting process in 2018 (known as TOOT projects). These maps show that again almost all market areas and cross-country sections in the region might need to be investigated beyond the 2027 grid, with more urgent focus on island or peninsular systems (Great Britain and Iberian Peninsula). In particular:

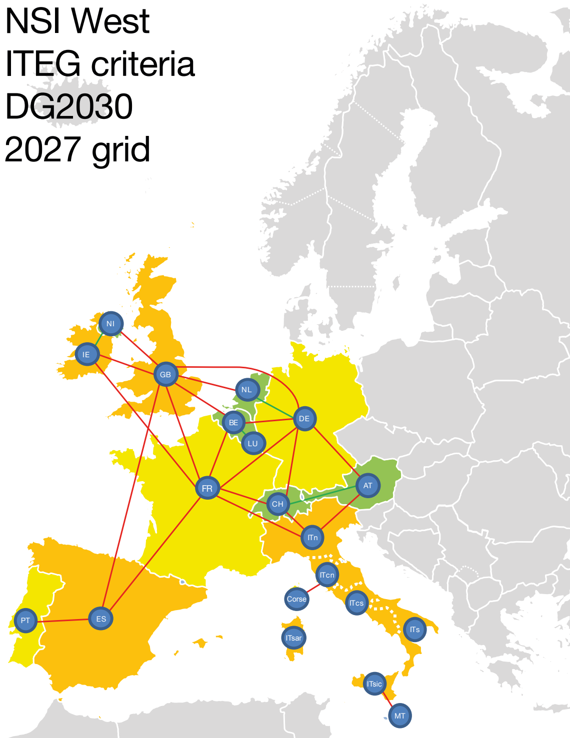
— In all 2030 scenarios, large marginal cost differentials (>2€/MWh) exist between each border showing the need for possible additional interconnection development based on this criterion (except the Netherlands-Germany, Belgium-Luxemburg and Switzerland-Austria borders with cost differentials <2 €/MWh in all scenarios and Belgium-Germany, Switzerland-Germany and Austria-Germany borders with cost differentials <2 €/MWh only in EUCO).]

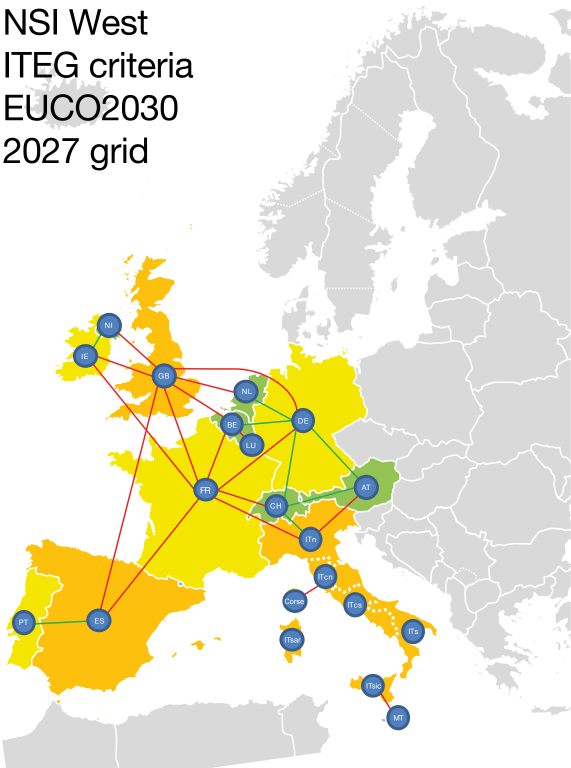
— With respect to the security of supply and RES integration criteria, the assessment of interconnection development towards GB, and Iberian Peninsula appears to be most urgent in all scenarios and towards Italy in EUCO. For Belgium, the Netherlands, Luxembourg, Switzerland, and Austria, the criteria appear to be satisfied with levels >60% in all scenarios, however the development of interconnections with these countries can remain a relevant option for the countries not yet reaching the thresholds.

[7] In this analysis, 2030 scenarios with 2020 grid, the reinforcement of the interconnection between Portugal and Spain was considered already in service, although currently the commissioning of the project is expected only for 2021.

Figure 4.15: Interconnection targets for the three 2030 scenarios, applied to the 2030 grid







Avg. hourly marginal cost differences (€/MWh)

- Yearly average marginal cost difference <2€MWh
- Yearly average marginal cost difference >2€MWh
- At least one of the 30% criterias show <30%
- At least one of the 30% criterias show >30% but <60%
- Both criterias show >60%
- No interconnection targets

4.5
Differences between TYNDP 2016 and TYNDP 2018 project indicators

As a result of updated scenarios, scenario assumptions and improvements to the methodology used as part of the CBA 2.0, there are notable differences to the CBA results for projects within the NSI West Corridor for TYNDP 2018 when compared to TYNDP 2016. These differences include:
- a reduction in SEW, RES values and CO_2 indicators of the overall European portfolio of projects
- an increase in losses associated with projects.

Continued improvements to the assumptions and methodology means that projects can appear more beneficial in one TYNDP and less beneficial in the next, or vice-versa. These effects are caused by multiple reasons, which tend to interact with each other.

Some of the main trends affecting projects within the NSI West Corridor are discussed below.

4.5.1 Changes to the reference grid

For TYNDP 2018, the guidelines explaining how the reference grid is composed have been tightened; the reference grid is defined by:
- today's existing grid, plus
- projects under construction; and
- projects commissioned by 2027 with proof of commencement of the national permitting process.

These rules have led to an increase of cross-border capacity in some areas and a decrease in other parts. One area showing increases in the NSI West Corridor is the GB to Continental Europe/Nordics boundary. In the past two years, several projects have advanced in their development and as such now qualify to be part of the reference grid, despite regulatory uncertainty for some of them (esp. on F-UK border, see ACER report of 11/07/2018 on the progress of electricity and gas projects of common interest, annex-IV PCI specific information – electricity). For TYNDP 2018, the reference capacity on this boundary is 14.4 GW, an increase of 4.2 GW compared to the reference capacity of 10.2 GW in TYNDP 2016.

The SEW of the projects of this boundary are significantly lower than in TYNDP 2016, indicating that for this boundary (and especially for France-UK border), with TYNDP 2018, the level of economically viable NTC in the sense of the CBA 2.0 monetised indicators may be questioned and is probably lower than the NTC value in the reference grid.

Nevertheless, the SEW is not the only benefit of these projects and other potential benefits included in the CBA methodology or beyond it should also be analysed.

On the Spanish-French border, the reference cross-border capacity which was set at 8 GW in TYNDP 2016 is now set at 5 GW in the TYNDP 2018. This has a positive impact on the SEW of each project, since the Biscay Gulf project is assessed in the absence of the two trans-pyrenean projects, while the same trans-pyrenean projects are assessed in the presence of the Biscay Gulf only. Sequential assessment (the second trans-pyrenean in presence of the Biscay Gulf and the first trans-pyrenean project) is however provided in the project sheets, as it's considered more relevant.

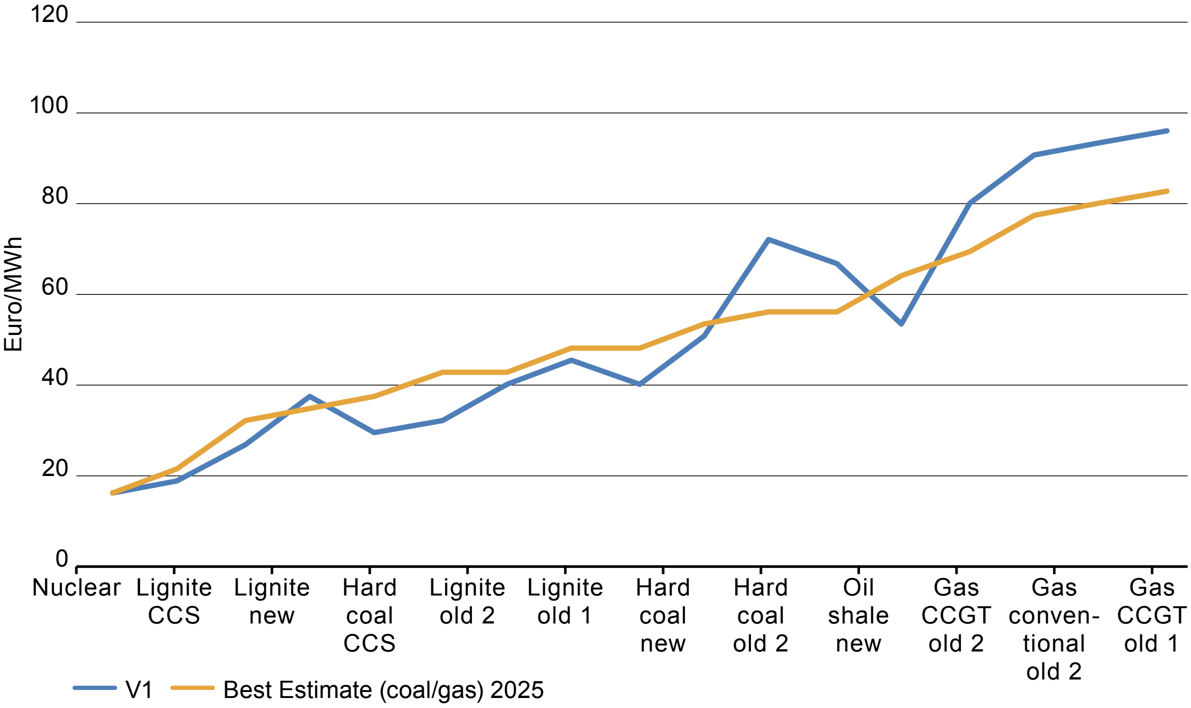
4.5.2 Changes to the fuel prices

In TYNDP 2018, there is a general reduction in the assumed fuel prices used for the CBA analysis. Additionally, there is a lower price spread between differing thermal plant types. This is demonstrated in Figure 4.15, where the TYNDP 2016 Vision 1 fuel price assumptions are compared to the 2025 BE prices used in TYNDP 2018.

The fuel prices are arranged from lowest to highest for each fuel type for 2025 BE, indicated with the orange line. The equivalent fuel price for each technology used in TYNDP 2016 is shown with the blue line. While coal and lignite prices are comparable, there is a notable reduction in gas prices used in TYNDP 2018.

This results in lower SEW values for new projects, mainly impacting projects on the large Continental European system. The lower overall thermal prices reduce the benefits provided by projects, resulting in lower SEW indicators.

Figure 4.16: Marginal price spreads: example TYNDP 2016, Vision 1 versus TYNDP 2018, BEST 2025



4.5.3 Updated renewable energy assumptions

For TYNDP 2018, the scenarios have been built according to storylines consulted on with stakeholders and, in the case of the EUCO scenario, provided by a third party. Therefore, whilst the scenarios incorporate comparable overall European quantities of RES generation to TYNDP 2016, the distribution and location of this generation has changed. Examples of how the distribution of RES differs include:

- A reduction in offshore wind around GB in TYNDP 2018 compared to TYNDP 2016
- An increase of solar energy in France, Spain and Portugal and of wind energy in France
- Smaller differences of onshore wind capacities between the scenarios, all being close to Visions 3 and 4 (the high RES scenarios) from TYNDP 2016
- The inclusion of the distributed generation scenario in TYNDP 2018, where significant RES development occurs at the customer level, rather than large-scale grid connections.

4.5.4 Updated load assumptions

The range of loads forecast by 2030 for each country remains almost the same for most countries of the region from TYNDP 2016 to TYNDP 2018; one exception is the load in Spain which was in the range 300 TWh-380 TWh by 2030 for TYNDP 2016, and is now in the range 270TWh-300 TWh by 2030 for TYNDP 2018, with the biggest differences in the top-down or centralised scenarios. This is also one of the factors combined with others explaining the increase in the SEW for France – Spain interconnection projects from TYNDP 2016 to TYNDP 2018.

4.5.5 The use of multiple climate years

For the current TYNDP, multiple climate years have been considered in the CBA assessment; 35 climate years have been clustered into 3 representative years and used during the CBA calculations. For TYNDP 2016, just one climate year was used in the analysis. At a high level, the NSI West Corridor's sensitivity to climate year impact is low.

At a country level, however, the choice of climate year has a more significant impact. These include:

- Countries with a large quantity of hydro generation, e.g. the Nordic countries, see a higher influence of wet/dry/normal years, than non-hydro based countries. Projects connecting to these countries tend to see an increase in SEW and RES indicators.
- Countries with a large proportion of wind generation, both onshore and offshore, will experience effects relating to the short-term variability of the generation output. This increasingly drives either international exchanges or the need for other flexibility options.

4.5.6 Increased losses

The increase of interconnection capacity enables power to flow from one side of Europe to the other, in line with political objectives. In many cases, these power transfers are accompanied by an increase in grid losses.

Additionally, some projects facilitate entirely new flows which would not be possible without the project. This phenomenon has been observed for several projects in the NSI West Corridor during their CBA assessments, and these new flows again drive an increase in losses.

These increased losses can be interpreted as the price to pay for fulfilling the European energy targets. In general, the assessment of losses induced by new projects has been improved in TYNDP 2018 when compared to TYNDP 2016, especially for monetisation.

A comprehensive all year round simulation and European-wide calculation has been applied to obtain a view on the region's losses. The monetisation of losses based on an hourly basis rather than a yearly pan-European marginal cost has a significant impact, as no particular deviation could be noticed when considering results in volume.

The results should be treated with caution, as a result of the very high sensitivity of losses to generation assumptions, in particular the location of generation units.

Section 5

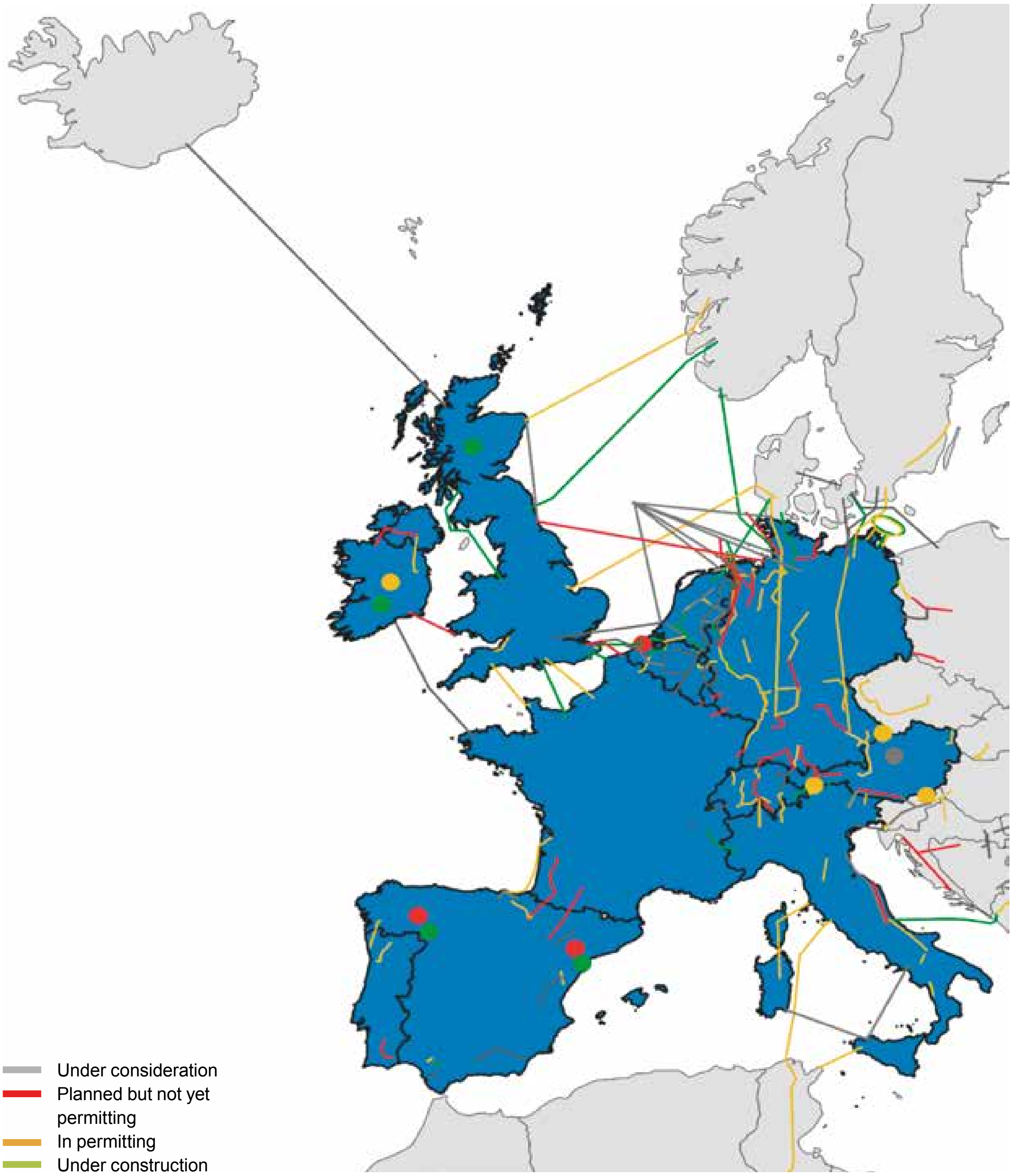
Grid development in the region

The project promoters in the region are already making plans to meet the needs identified and discussed in Section 4. Projects already under construction, applying for permissions and in the planning phase are among those subject to CBA assessment in TYNDP 2018. In spite of this, there is still a gap in meeting the potential 2040 needs.

5.1
Projects being assessed in TYNDP 2018

To accommodate the energy transition and help the region to meet the challenges described before, a large number of projects are required in the NSI West Corridor. Figure 5.1 shows the promoted projects in the region for TYNDP 2018 that will be CBA assessed (except projects under construction).

Figure 5.1: Promoted projects in NSI West Corridor



5.2
Monitoring the projects of the region

The status of the development of the region's projects is shown in Figure 5.2. The vast majority of projects are expected to be completed by 2025. Several projects are already under construction. The projects are almost equally divided between the four categories: Under construction, In permitting, Planned but not yet permitting, Under consideration.

Projects under construction will be commissioned between 2018 and 2023. Projects in permitting will be constructed mainly between 2018 and 2025, although some projects to be commissioned between 2026 and 2030 have already starting the permitting processes. Projects in the planning phase that have not started the permitting process will be commissioned after 2021, and the projects under consideration start their commissioning dates after 2024.

Figure 5.2: Status of projects in the NSI West Corridor

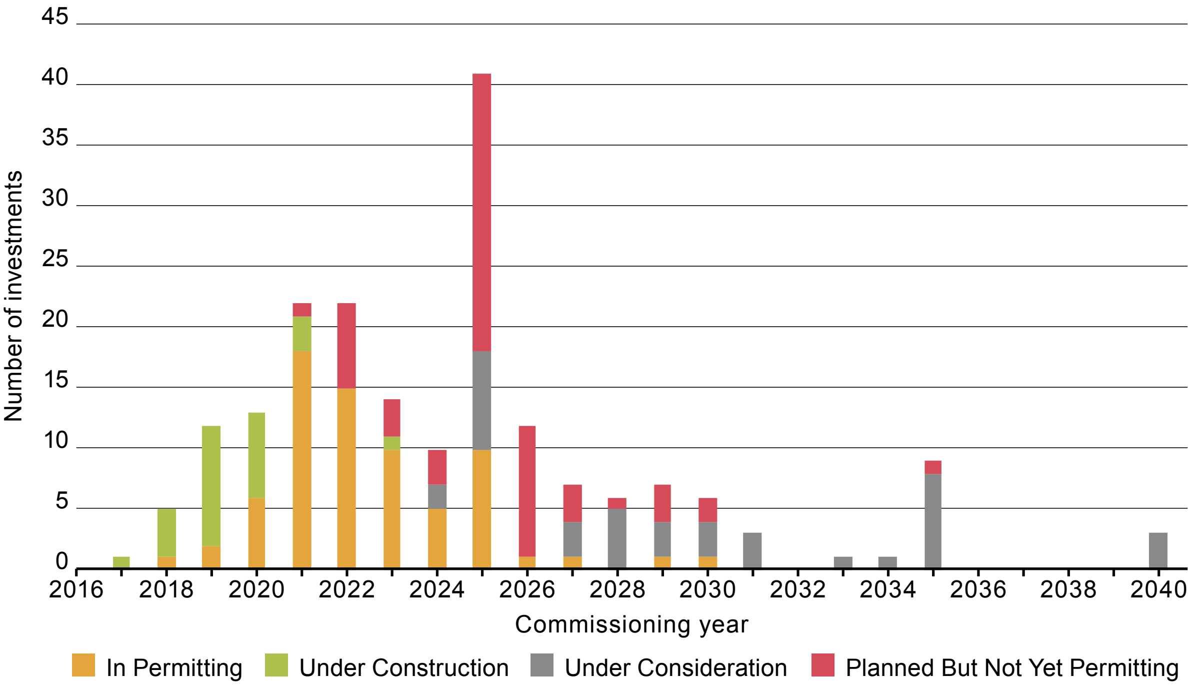
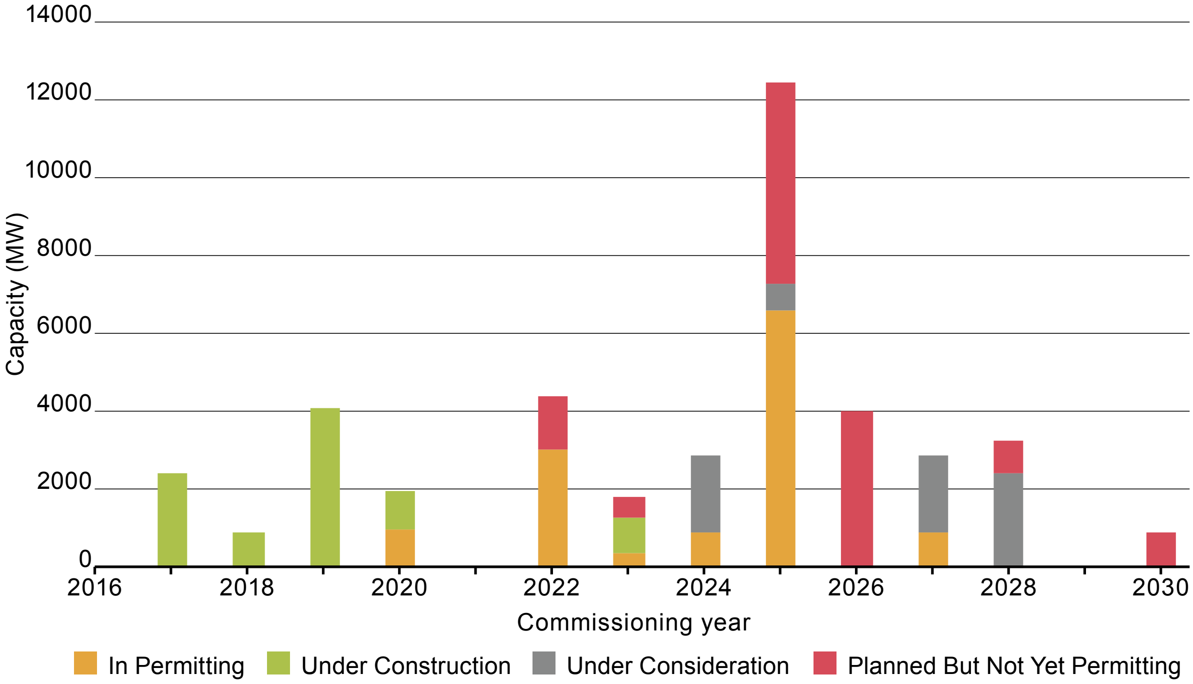


Figure 5.3 shows the types of projects in the region. Traditionally, grid development has almost exclusively comprised overhead line HVAC circuits. Although AC is still the main technology with 78% of the project portfolio, both undergrounding and HVDC technology play a more prominent role in the future grid development. Just 60% of the promoted projects are overhead line developments, with cables – underground and subsea – making up 25% of the portfolio and other substation components the rest of the portfolio. Looking at total lengths of circuit built, it is clear that HVDC is becoming the more prominent technology type in the region for TYNDP projects.

This is not unexpected; to enable the integration of the anticipated renewable generation, the NSI West Corridor requires additional cross-border capacity. Many of the projects integrate the islanded systems of GB, Ireland and the Iberian Peninsula with Continental Europe. These interconnections will require significant amounts of subsea HVDC cable.

Figure 5.3: AC and DC projects in the region and their commissioning year



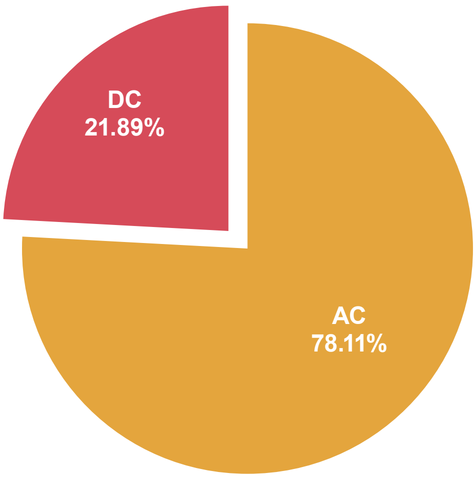
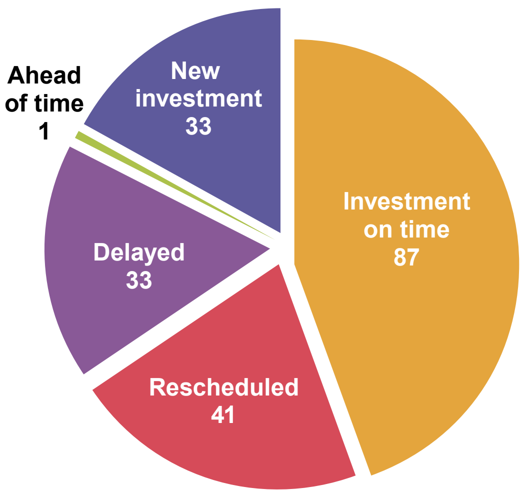
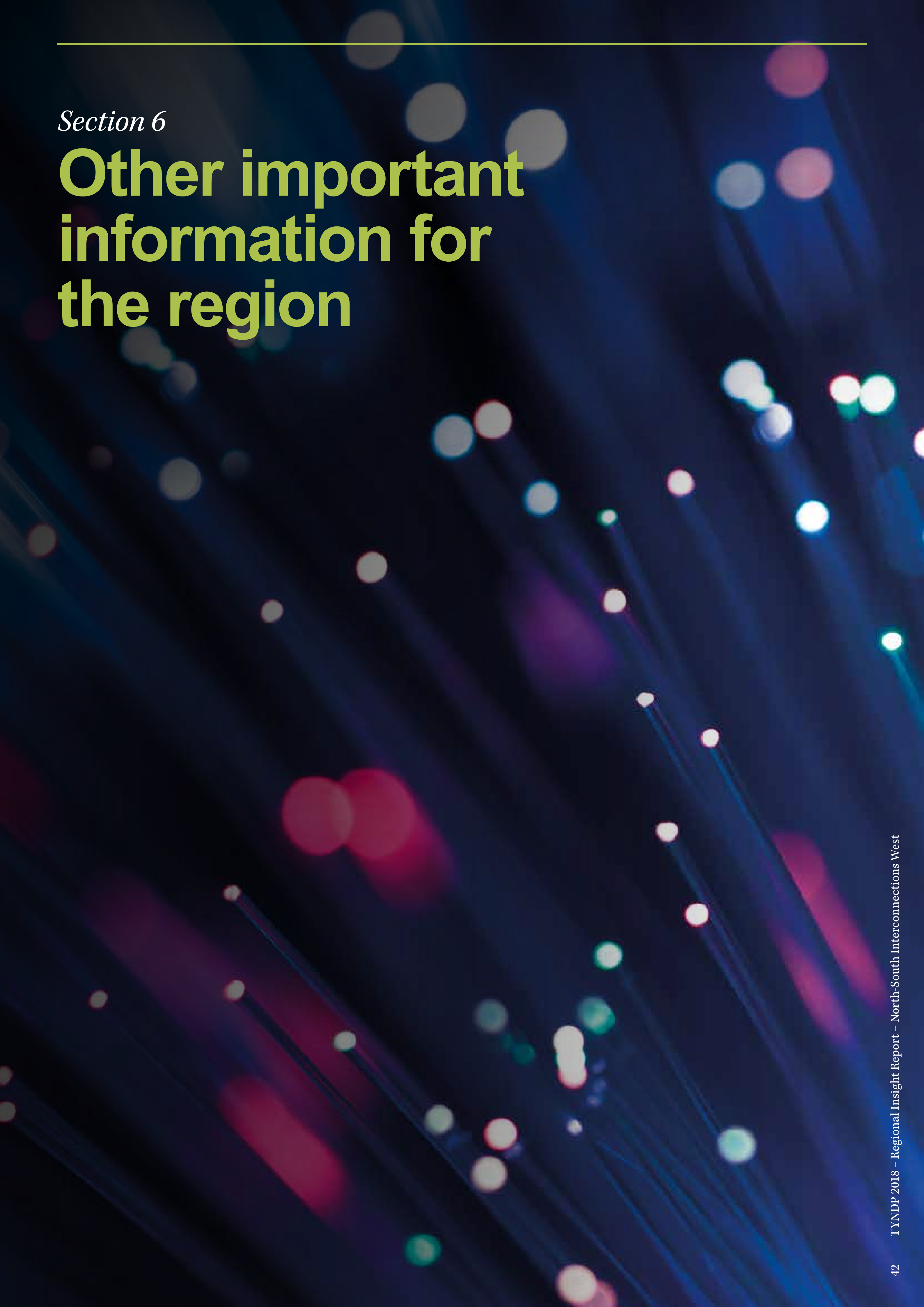


Figure 5.4: Investment evolution status in the NSI West Corridor



Section 6

Other important information for the region



6.1
PLEF Generation Adequacy Assessment (GAA)

The Pentalateral Energy Forum (PLEF) is the framework for regional cooperation in Central Western Europe (AT-BE-DE-FR-LU-NL-CH) towards improved electricity market integration and security of supply. The further development of a coordinated approach to security of supply in the Pentalateral region was defined as one of the key objectives by the governments of the PLEF countries. As part of this framework, the TSOs of the PLEF countries have performed two Generation Adequacy Assessments (GAA) studies within the last four years.

The first GAA was issued in 2015. It was based on the political declaration of the PLEF from 7 June 2013, and provided a first probabilistic analysis on electricity security of supply in Europe conducted from a regional perspective. As a result, the ability to perform joint regional generation adequacy assessments was improved across the PLEF countries. The resulting methodology has since been used by ENTSO-E as part of its Mid-Term Adequacy Forecast (MAF).

In June 2015, a second political declaration was issued seeking further milestones on security of supply, market integration and flexibility. It included the aim for further improvements to the common methodology used to assess security of supply at a regional level. Following this, the relevant TSOs committed to publishing a bi-annual report on the status of security of supply in the central western European region, commencing in 2017.

The June 2015 declaration was followed with a roadmap, prepared together with the relevant TSOs, defining the contents of the next adequacy study. It aimed to improve the methodology based on experiences from the first GAA. The TSOs have since worked together to carry out the new study, establishing an improved level in adequacy assessment.

The second Pentalateral Generation Adequacy Assessment[8], published in January 2018, had two main objectives – the development of state of the art methodologies (including high quality data collection and enhanced adequacy modelling), and provision of the best possible adequacy assessment for the PLEF region. This resulting adequacy assessment was performed for both a short-term (2018/2019) and mid-term (2023/2024) horizon. The results of the study show that adequacy margins will become tighter on the mid-term horizon (2023/2024).

The main achievement of the study is the implementation of a Flow Based (FB) approach at a regional level. The approach for FB-Market-Coupling (FB-MC) is a significant step towards a more realistic modelling of operational planning in practice nowadays. Additionally, the future potential of Demand Side Flexibilities and their contribution to generation adequacy has been studied in greater detail. The study also highlights the key role played by planned interconnection projects, which not only enhance market integration but also increase the security of supply. The grid projects considered in the PLEF region up to 2023/24 improve the level of security of supply within the region, particularly in Belgium and France. Without them, the loss of load expectation (LOLE) from these two countries would exceed 10 hours by 2023/24. This would be two to three times greater than the LOLE for the same countries in the base case.

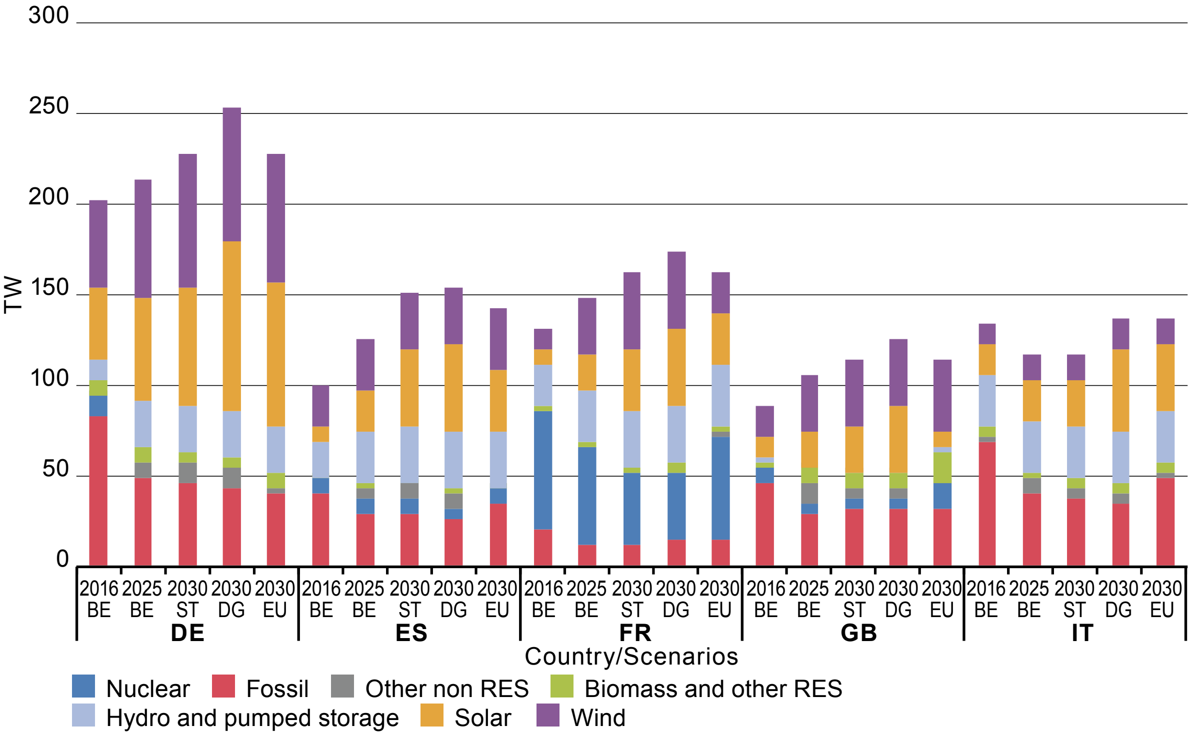
Furthermore, probabilistic approaches such as the ones used in this PLEF GAA are key to assess the security of supply contribution of future interconnectors. A method based on probabilistic assessments is currently being evaluated within the framework of the ENTSO-E CBA.

[8] PLEF GAA 2.0 publication links:
Link to 2nd PLEF GAA report,
Link to common statement by Ministries on 2nd PLEF GAA report,
Link to TSO statement on 2nd PLEF GAA report

Section 7
Annex

7.1
Additional figures

Figure 7.1: Installed capacity per country and scenario (2016, 2025, 2030)



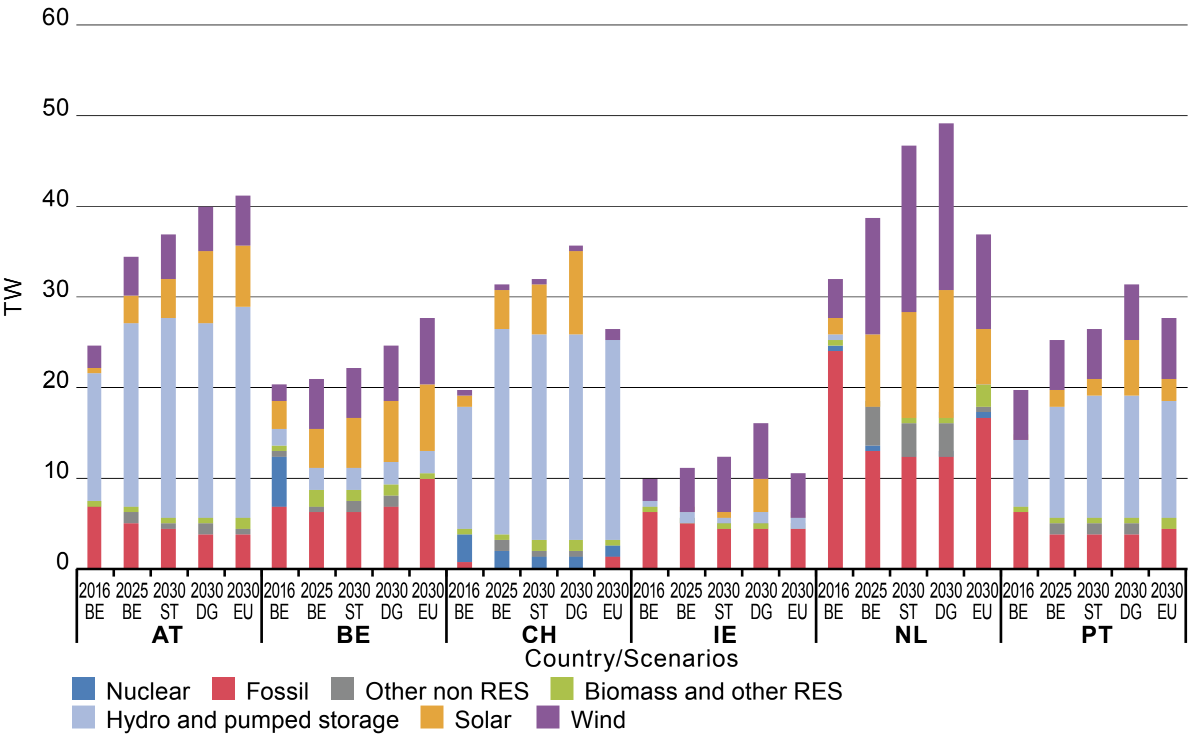


Figure 7.1 continued: Installed capacity per country and scenario (2016, 2025, 2030)

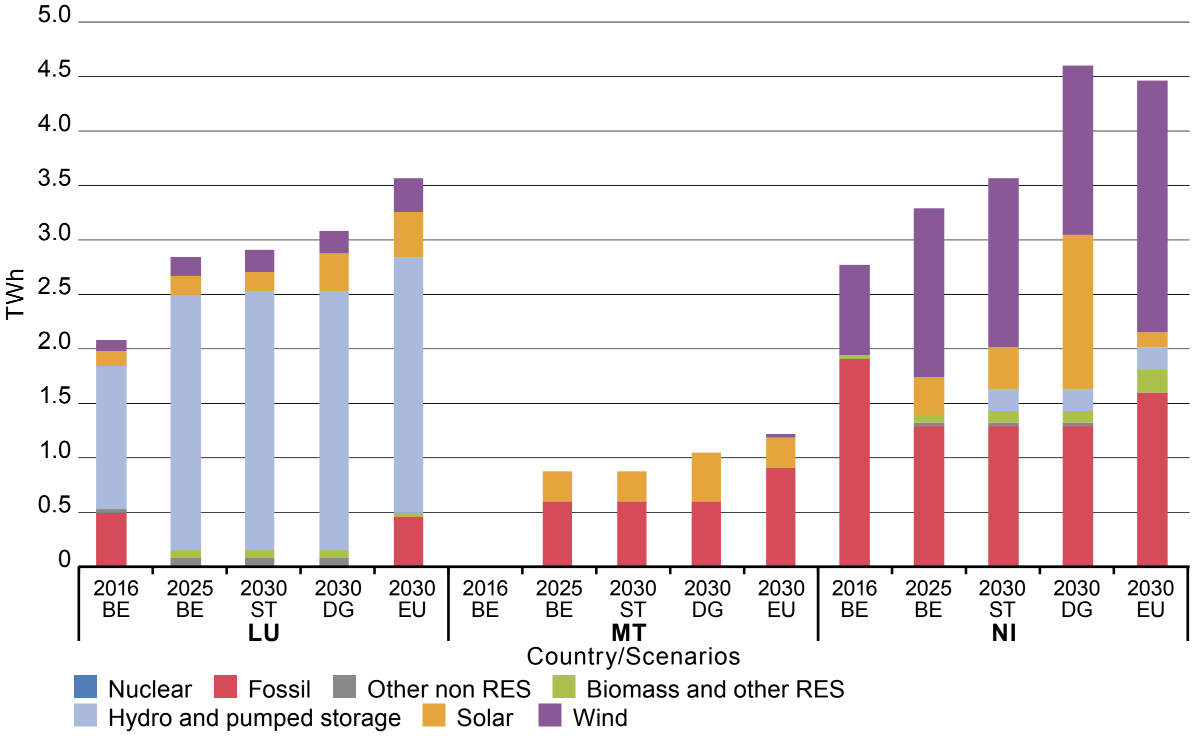


Figure 7.2: Generation production and demand per country and scenario (2016, 2025, 2030) with the reference grid

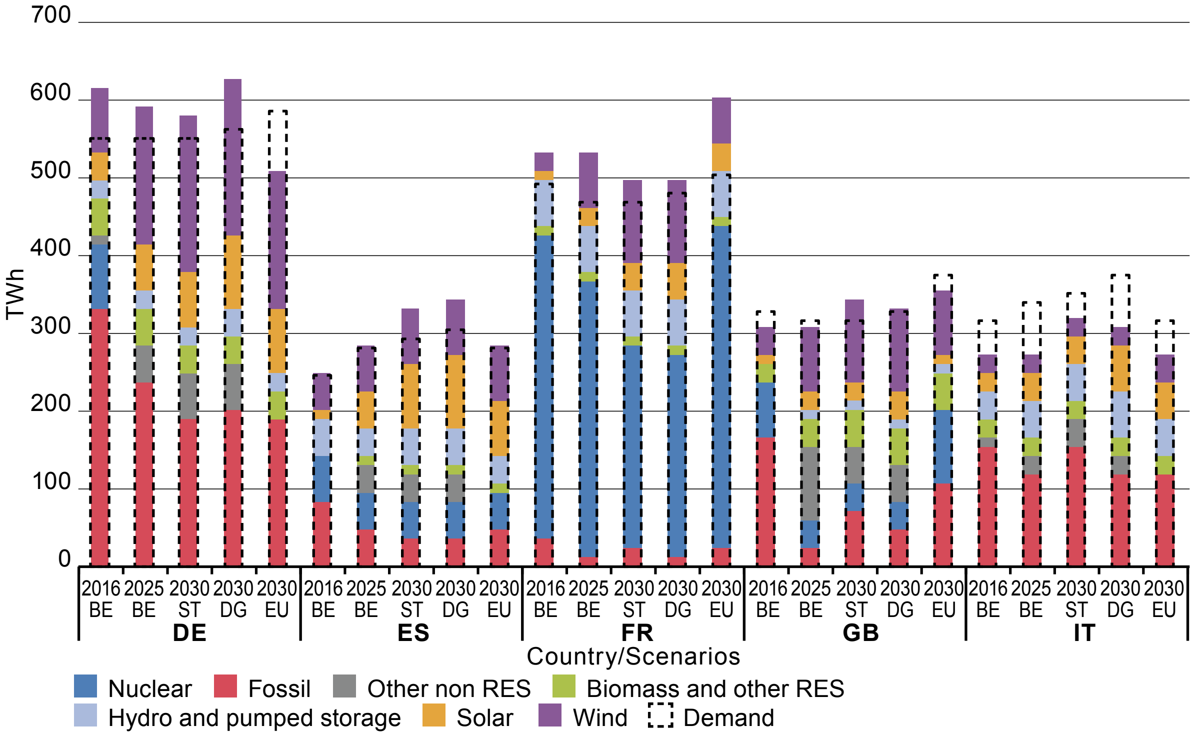
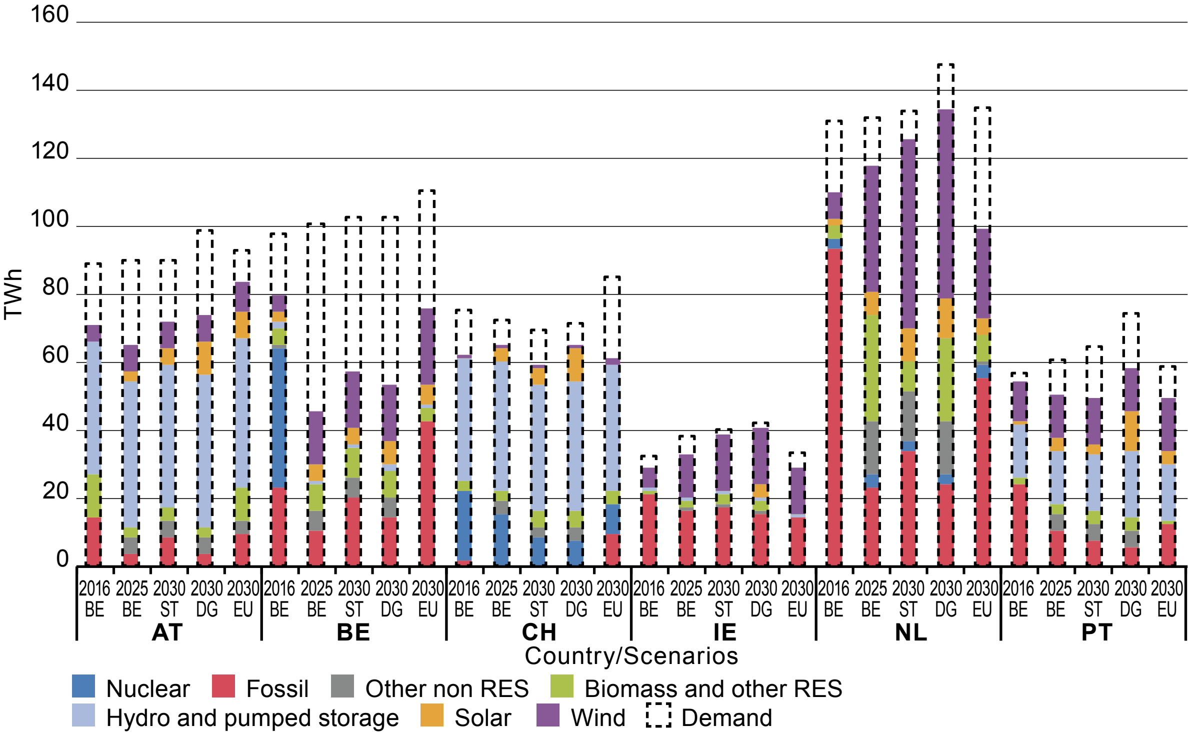
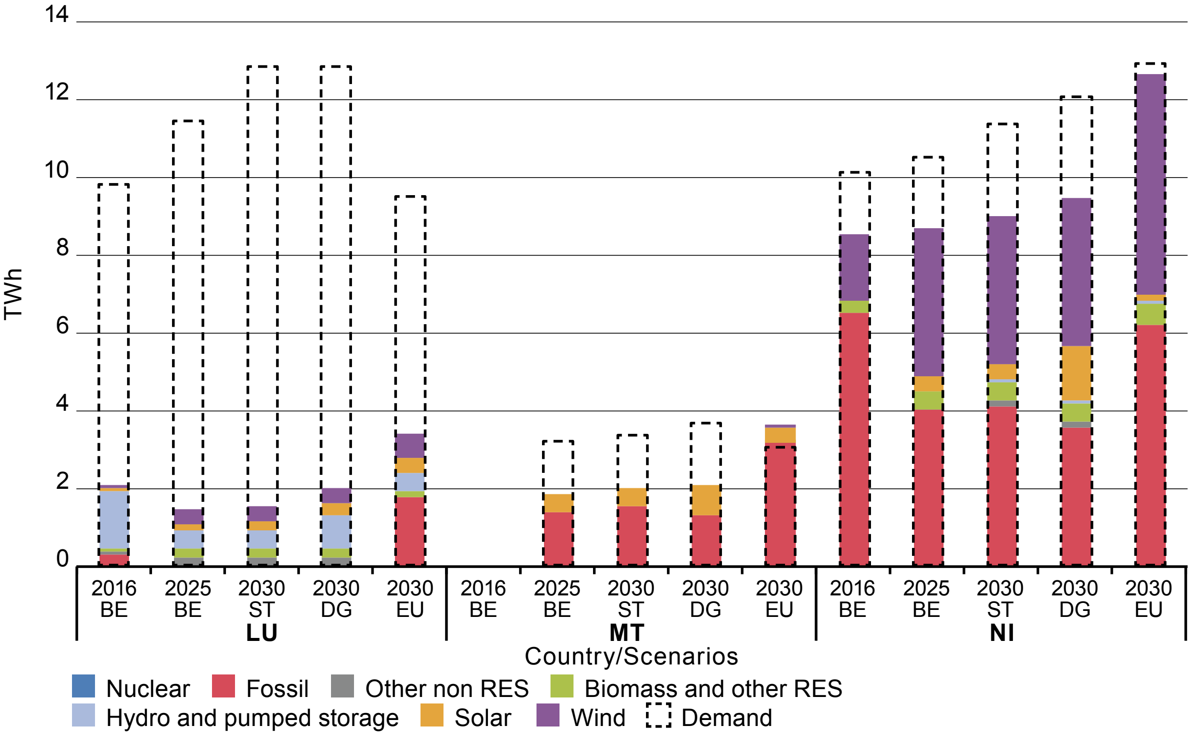


Figure 7.2 continued: Generation production and demand per country and scenario (2016, 2025, 2030) with the reference grid





The following figure displays further the RES shares in various countries of NSI West Corridor:

Figure 7.3: RES share of consumption in NSI West countries in various scenarios with reference grid

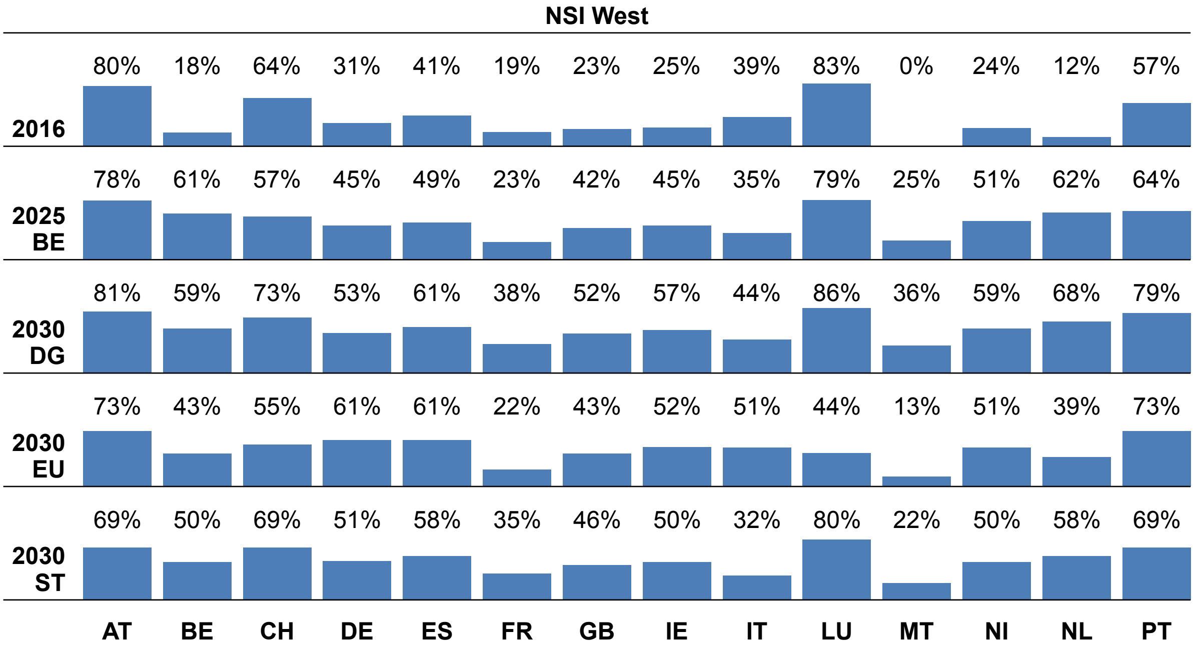
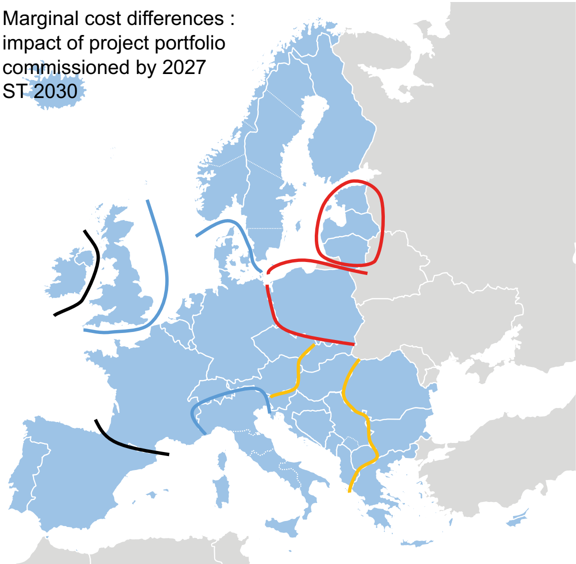
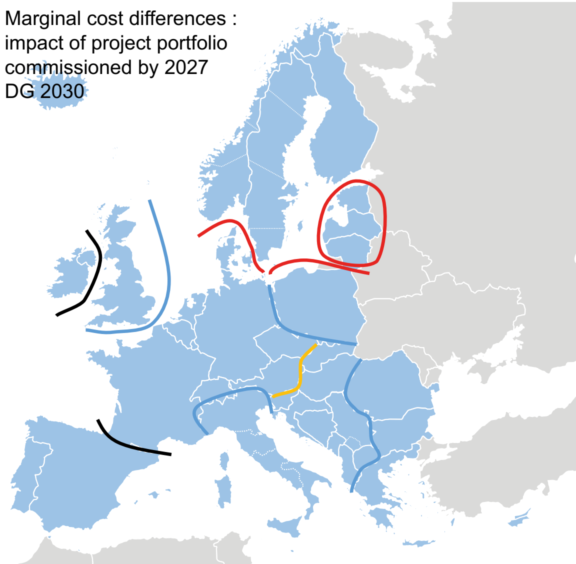
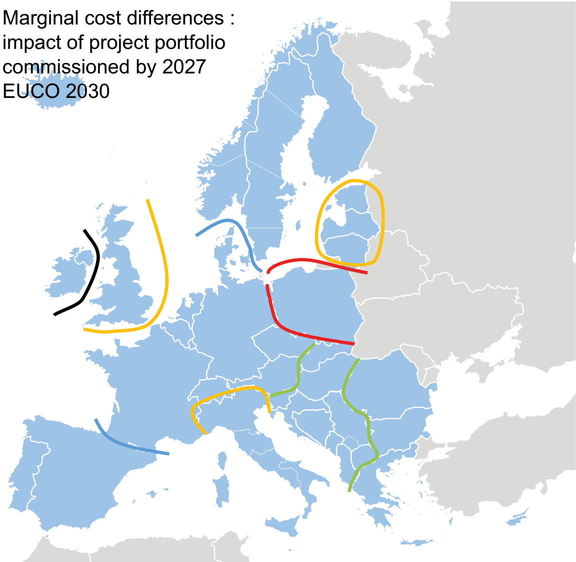


Figure 7.4: Price difference across the main boundaries for the three 2030 scenarios: reference grid projects







Avg. hourly marginal cost differences (€/MWh)

- From 0 to 2
- From 2 to 5
- From 5 to 10
- From 10 to 15
- More than 15

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