TYNDP 2018 Regional Insight Report

Focus on the Nordic and Baltic Sea

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

Section 1

Executive summary

Historically ENTSO-E has divided grid planning into six geographical planning regions for which the organization has published a separate, 'Regional Investment Plan' every two years as part of the TYNDP-package. Now, ENTSO-E has merged four of its regions into two[1] to match the so-called priority electricity corridors introduced in regulation (EU) No 347/2013. The so-called BEMIP planning region remains the same, and hence the content of this regional insight report is essentially the same as in the ‚Regional Investment Plan 2017' for the Baltic Sea region.

The Baltic Sea region comprises nine countries[2], and within the region, there are three separate synchronous systems[3]. It is rich in renewable resources and the Nordic hydropower system constitutes a valuable renewable flexibility resource. In spite of this, the energy transition poses challenges for the TSOs grid planning. The main challenges and drivers of grid development in the region are:

- Renewable resources are far from the consumption centres.
- Nuclear and other thermal generation are decommissioned and being replaced by renewable generation
- The need for flexibility, also between synchronous areas, is increasing.
- Consumption is being established in new places because of the electrification of new sectors in society.
- A special challenge in this region is the ongoing process of integrating the Baltic States in the EU electricity system. This is both a national and an EU strategic priority.

The ENTSO-E projections suggest the following development of energy balances until 2030:

- Norway, Sweden and Denmark: A rather large surplus
- Finland: Current large energy deficit will persist, despite an increase of nuclear power generation
- Baltic States: Roughly in balance
- Poland: A large deficit, due to thermal decommissioning
- Germany: A large surplus, due to increased renewables, except in the EUCO-scenario with slower RES-increase

In the 2040-perspective the scenarios suggest that we will see increased local fluctuations of power infeeds and that the energy imbalances between the countries will be exacerbated. This causes higher price differences, potential spillage and risk to security-of-supply. The main constraints to power flow in this planning region are between the boundaries of the Nordic hydropower system and the systems in Continental Europe West and East. This is because of the inherent capability of the flexible hydropower system to balance the fluctuations of the Continental systems. In addition the ambition to integrate the Baltic States into the EU electricity system is an important driver for grid reinforcements to that part of the region.

In the 2040-perspective we have found that there might be a need to reinforce the transmission capacity over the following borders:

- Germany-Poland, in order to increase market-integration and in order to facilitate thermal decommissioning in Poland,
- Sweden-Finland in order to increase market-integration,
- Norway-Denmark, due to price-differences and due to improving Danish security of supply during periods with high demand and low renewable generation,
- Sweden/Denmark and Germany, due to price-differences and due to better optimization of the renewable generation,
- The Baltics, mainly due to Security of Supply.

The TSOs in the region are already well underway in implementing measures and in making plans to meet the above-mentioned needs. In the TYNDP 2018 ENTSO-E are doing cost-benefit analyzes of projects in this region being at different stages of development. Still, there might be a gap towards the potential 2040-needs, but the region's TSOs are on the way forming the future power system.

The 2030- and 2040-analyses clearly show that if building the proposed infrastructure, huge positive effects will be seen:

- security of supply (reduced energy not served)
- climate effects (increased RES-generation and decreased CO_2-emissions)
- market integration (decreased price-differences, decreased power-prices).

[1] The ENTSO-E regions Continental South West and Continental Central South have been merged to become 'North-South electricity interconnections in Western Europe'. The ENTSO-E regions Continental South East and Continental Central East have been merged to become 'North-South electricity interconnections in Central Eastern and South Eastern Europe'
[2] Denmark, Norway, Sweden, Finland, Estonia, Latvia, Lithuania, Poland and Germany.
[3] The Nordic, the Continental and the Baltic system. The latter is currently operated in parallel with the Russian and Belarus systems.

Section 2

Key messages of the region

The electricity system in the Baltic Sea region is undergoing an unprecedented change as the electricity generation structure is rapidly becoming carbon-free and simultaneously more variable according to the weather.

Construction of renewable energy in the region has been accelerated by rapid technology development and national subsidy mechanisms. In particular, the increase in wind power production has reduced the wholesale market price of electricity. The profitability of traditional generation has weakened significantly, which has resulted in the closure of adjustable production capacity. This development has reduced carbon dioxide emissions, but it has also increased the risk of an electricity shortage in parts of the region. At the same time, society is becoming more electrified and electricity dependence is increasing. As a result, the power system of the future might be expected to provide even greater reliability in order to safeguard the vital functions of society.

Large quantities of new renewable generation are still planned across the region, and these must be integrated while both maintaining the good security of supply and facilitating an efficient and secure European Energy market. The integration of renewables will further replace production from thermal power plants and the grid needs to facilitate the flows to cover the deficit at the load centres due to closure of power plants and the growing flows between synchronous areas. To solve the challenges to balance the load and generation in all parts of the region in short and long term when generation portfolio is becoming more and more weather dependent, more grid development, electricity and energy storage and demand response are required.

From a grid development perspective, the main drivers within the Baltic Sea Region are the following.

Driver 1: Flexibility-need from other synchronous areas – Further integration between the Nordic countries and the Continent/UK
The Nordic system is likely to increase the annual energy surplus (even if some nuclear is decommissioned), which makes it beneficial to strengthen the capacity between the Nordic countries and UK/Continental Europe. This will increase market integration as well as it increases the value created by renewables. In addition, for daily regulation purposes, it will be beneficial to further connect the Nordic hydro-based system to the thermal based continental and wind based Danish system, especially when large amounts of renewables are connected to the continental system.

Driver 2: Integration of renewables – **North-south flows**
Based on the political goals of reduced CO_2-emissions and based on the cost development of wind and solar, further integration of renewables is expected in the Nordic countries. New interconnectors to the continent/UK/Baltic States in combination with substantial amounts of new renewable generation capacity are increasing the need to strengthen the transmission capacities in the north-south direction in Germany, Sweden, Norway, Finland and Denmark. In addition, nuclear and/or thermal plants are expected to be decommissioned in southern Germany, Sweden, Denmark and Finland, which will further increase the demand for capacity in the north south direction.

Driver 3: New consumption/electrification – **reinforcements lead to increased Security of Supply**
Depending on location and size, new electrical consumption may also trigger the need for grid investments. In the far north, the establishment of new power intensive industries such as mines, or the shift from fossil fuel to electricity in the petroleum industry, could create a need for substantial reinforcements. The general trend with electrical transportation, consumption increase in the larger cities etc. will also put focus on how to secure the supply.

Driver 4: Baltic integration – Security of Supply for the Baltic system
Since the last Baltic Sea Regional Investment Plan 2015 the integration of Baltic countries with European energy markets has made major steps forward with the commissioning of NordBalt and LitPol link. Baltic countries are now connected to Finland, Sweden and Poland via HVDC connections.

For historical reasons, the Baltic States are today operated synchronously with the Russian and Belarusian electricity systems (IPS/UPS system). The three Baltic TSOs are preparing for de-synchronisation from IPS/UPS and synchronisation with the Continental European Network (CEN) through current interconnection between Lithuania and Poland. Synchronization of Baltic countries with CEN will ensure energy security by connecting to this grid, which is operated following the common European rules.

Driver 5: Nuclear and thermal decommissioning – **Security of Supply is challenged**
All nuclear power plants in Germany and a substantial proportion of thermal and/or nuclear power plants, especially in Sweden but some also in Finland and Denmark, are expected to be decommissioned in the 2030 horizon. Further, decommissioning of thermal power plants, especially in Poland, is a need in order to reach the climate goals of the European society. Decommissioning of both nuclear and thermal power would lead to an increased system adequacy risk. Nuclear power has many important features in today's system, and a phase out will require new generation capacity, grid development, and further development of system services.

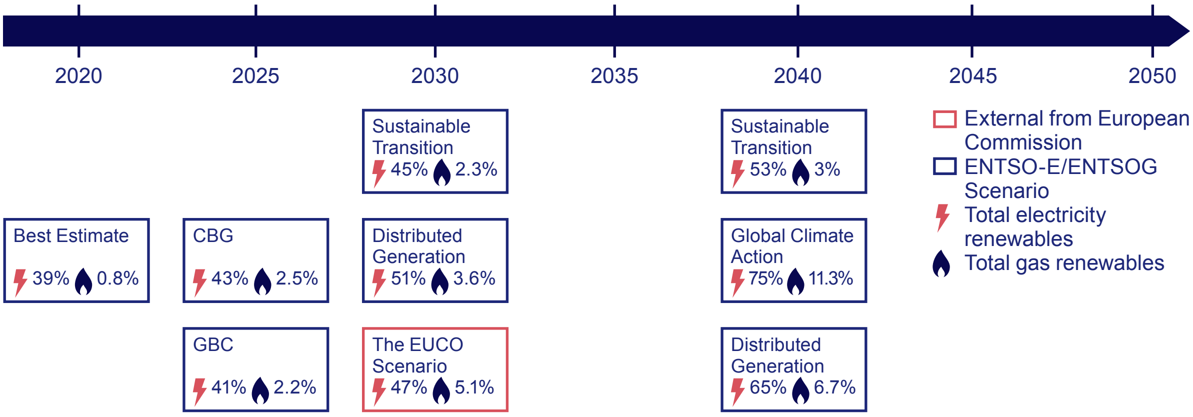
Section 3

Regional scenario overview – Future perspectives

3.1
Scenario overview and main storyline

The respective TYNDP scenarios include a best estimate scenario for short (2020)- and medium-term time horizon 2025, but three story lines for the longer-term (2030 -2040) to reflect increasing uncertainties. They all are on track by 2030 to meet the decarbonisation targets set out by the EU. The scenario pathways are shown in Figure 1, also showing the RES-share of the European gas- and electricity-sector.

Figure 1: 2020 to 2030 scenario building framework for TYNDP 2018



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.

The Best Estimate scenarios for 2020 and 2025 are based on the TSOs perspective, reflecting all national and European regulations in place, whilst not conflicting with any of the other scenarios. A sensitivity analysis regarding the merit order of coal and gas in the power sector is included for 2025 and the results are given as 2025 Coal Before Gas (CBG) and 2025 Gas Before Coal (GBC).

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

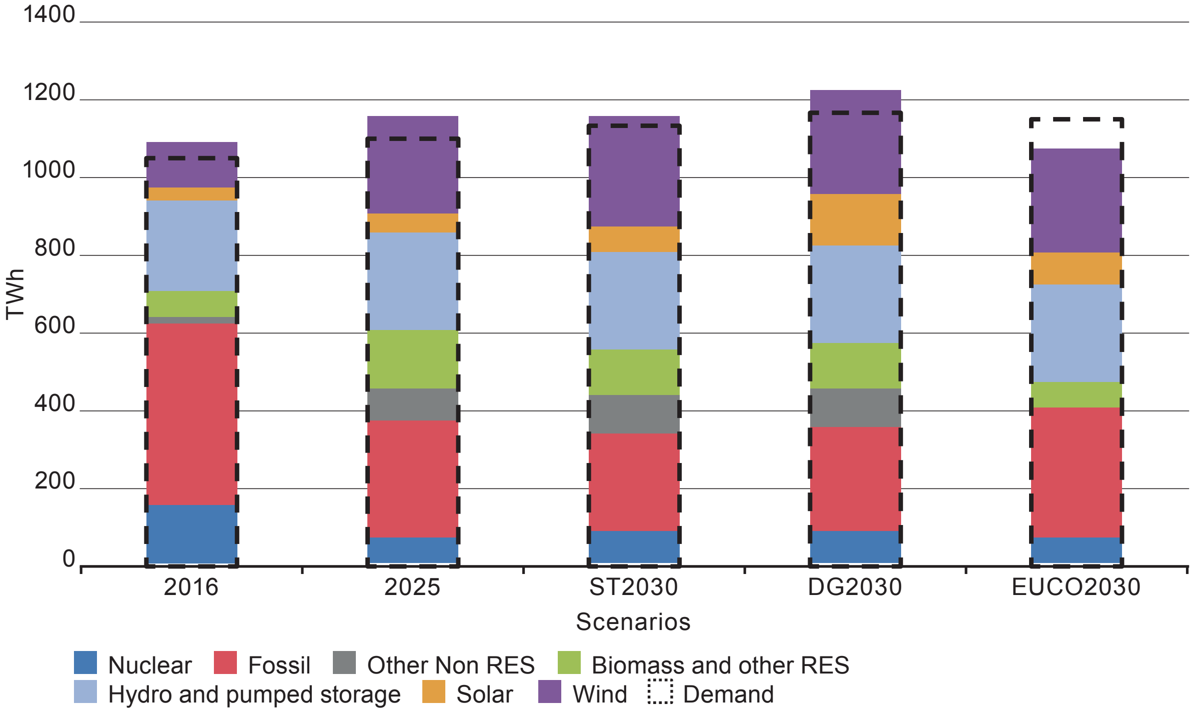
Sustainable Transition (ST)
This scenario will be achieved by replacing coal and lignite by gas in the power sector leading to a quick and economically sustainable CO_2 reduction. The targets are reached through national regulation, emission trading schemes and subsidies and steady RES growth, moderate 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 a scenario 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 a energy efficiency target of 30%.

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

Figure 2: Generation in the region Baltic Sea for the year 2016 and the scenarios BE2025, ST2030, DG2030, EUCO2030.



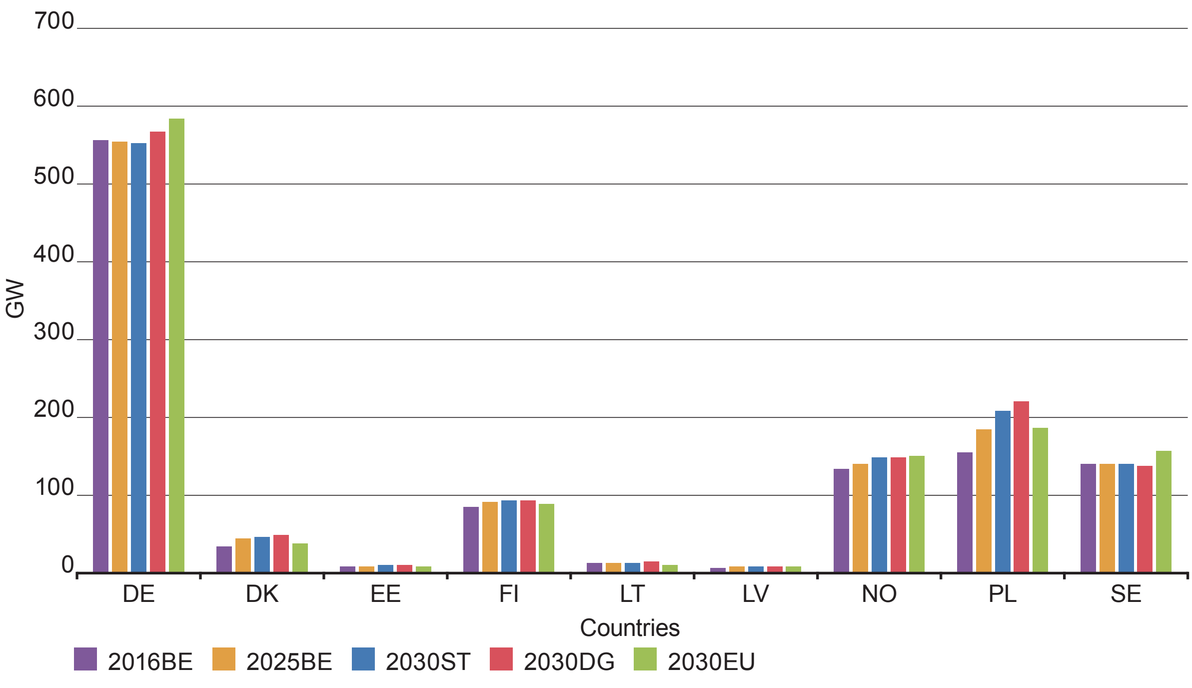
3.2
Energy balances in the scenarios

Summarised below are the results of the scenario process, covering the electricity sector in terms of generation (mix), demand and balances per country.

Regarding the generation-mix the general trends that can be seen throughout the years is a reduction in nuclear (except for the EUCO 2030 scenario where there is a similar level as in the 2025 scenario), a noticeable reduction in fossil, and a strong increase in wind and solar. The levels of Hydro and Pumped Storage slightly increase and Biomass and other RES remain relatively constant throughout. The highest share of renewable generation is seen in the scenario DG 2030.

Figure 3 shows the demand per country for every scenario discussed in this report. The total demand for the countries within planning region Baltic Sea is about 1100 TWh, in which approximately half is in Germany. In 2016 the total demand for Germany was about 550 TWh, for the Nordic countries about 400 TWh, for Poland about 160 TWh and for the Baltic States about 30 TWh. The demand is expected to slightly increase towards 2025 and 2030, with the highest increase in the scenarios DG2030 and EUCO2030.

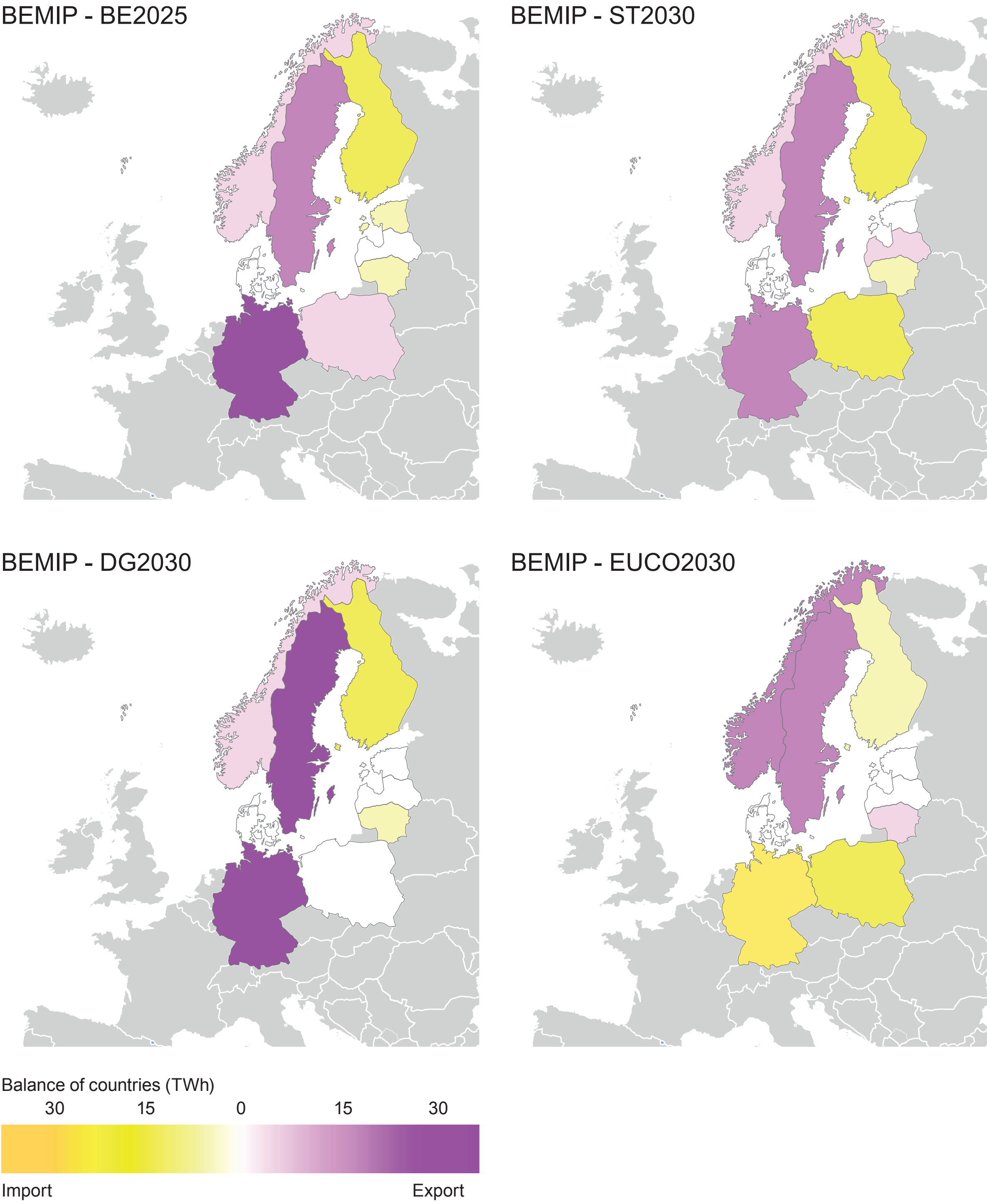
Figure 3: Demand in the region Baltic Sea for the year 2016 and the scenarios BE2025 and ST2030, DG 2030, EUCO 2030.



Based on the scenario-assumptions (generation capacity, demand, CO_2-prices, coal/gas-prices etc.) the scenario-analyses show the expected energy-balances for the different scenarios. For the 2030-scenarios the general trend for the RGBS-countries is:

- Norway, Sweden and Denmark: These hydro- and wind-based countries show a rather large energy surplus in all the scenarios.
- Finland: The large energy deficit seen today is also recognised in all the 2030-scenarios, even if developing new nuclear generation.
- Baltic States: The Baltic States vary between a small surplus to a small deficit in the 2030-scenarios. Estonia show a small deficit in all scenarios, while Latvia and Lithuania are varying between a small surplus and a small deficit.
- Poland: Due to decarbonisation of the generation, Poland is showing a tendency to be a large importer. In the DG2030-scenario Poland however turns to be a net exporter.
- Germany: Despite decommissioning nuclear generation, Germany is likely to be a net energy-exporter. This is due to a high growth of wind and solar production. In the EUCO2030-scenario, the RES is however growing less rapidly, hence Germany becomes a net importer.

Figure 4: Energy-balances in the countries in the Baltic Sea region for the scenarios ST2030, DG 2030, EUCO 2030.



It should also be noted that, to ensure adequacy standards are met, new flexible thermal generation has been assumed in the TYNDP 2018 scenarios. This generation is not necessarily economically viable in an energy-only market, hence (partially) relying upon capacity remuneration mechanisms. The implications of this is on the one hand that benefits of additional grid capacity may be underestimated in the TYNDP 2018 analysis, and on the other hand it raises concerns about the present market´s ability to incentivize sufficient generation capacity to ensure adequacy. This issue will be further investigated in coming TYNDPs.

Section 4

Regional bottlenecks, future long-term needs and mid-term targets

This chapter bridges the regional long term-term needs 2040 (identified in the Regional Investment Plan 2017), via the interconnection targets for 2030 to the list and description of European and regional significant boundaries. The storyline of this chapter is schematically depicted Figure 5.

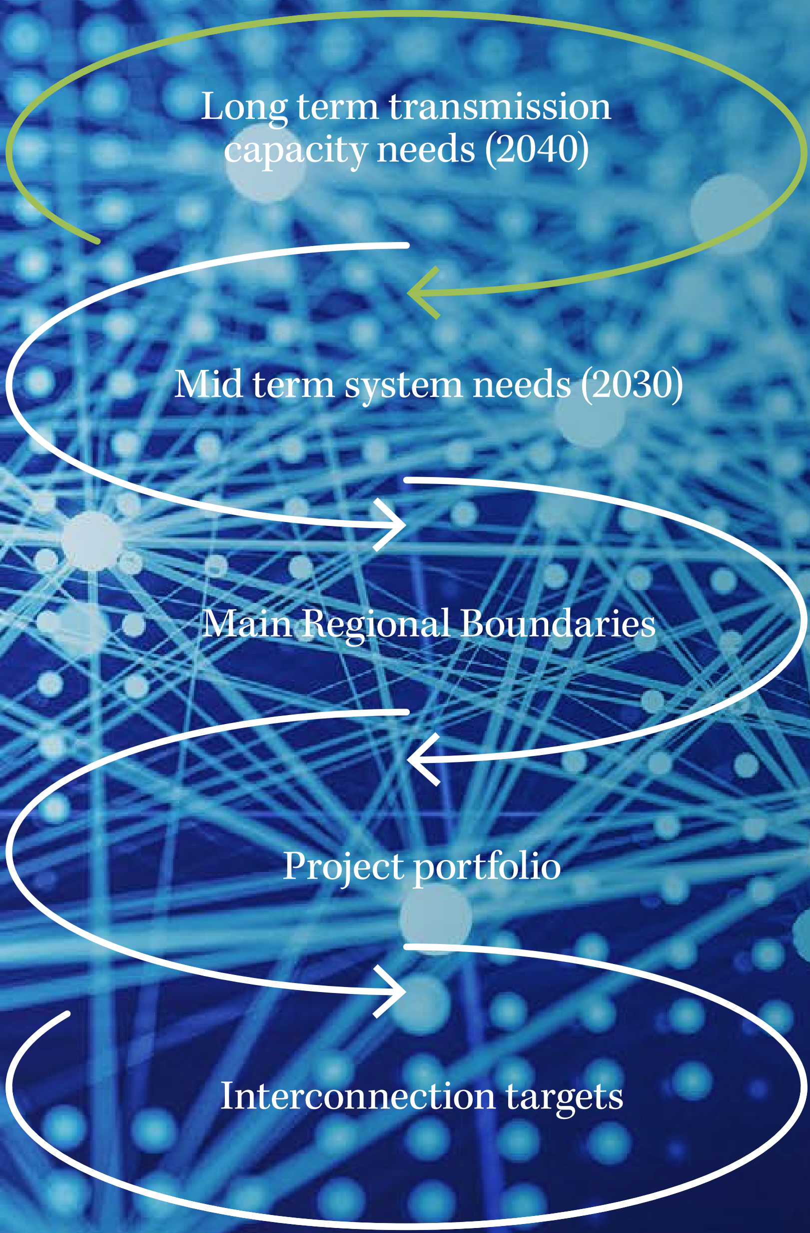


Figure 5: Study overview
– Needs, targets and projects

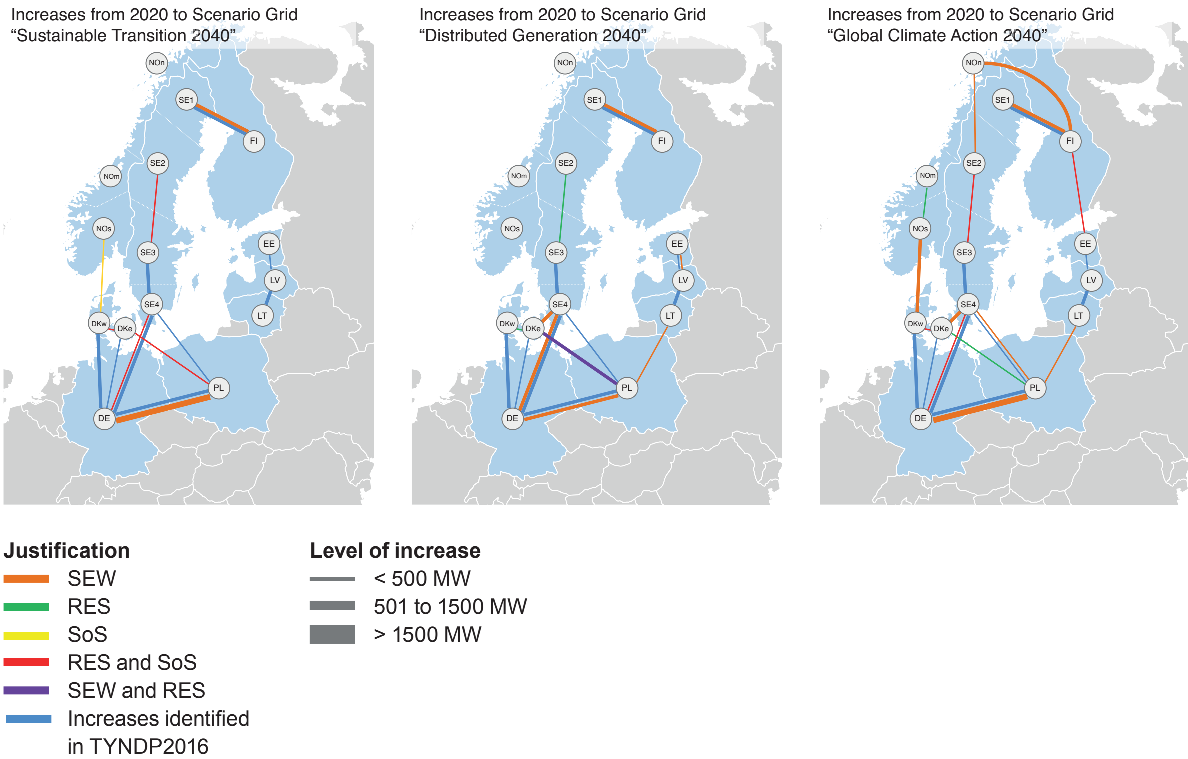
4.1
Future long term needs in the region

The Regional Investment Plan 2017[4] 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.

Based on the pan-European Investigation of System needs, for the Baltic Sea Region the 2040-needs can mainly be described by:
— Stronger integration Germany-Poland, in order to increase market-integration and in order to facilitate thermal decommissioning in Poland,
— Further integration Sweden-Finland in order to increase market-integration,
— Further integration Norway-Denmark, due to price-differences and to improve Danish security of supply in high demand and low variable RES (wind and solar) periods,
— Further integration between Sweden/Denmark and Germany, due to price-differences and to enable better optimization of the RES-generation (hydro/wind),
— Further internal integration in the Baltics, mainly due to Security of Supply.

In addition to these main increases, the high wind scenario (Global Climate Action) introduces huge wind growth in the north of Norway. This scenario will lead to an increased capacity-need in the north-south direction, through Finland, Sweden and Norway. The dependency of the needs to the respective scenario assumptions needs to be taking into account. Only by considering a variety of studies (e.g. several TYNDPs) can a robust statement of the needs be made.

Figure 6: Identified capacity increase needs in the three 2040 scenarios studied in BS region[5]



[4] https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP2018/rgip_BS_Full.pdf
[5] “Increases identified in TYNDP2016” refers to the reference capacities of TYNDP 2016 for 2030 which for some borders had been adjusted for the TYNDP18 purpose. Projects commissioned in 2020 are not included as increases.”

4.2

Main boundaries in the region

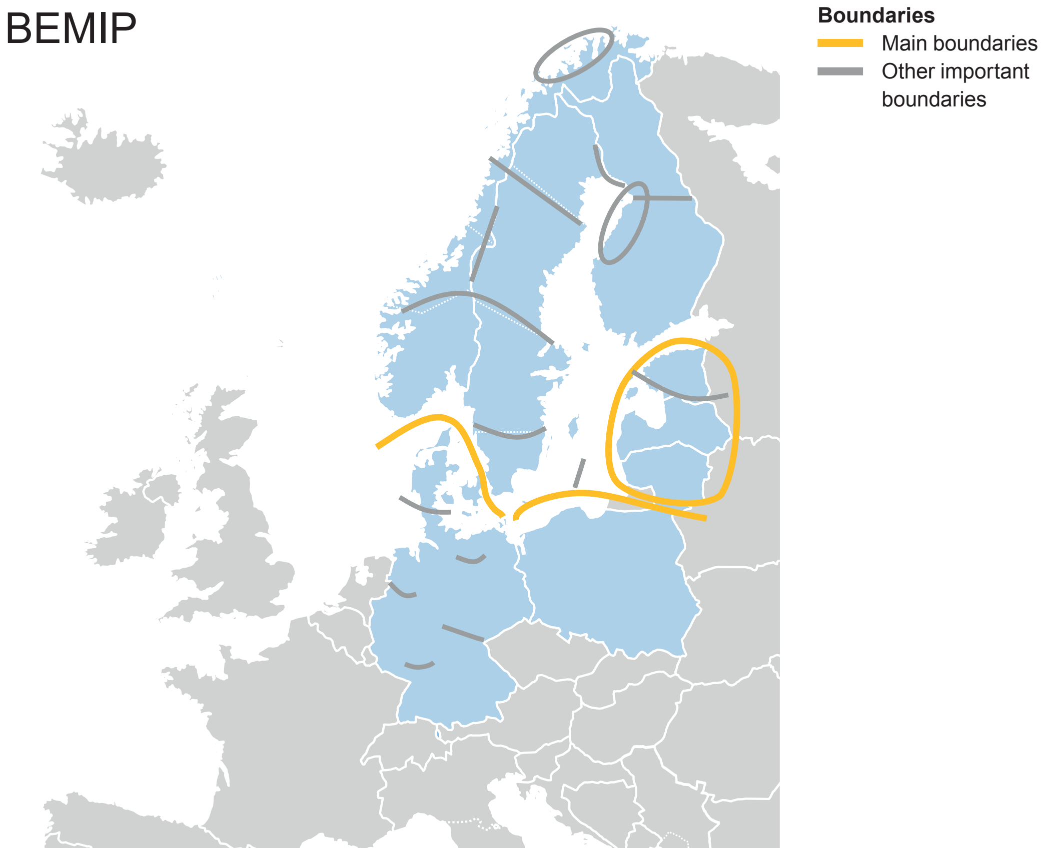
A boundary is defined by major barriers preventing optimal power exchanges between countries or market nodes, which – if no action is undertaken – lead to high price differences between countries, to RES spillage, as well as to security-of-supply risk. The boundaries of the previous TYNDP2016 are still valid for TYNDP2018.

General reasons for these boundaries/barriers are:

- Extensive increases in production from Renewable Energy Sources, like wind, solar and hydro
- High price differences between countries
- Increased local fluctuations of power infeeds causes higher flows between the synchronous areas, which require stronger integration of power systems

The map below shows the main European boundaries inside the planning region Baltic Sea, as well as other regionally important boundaries.

Figure 7: Main European boundaries inside the planning region Baltic Sea



The European main boundaries in the planning region Baltic Sea are defined as:

— **Nordics – Continental Europe West**
Further interconnection of Nordic countries and their hydro-storage, with mainland Europe (including Denmark west), especially to mitigate variations in power production from wind along the North Sea coastline.

— **Nordic/Baltic to Continental Europe East**
Further interconnection of Nordic countries and their hydro-storage, with mainland Europe, especially to mitigate variations in power production from wind along the Baltic Sea coastline.

— **Baltic integration**
Interconnection of the Baltic States to Europe, to secure their supply from the West.

Beside the European boundaries, there exists a couple of regionally important boundaries as well. These boundaries are related to the long-term needs described in Chapter 4.1, and are reflected in the regional key messages of Chapter 2. These regional boundaries are described through the planning-process of the national plans.

The table below gives an overview of the different capacities on the three European boundaries of the region. These capacities represent the sum of all cross-border interconnectors crossing a boundary. The 2027 capacity describes the reference grid, 2035 capacities result from the project collection of the Identification of System Needs process and the three 2040 scenario capacities were identified during the Identification of System Need-phase. Additional information on these can be found in the Regional Investment Plan 2017.

Table 1 – Identified capacities of full project portfolio in the BS region.

Year/Scenario	Capacity (MW) at European boundaries		
	Nordics-Continental Europe West (GW) North =>/<= South	Nordic/Baltic -Continental Europe East (GW) North=>/<= South	Baltic integration (GW) Export/Import
2016	4.94/5.40	1.1	2.22/2.20
2020	6.34/6.80	1.1	2.22/2.20
2027 (Ref.cap. CBA)	7.02/7.56	1.6	2.72
2035 ST, DG, EUCO	7.72/8.26	2.2	2.72
2040 (ST2040)	9.04/9.50	1.6	2.22/2.20
2040 (DG2040)	10.04/10.5	3.1	2.72/2.70
2040 (GCA2040)	11.04/11.5	2.6	3.22/3.20

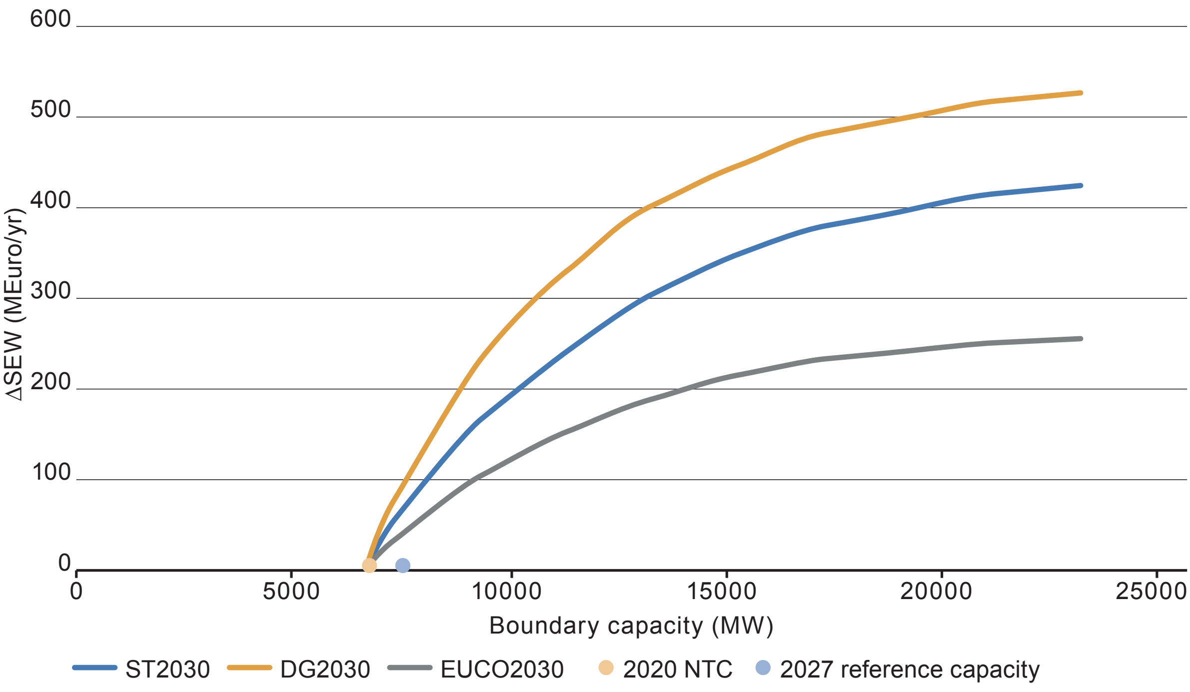
4.3
Socioeconomic benefits and capacity changes on main boundaries

All the scenarios studied include a large increase in renewable generation and decrease of CO_2 emissions. However, without any additional grid development the price spread between market areas in the region would largely increase and parts of the climate benefit would not be realized. The benefits of all projects within the BS-region are shown in the different project sheets.

Socio-economic benefit versus boundary-capacity
In order to show the benefits when increasing the capacity of a boundary the so-called SEW/boundary-capacity-curves are developed. These figures do not show the full total benefits, neither is the cost shown in the figures. The figures can be used to get an idea of the socioeconomic welfare of increasing capacities beyond 2020 values.

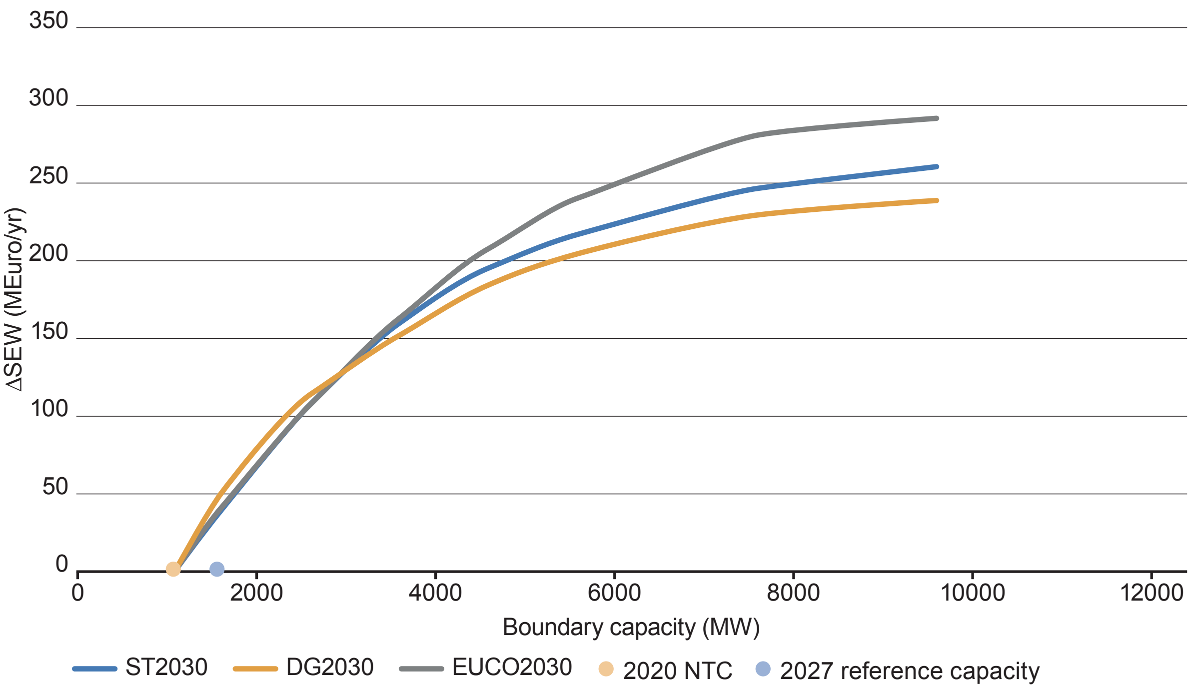
The following figures show the development of the socioeconomic welfare in case of uniform capacity increases and decreases across the three European boundaries of the region. The benefits are dependent on the assumptions in the different scenarios.

Figure 8: Potential socioeconomic benefit, boundary Nordics-Continental Europe West



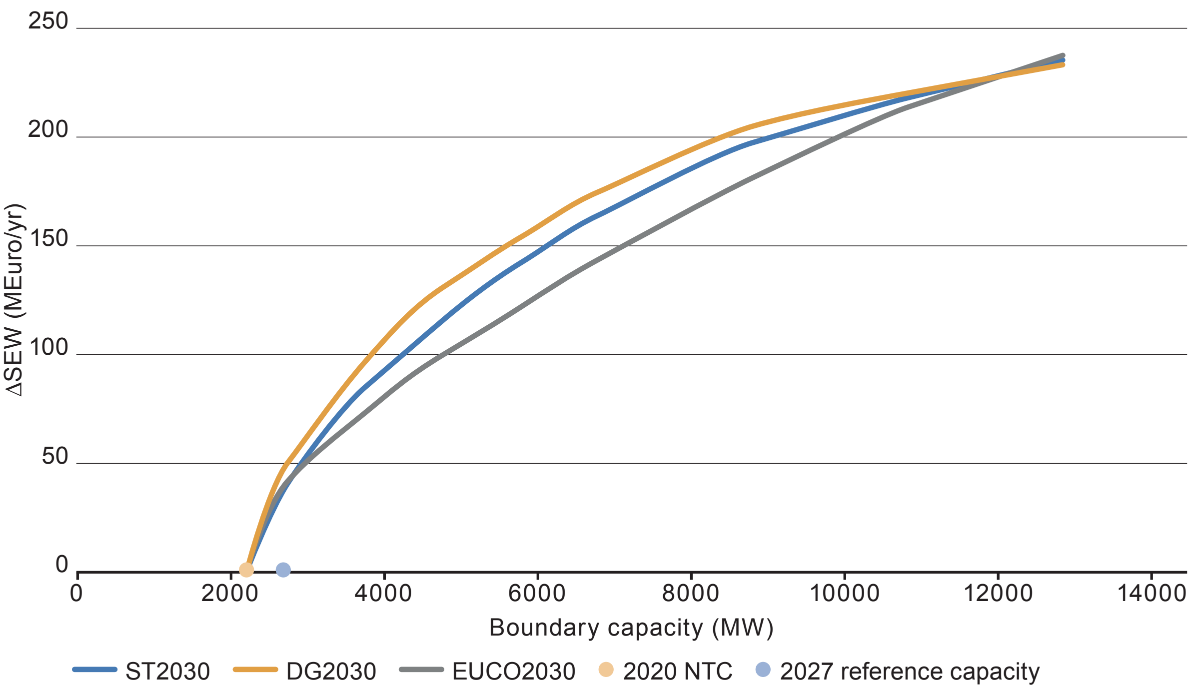
In the “Nordics – Continental Europe West” boundary, benefits are primarily driven by integrating RES generation and utilizing flexible Nordic hydro in the Continent. Therefore, scenarios with high CO_2 price (ST, DG) and high solar PV generation in the Continent (DG) are showing the highest benefits.

Figure 9: Potential socioeconomic benefit, boundary Nordic/Baltic to Continental Europe East



In the "Nordic/Baltic – Continental Europe East" boundary, benefits are primarily driven by the ability to export RES and flexible hydro from the Nordics to Poland. The need for imports is highest in EUCO and ST scenarios, which are also showing the highest benefits.

Figure 10: Potential socioeconomic benefit, boundary Baltic integration



In the "Baltic integration" boundary, benefits are primarily driven by the ability to export RES and flexible hydro from the Nordics to Baltics and onwards through Baltics to Poland. In addition to Polish balance, Baltic import needs / balance and PV-related RES integration need in Baltic countries influences the benefit.

4.4

Interconnection targets 2030

The European Council in October 2014 endorsed the proposal by the European Commission (EC) of May 2014 to extend the current 10% electricity interconnection target (defined as import capacity over installed generation capacity in a Member State) to 15% by 2030.

To make the 15% target operational, the EC decided to set up an Expert Group (EG) - composed of industry experts, organizations, academia, NGOs, ACER and ENTSO-E/G - to provide specific technical advice. In November 2017, the expert group delivered their report[6] to the EU Commission, introducing a methodology using the following 3 criteria:

— Minimizing 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 for 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 maximized.

The multi-criteria assessment helps to identify where urgent action is required. A country being below the thresholds for one or more of the above criteria is urged to investigate options to develop interconnection capacity. In addition, countries lying between the 30% and 60% thresholds for the security of supply and/or RES integration criteria are recommended to regularly investigate options to further develop interconnection capacity.

The report introduces a very important precondition when evaluating options to further develop interconnection capacity, namely that any implementation of a project should only be done if the project show a positive socio-economic value.

The following maps show the results for the BS Region when these above criteria are utilized on the three 2030 scenarios of TYNDP2018. In Figure 11 the interconnection targets are measured based on the 2020-grid (includes projects already permissioned/ under construction), while Figure 12 show the interconnection targets measured based on the more hypothetic 2027-grid. Important hypotheses taken are:

— Scenarios are assumed adequate – using the 2027 reference grid

— Nominal transmission capacity used is the physical interconnection capacity, respecting system security criteria (such as N-1)

— Price differentials between bidding zones shown on the map are limited to those for which either direct interconnection exists or projects are currently being assessed in the CBA phase of TYNDP18. They are hence not necessarily fully exhaustive.

[6] https://ec.europa.eu/energy/sites/ener/files/documents/report_of_the_commission_expert_group_on_electricity_interconnection_targets.pdf

Figure 11: Interconnection Targets according to the TYNDP 2018 – scenarios. 2030 ST, DG, EUCO applied upon the 2020 grid.

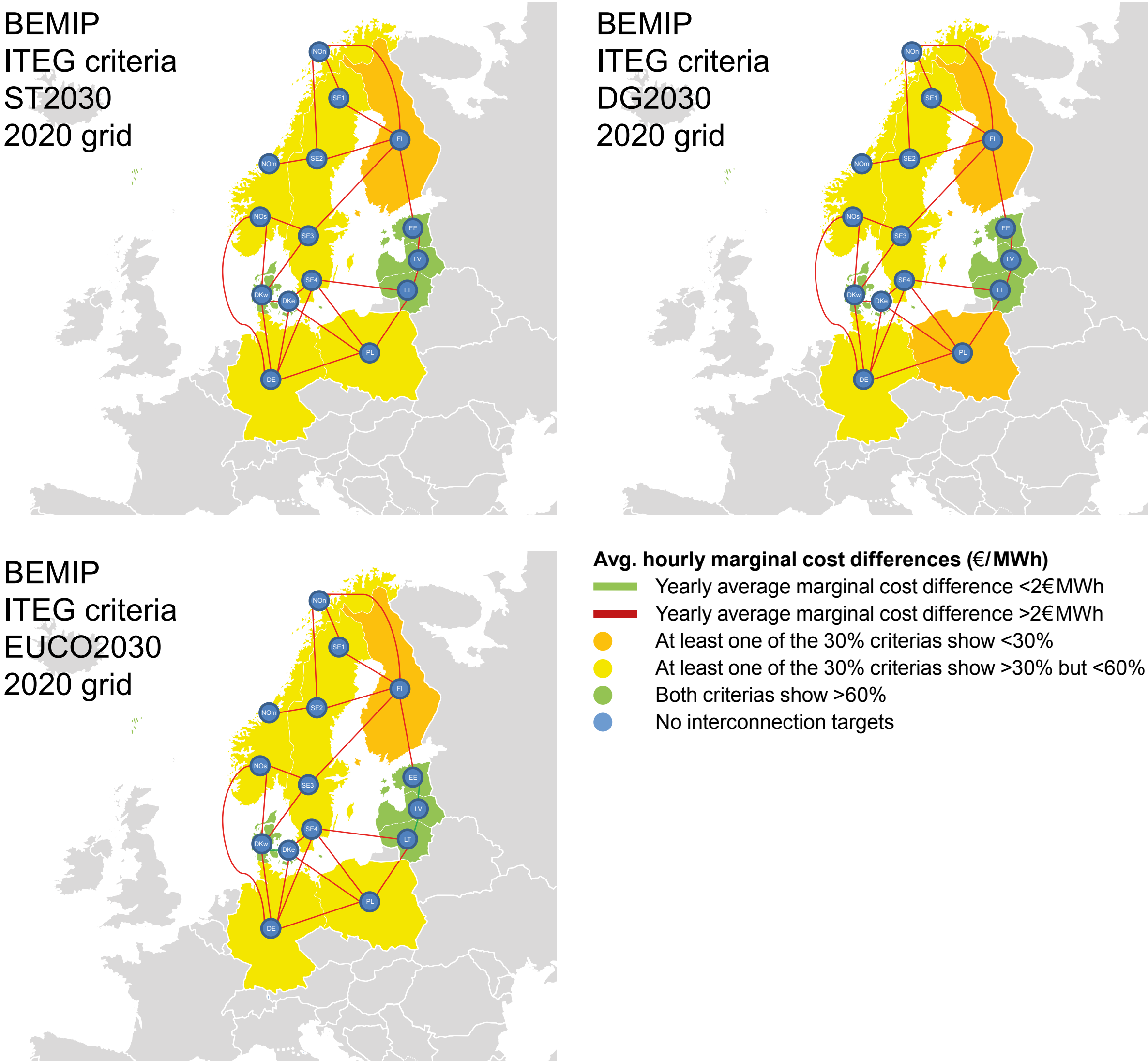
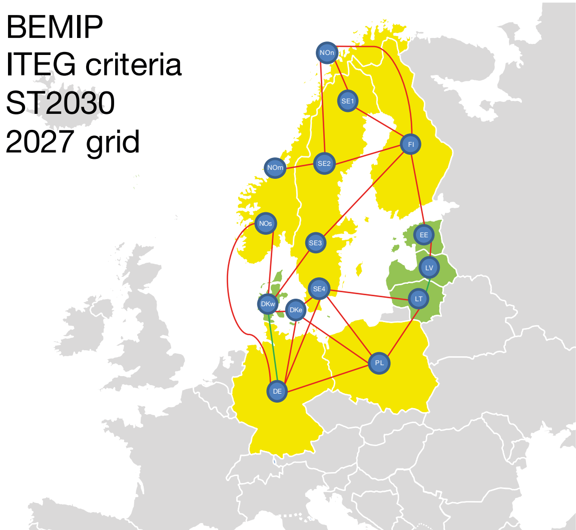
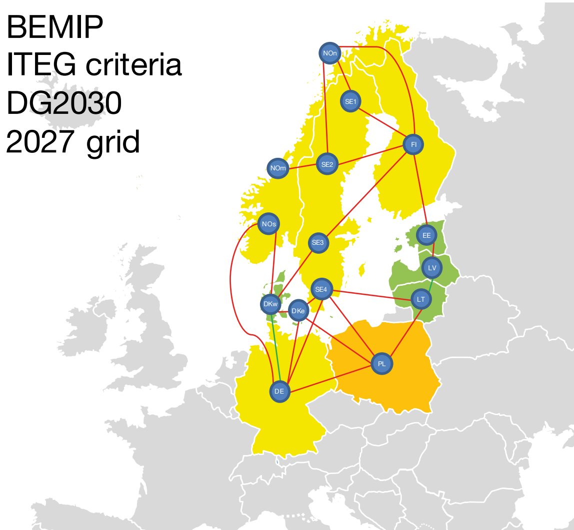
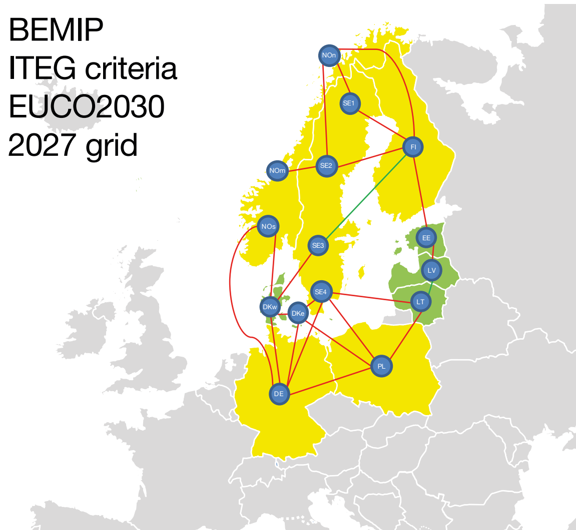


Figure 12: Interconnection Targets according to the TYNDP 2018 – scenarios. 2030 ST, DG, EUCO applied upon the 2027 grid.







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

The maps show, that the following market areas and cross-country sections in the region might need to be investigated:

— Immediate assessment of interconnection development (criteria below 30%) appears:
— For Poland and only in one scenario.
— For Finland assuming the 2020-grid. The situation improves assuming the 2027-grid.
— The Baltic States and Denmark satisfy the 60% criteria in all 2030 scenarios, and are green based on this in all scenarios.
— Germany, Finland, Norway and Sweden are yellow (between 30 and 60%) in all scenarios. The reason why Norway is yellow is that hydro-production is not counted in the method proposed for the Commission.

In all 2030 scenarios, price differentials (>2 €/MWh) exist between most Member States showing the need for further investigation of possible additional capacity (based on the 3rd criterion).

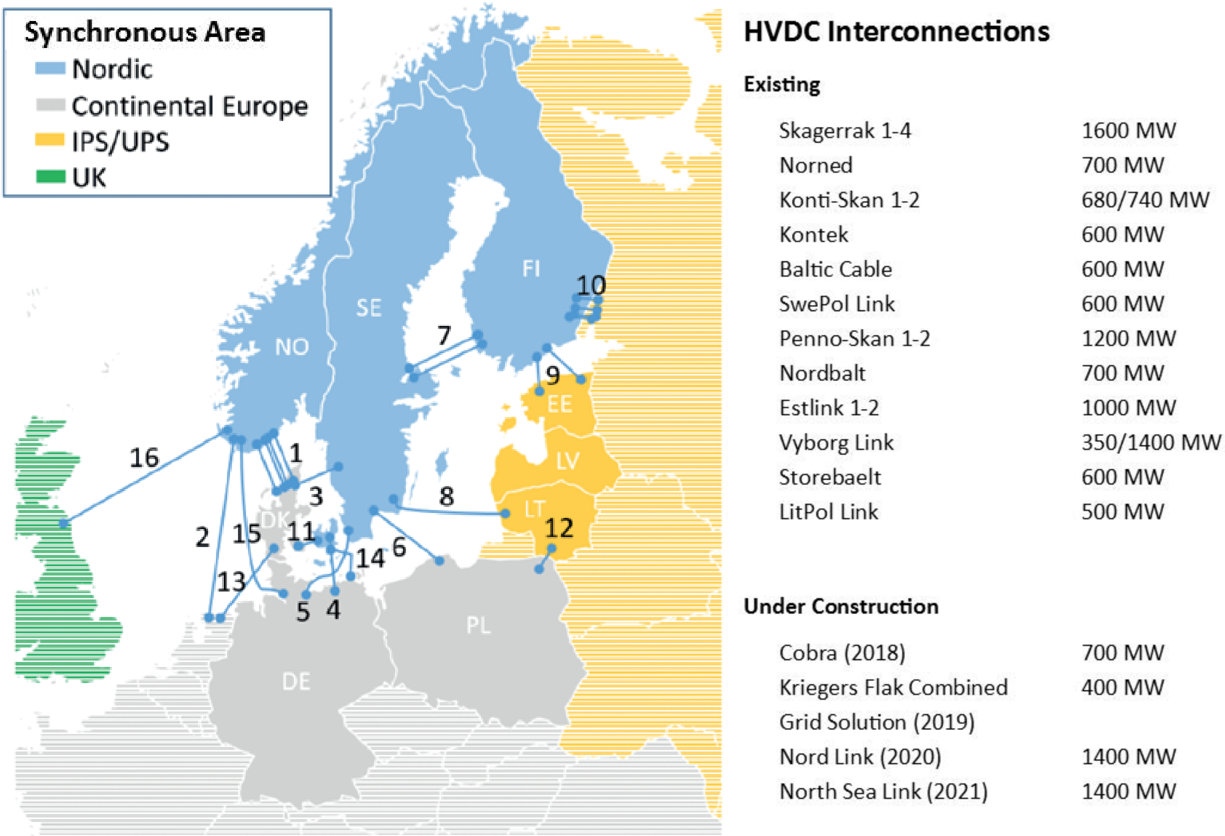
Even if the 2 €/MWh-criterion is exceeded, this is generally an all too low value to show CBA>0 for any project. The sizes of the price-difference between different countries and different price-areas are shown in Appendix 1.

Section 5

Grid development in the region

The Baltic Sea region comprises nine countries: Sweden, Norway, Finland, Denmark, Estonia, Latvia, Lithuania, Poland and Germany. Within the region there are three separate synchronous systems: the Nordic system, the Continental system, and the Baltic power system; the last is synchronously connected with the IPS/UPS system (i.e. Russia and Belarus). The synchronous areas are illustrated in Figure 13, notably Denmark is divided between two synchronous areas: Denmark-East, which is part of the Nordic system, and Denmark-West, which is part of the continental system.

Figure 13: Development of HVDC-projects out of and between the synchronous areas of the region Baltic Sea.



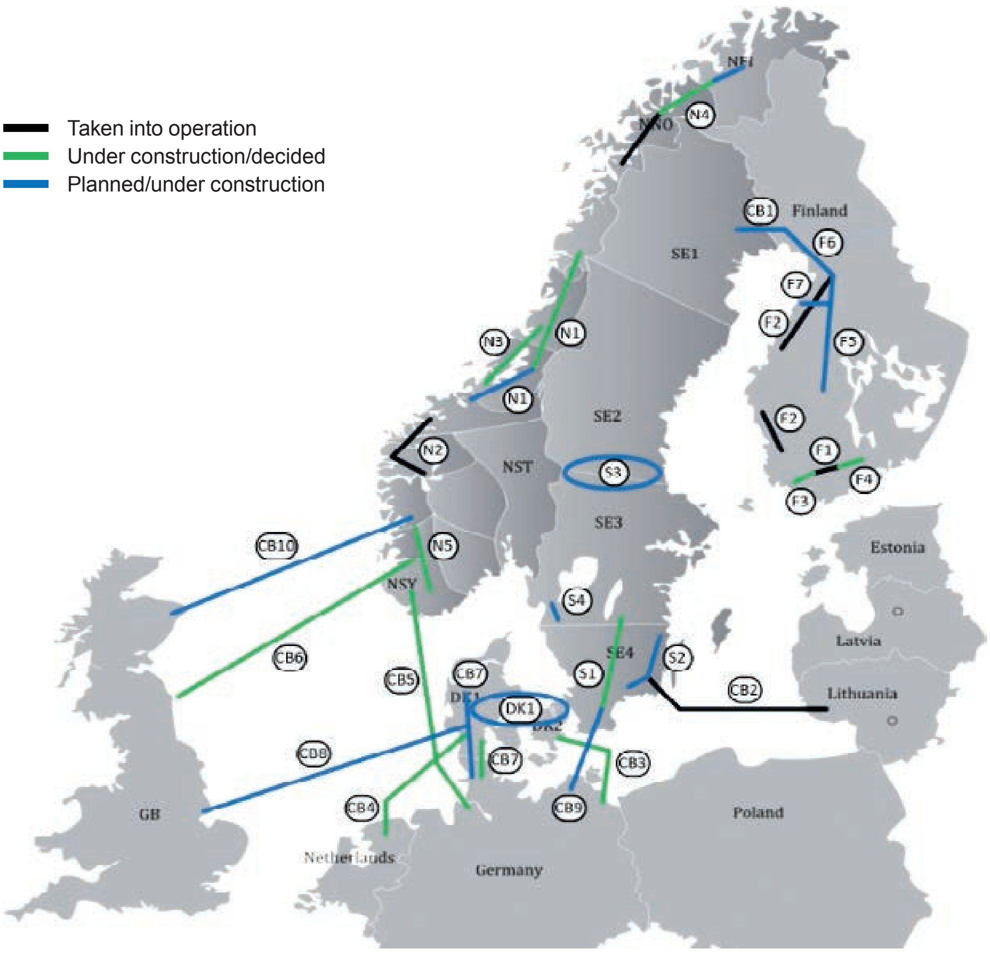
5.1
Grid development in the Nordic system

For the Nordic system a huge number of internal grid-reinforcements are being realised. These are both shown in the national grid development plans as well as in the Nordic Grid development Plan 2017.

In total the Nordic TSOs are expected to reinforce the Nordic system with projects totalling more than 17 Billion Euros for the 10-year period 2016-2025. Norway has the largest investment-level, followed by Sweden and Denmark. The reinforcements are driven by an increased north-south flow, implementation of renewables, further connection to other synchronous areas as well as keeping the security of supply at an adequate level.

For the next Nordic Grid Development Plan (2019) the Nordic TSOs will investigate the need for further capacity for the corridors: Norway-Denmark, Norway-Sweden, Norway-Finland, Sweden-Finland and Sweden-Denmark. These investigations will be reported as well in TYNDP 2020.

Figure 14: Projects being described in the Nordic Grid Development Plan 2017.



5.2
Grid development in the Baltic system

The most important topic for the Baltic system is the de-synchronization from IPS/UPS-system and the synchronization with the European system. The status of this is described in Chapter 6.

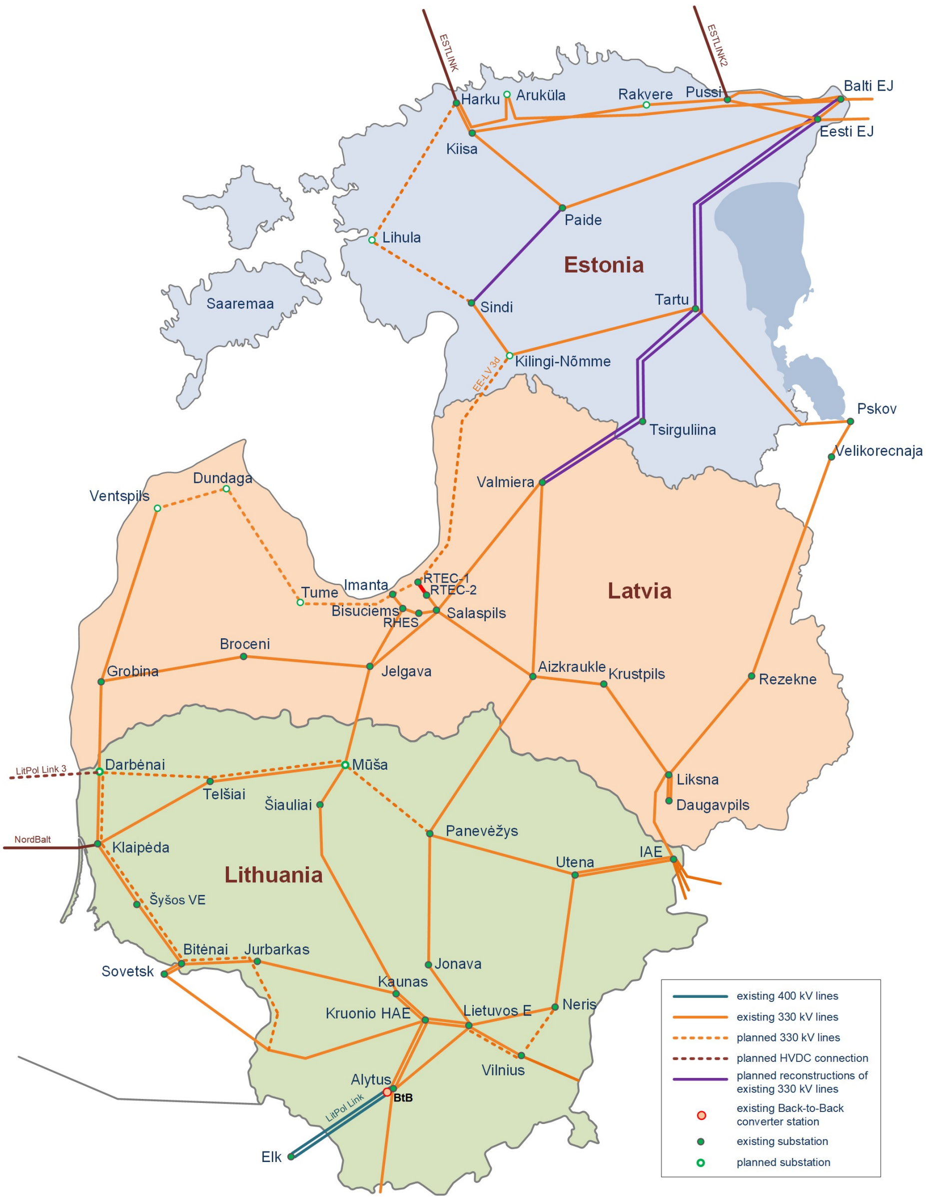
Reinforcements include building new lines, reinforcing existing lines, implementing new voltage control units, upgrading control systems, new generation units. On-going studies will specify exact amount of necessary reinforcements.

Baltic States have decided upon the alternative to synchronize with the Continental system, and currently the Baltic Synchronization project is under discussion and decision making process with the TSOs of Baltic States, governments of Baltic States and European Commission.

In June 2018 the President of the European Commission Jean-Claude Juncker together with the Heads of State or Government of Lithuania, Latvia, Estonia and Poland agreed on the Political Roadmap for synchronising the Baltic States' electricity grid with the continental European network by the target date of 2025. The Leaders called for swift completion of the project.

The project assessment in the TYNDP 2018 package is also happening as the project is included in the third list of Projects of Common Interests under European Union and Parliament Regulation No 2016/89 adopted in November 2017. During 2018, the decision about the desynchronization scenario is expected to be made and the necessary costs and technical needs for successful desynchronization from IPS/UPS power system have been estimated.

Figure 15: Baltic States power system.

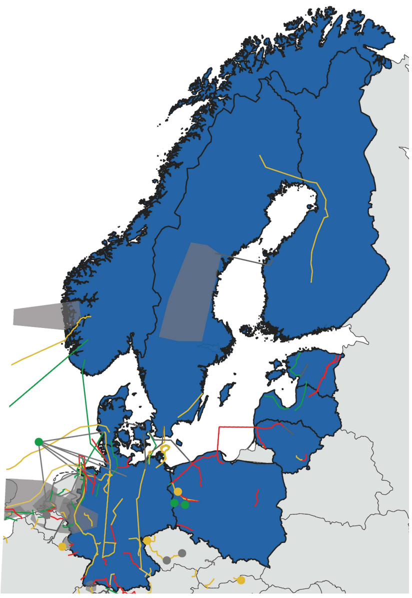


5.3

Overview of projects being assessed in TYNDP 2018

The TSOs in the region are already making plans to meet the needs described in Chapter 4. Projects both under construction, applying for permissions and in the planning-phase are among the projects being CBA-assessed in TYNDP 2018. Still, there might be gap towards the potential 2040-needs, but the region's TSOs are on the way forming the future power system. The figure and table below show projects in the Baltic Sea-region being CBA-assessed in TYNDP 2018. In addition, a lot of projects connecting the Baltic Sea-region to neighbouring regions are being assessed. Some of these projects however belong to neighbouring planning regions of ENTSO-E and are reported there. Among the most important projects reported elsewhere are interconnectors from Norway to Germany and Great Britain, interconnectors from western Denmark to the Netherlands, Germany and Great Britain, as well as internal German interconnectors in the North-South-direction of Germany.

Figure 16: Map of projects being assessed in TYNDP 2018. The table show projects of the responsibility of region Baltic Sea.



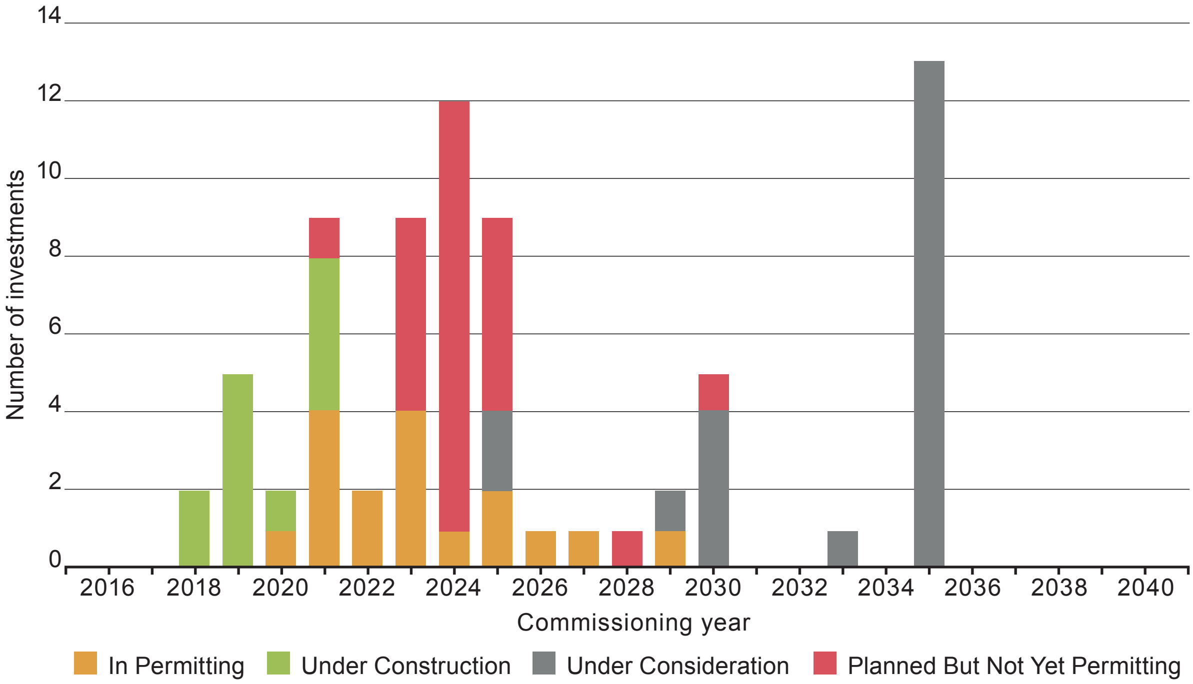
Project ID	Project name	Country 1	Country 2
96	Keminmaa-Pyhänselkä	FI	
111	3rd AC Finland-Sweden north	FI	SE
123	LitPol Link Stage 2	LT	PL
124	NordBalt Phase 2	LT	SE
126	SE North-south Reinforcements	SE	
170	Baltics synchro with CE	LT, LV, EE	PL
175	Great Belt II	DK	
176	Hansa Powerbridge I	SE	DE
179	DKE-DE (Kontek2)	DK	DE
197	N-S Finland P1 Stage 2	FI	
234	DKE-PL-1	DK	PL
239	Fenno-Skan 1 Renewal	SE	FI
267	Hansa Powerbridge II	SE	DE

5.4
Monitoring the projects of the region

The status of the development of the region's projects/ investments is shown in Figure 17. The vast majority of projects is expected to be completed in advance of 2025. Several projects are already under construction.

The projects are almost equally divided between the 4 categories; Under construction, In permitting, Planned but not yet permitting, Under consideration.

Figure 17: Status and expected commissioning year for investments in region Baltic Sea.



Traditionally, grid development has mostly comprised overhead line HVAC circuits. In the future both undergrounding and HVDC technology play a more prominent role in the future grid development.

From a pan-European perspective, this is expected. To enable the integration of the anticipated renewable generation, the region requires additional cross border capacity.

Section 6

Baltic synchronisation – status

6.1
Summary from the previous TYNDPs

The power systems of Baltic States including Estonia, Latvia and Lithuania currently are operating in parallel with Russian and Belarus power systems as members of Integrated Power System/Unified Power System (IPS/UPS) where primary power reserves and frequency regulation is provided by Russian power system. Baltic power systems together with Russia and Belarus are members of electrical BRELL ring (shortened Belarus, Russia, Estonia, Latvia and Lithuania), consisting of 330 kV, 500 kV and 750 kV transmission lines. The tight electrical interconnection of Baltic States with Russia and Belarus is providing by now reliable, flexible and secure system operation within Baltic States and whole BRELL ring. After Baltic States joining to European Union, integration of Latvia, Lithuania and Estonia within common EU energy market has been identified as a strategic priority for the Baltic States and the EU, and has been analysed in the previous Pan-European TYNDPs 2012, 2014 and 2016, prepared by ENTSO-E.

During the years since 2007 different kind of reasons has been crystallized for the Baltic States to shift from operation within IPS/UPS power system to operation with the Continental Europe. On June 11, 2007 Prime Ministers of the Baltic States signed the Communiqué and set out for TSOs from Estonia, Latvia and Lithuania to recognise and start overall studies on very ambitious strategic goal to achieve full integration of the Baltic electricity market into EU common electricity market and possibilities of synchronisation with the Continental Europe. The strategic goal for possible Baltic power systems synchronisation with EU is Baltic States' target of increasing of electricity independency. The synchronisation project is supported by the European Commission, so taking all above into account the Baltic States and the European Commission, the Kingdom of Denmark, the Federal Republic of Germany, the Republic of Poland, the Republic of Finland, and Kingdom of Sweden has established the Memorandum of Understanding on the reinforced Baltic Energy Market Interconnection Plan "BEMIP". The Declaration on energy Security of Supply has been signed on January 14, 2015 by the energy Ministers of the Baltic States. The Declaration calls for: developing liberal, transparent, competitive and fully functioning regional gas and electricity markets; full implementation of the third energy package; market integration; construction of necessary infrastructure; synchronisation of the Baltic States with the Continental European network, and implementation of the European Energy Security Strategy.

Since establishing of different kind of cooperation agreements on further desynchronization from IPS/UPS power system, TSOs from the Baltic States have carried out some feasibility studies to investigate possibilities of the Baltic system synchronization with the Continental Europe (former UCTE) synchronous area, which have included technical, economic and beneficial assessment and favourableness aspects. The finalized studies are following:

— Feasibility study of "Interconnection Variants for the Integration of the Baltic States to the EU Internal Electricity Market" prepared by energy sector consultant Gothia Power and Baltic TSOs, 2012-2013,
— "Synchronisation roadmap" prepared by Baltic TSOs, 2015,
— "Large scale unit implementation in Baltic" study prepared by Gothia Power and Litgrid, 2015,
— "Integration of the Baltic States into the EU electricity system: A technical and economic analysis" DG ENER/JRC study for possible synchronization variants, 2015-2017,
— "Study of isolated operation of the Baltic power system" prepared by energy sector consultant Tractebel Engineering and Baltic TSOs, 2017.

6.2
Status of the project

During the JRC study in 2015-2017 different kind of interconnection scenarios have been studied: interconnection of Baltic power system with the Continental European power system or Nordic power system; synchronous and asynchronous and additional case isolation of the Baltic States power system from both the CE and from IPS/UPS (isolated island operation). As the best and the most feasible scenario from cost benefit analyses and technical perspective point of view was identified the Baltic States power system synchronous operation with the Continental European Network through Lithuania-Poland interconnection. This scenario has been assessed and developed further to clarify necessary power system developments from the Continental Europe and the Baltic States perspective. Expected results of such operation are stable system operation with increased vulnerability, due to considerably weaker AC interconnection of the Baltic Countries power systems to the CE power grids. Loop flows from/to IPS/UPS can be controlled/eliminated due to DC interconnections replacing the AC ones.

After JRC study results in the end of 2017 Baltic TSOs, Polish TSO and ENTSO-E agreed to prepare two additional studies for evaluation of dynamic stability in Continental Europe and Baltics and evaluation of frequency stability in Baltic States.
The studies have to be finalized by the middle of 2018 and based on those results the decision of synchronization scenarios is expected.

Three Baltic TSOs have started work for cost-benefit analysis (CBA) preparation for synchronization project and investment request preparation according to requirements of Regulation 347/2013 of European Parliament and of the Council on guidelines for trans-European energy infrastructure. The investment request is planned to be submitted to the National Regulatory Authorities (NRA) in the Baltic States in Q2 2018.

On the 28th of June 2018 at a special ceremony in Brussels the President of the European Commission Jean-Claude Juncker,together with the President of Lithuania Dalia Grybauskaitė, the Prime Minister of Estonia Jüri Ratas, the Prime Minister of Latvia Māris Kučinskis and the Prime Minister of Poland Mateusz Morawiecki, has signed the Political Roadmap on the synchronisation of the Baltic States' electricity networks with the continental European network. This follows the meeting on 22 March 2018, where President Juncker and the same Leaders gave the synchronisation project a renewed impetus.

The Political Roadmap sets the scene for the practical implementation by presenting a clear timetable of actions. The first of such action is the launch, this September, of the ENTSO-E procedure as a first technical step for extending the Continental European Network to the Baltic States. This project is a cornerstone and one of the most emblematic projects of the Energy Union and a concrete expression of solidarity in energy security. The synchronisation process is crucial to complete the integration of the Baltic States with the European energy system. It will constitute a major contribution to the unity and energy security of the European Union.

6.3
Ongoing studies

In January of 2018 the Service contract on the "Performance of the Dynamic Study extension of the Synchronous Area Continental Europe for the Baltic States' Transmission system" has been signed between four TSOs: "Polskie Sieci Elektroenergetyczne" from Poland, "Litgrid" from Lithuania, AS "Augstsprieguma tikls" from Latvia, "Elering" from Estonia with Institute of Power Engineering Gdansk Division from Poland as service provider. The overall objective of the project is to prepare a detailed dynamic study of extension of the synchronous area of the Continental Europe with the Baltic States' transmission systems. The general scope of work consists of:

- power flow studies which are determined by dynamic analyses requirements,
- dynamic analyses which comprise of model preparation as well as small signal and transient stability analysis.

In parallel to the study mentioned above in January 2018 the TSOs of Baltic States together with ENTSO-E has initiated Baltic TSOs' Frequency Stability Study to assess potential additional costs related to Baltic's power system frequency stability in case of different synchronization scenarios with the network of Continental Europe. This study will clarify and give the final assessment regarding the additional costs for all necessary measures to guarantee the system frequency stability in the Baltic States' power systems. The both studies are planned being finalized Q2-2018.

6.4
The next steps regarding project development

Currently the Baltic Synchronization project is under discussion and decision process among the TSOs of the Baltic States, governments of the Baltic States and the European Commission. The final decision is planned in June 2018. The project assessment under TYNDP 2018 package is going on as well as project is included in the third list of Projects of Common Interests under European Union. During 2018 the decision about synchronisation and desynchronization scenario has to be made and necessary costs and technical needs for successful synchronisation with the Continental Europe and desynchronization from IPS/UPS power system have to be estimated.

The planned future steps of the synchronisation project are following:

- June 2018 – Finalisation of dynamic and frequency studies, prepared by Baltic and Polish TSOs and ENTSO-E;
- April 2018 – Investment request to Baltic States NRAs of the synchronisation project and Cross Border Cost Allocation decision from NRAs;
- 2018-2019 – catalogue of measures of synchronisation study, issued by ENTSO-E and prepared by all involved TSOs;
- 2019 – experiment of Baltic power systems isolated operation;
- 2020-2025 – Preparation works of Baltic synchronisation including construction of additional infrastructure and upgrade of power system control and management equipment.
- 2025 – Baltic synchronisation.

Section 7

Annex

7.1

Average hourly price difference maps

The following maps show average hourly price differences between different market nodes of the region. These maps confirm the boundaries, driven by market integration, as shown above (Nordics – Continental E. West and Nordic/Baltic-Continental).

The integration of the Baltic countries, even if significant price differences are observed in some scenarios, is mainly caused by security of supply reasons.

Figure 18: Expected price-differences in the 2030 scenarios, assuming 2020-, 2027- and 2034-grid.

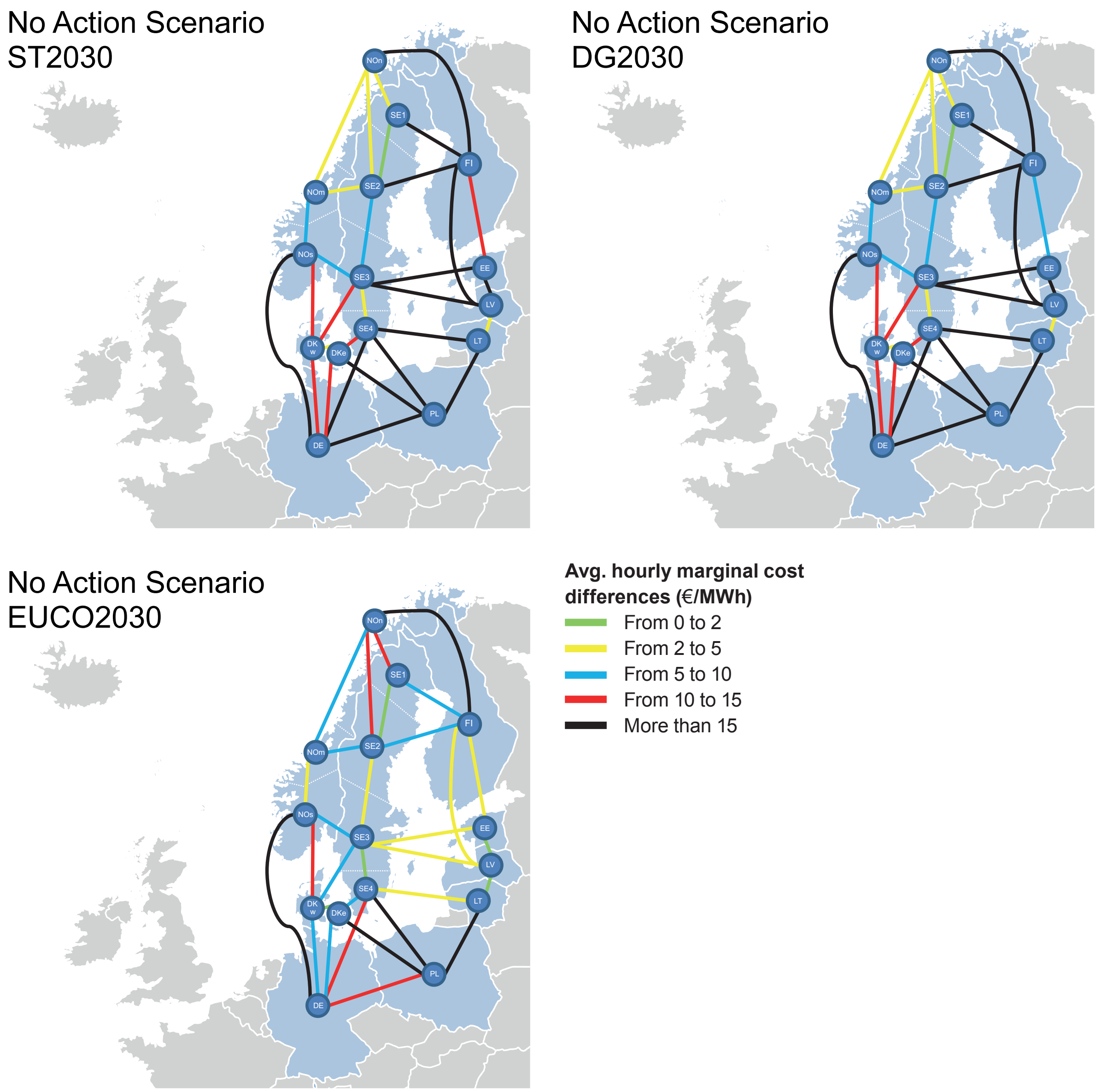
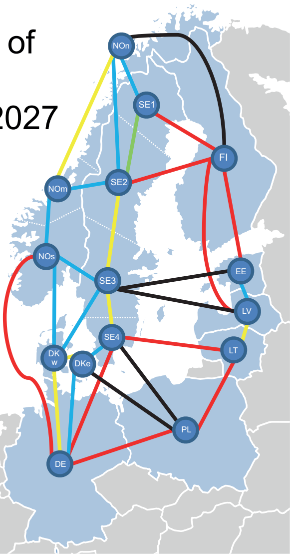
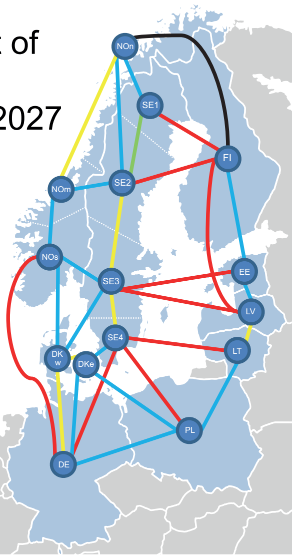


Figure 18 continued: Expected price-differences in the 2030 scenarios, assuming 2020-, 2027- and 2034-grid.

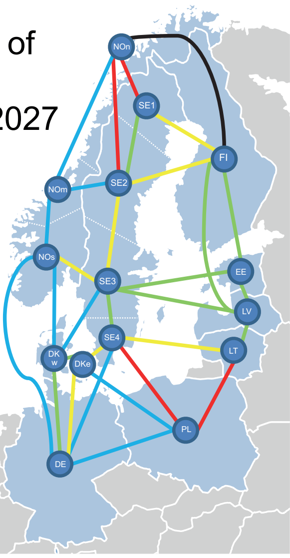
Marginal Cost differences: impact of project portfolio commissioned by 2027 ST2030



Marginal Cost differences: impact of project portfolio commissioned by 2027 DG2030



Marginal Cost differences: impact of project portfolio commissioned by 2027 EUCO2030

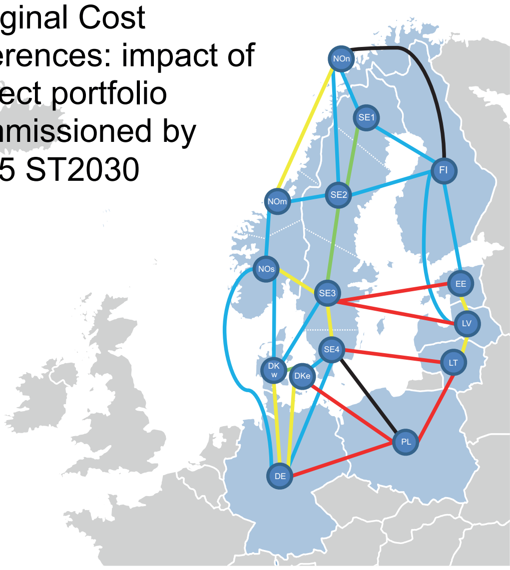


Avg. hourly marginal cost differences (€/MWh)

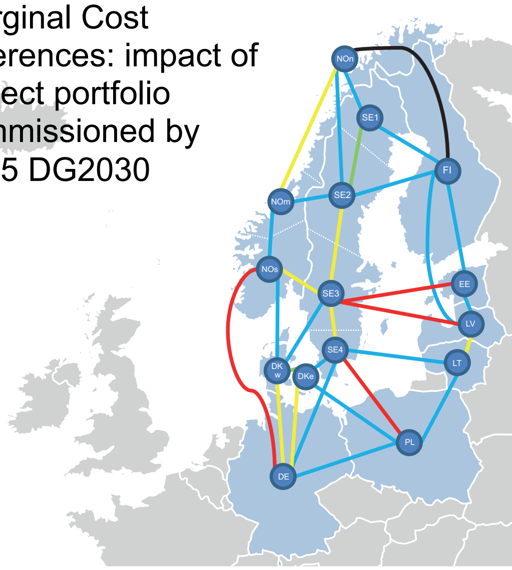
- From 0 to 2
- From 2 to 5
- From 5 to 10
- From 10 to 15
- More than 15

Figure 18 continued: Expected price-differences in the 2030 scenarios, assuming 2020-, 2027- and 2034-grid.

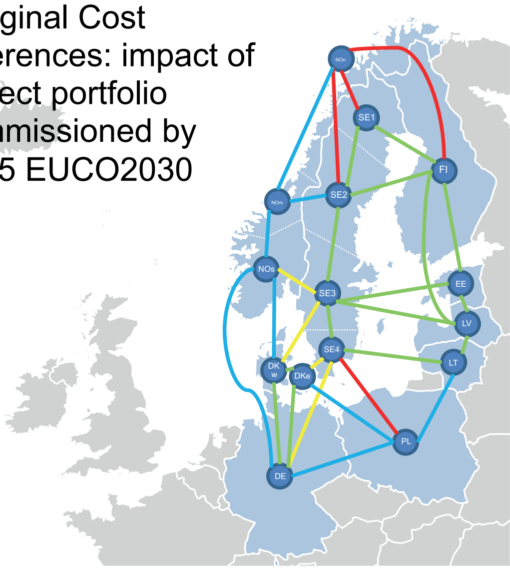
Marginal Cost differences: impact of project portfolio commissioned by 2035 ST2030



Marginal Cost differences: impact of project portfolio commissioned by 2035 DG2030



Marginal Cost differences: impact of project portfolio commissioned by 2035 EUCO2030



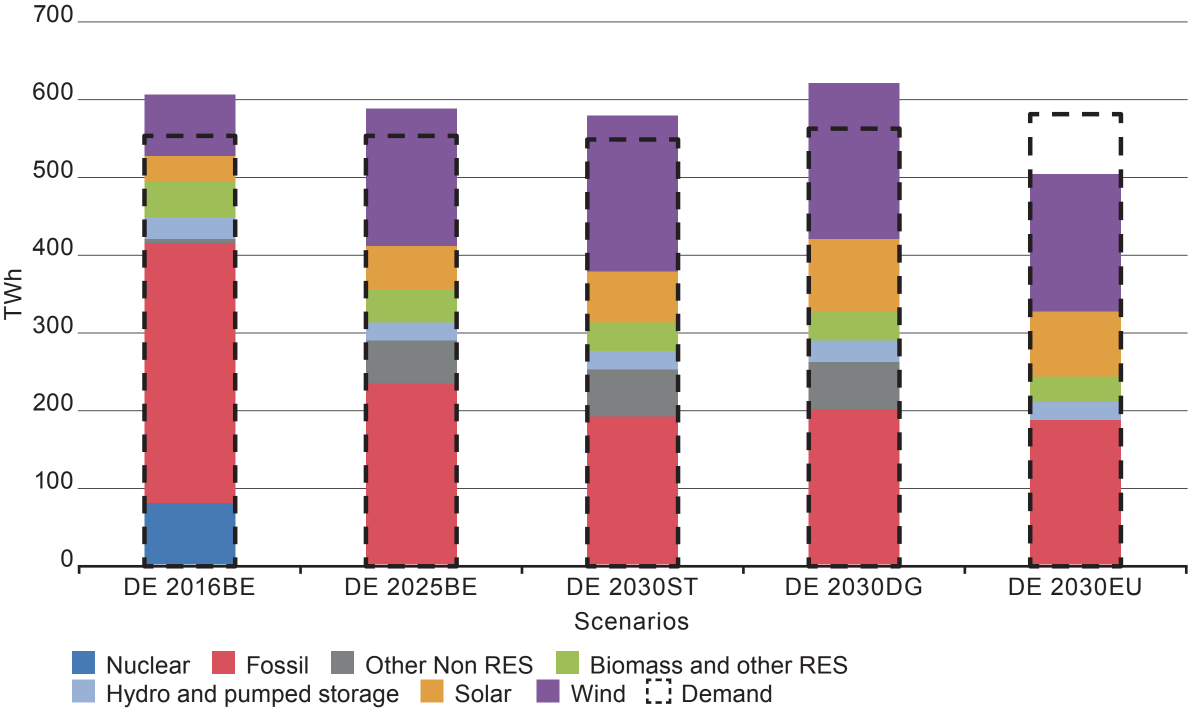
Avg. hourly marginal cost differences (€/MWh)

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

7.2
Generation and demand per country

The following maps show generation and demand
per country of the region for the different scenarios.

Figure 19: Generation and demand per country and per scenario.



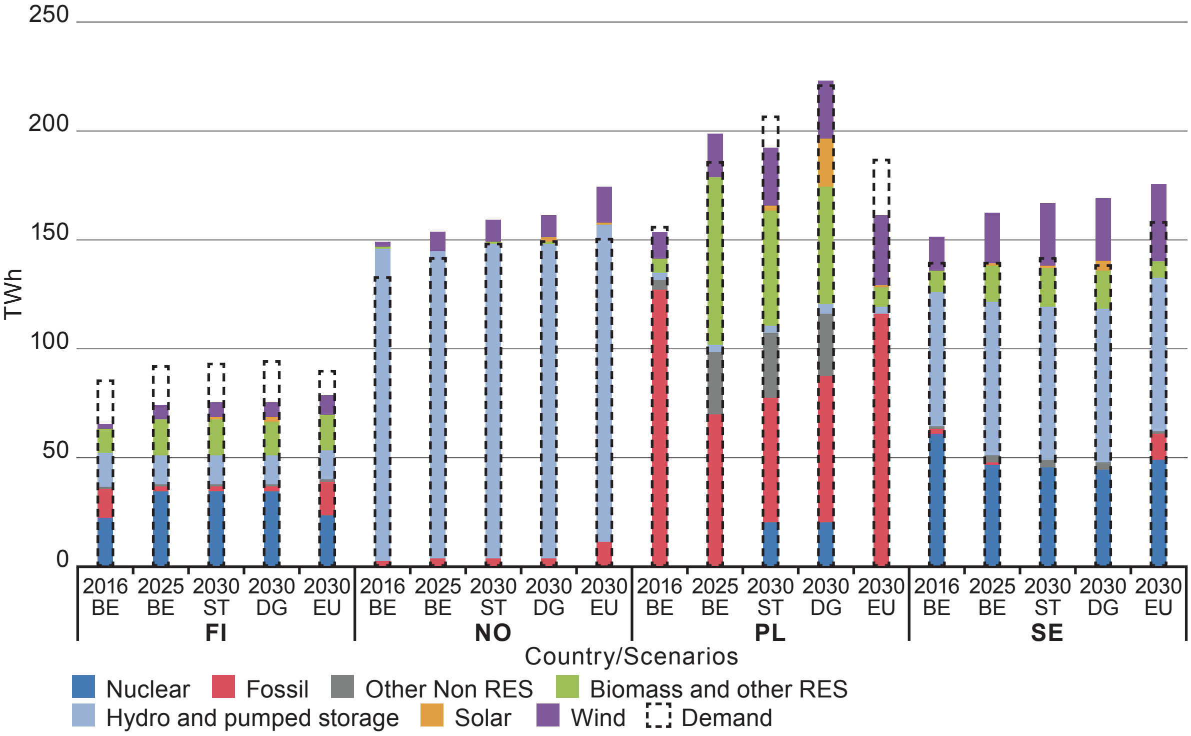


Figure 19 continued: Generation and demand per country and per scenario.

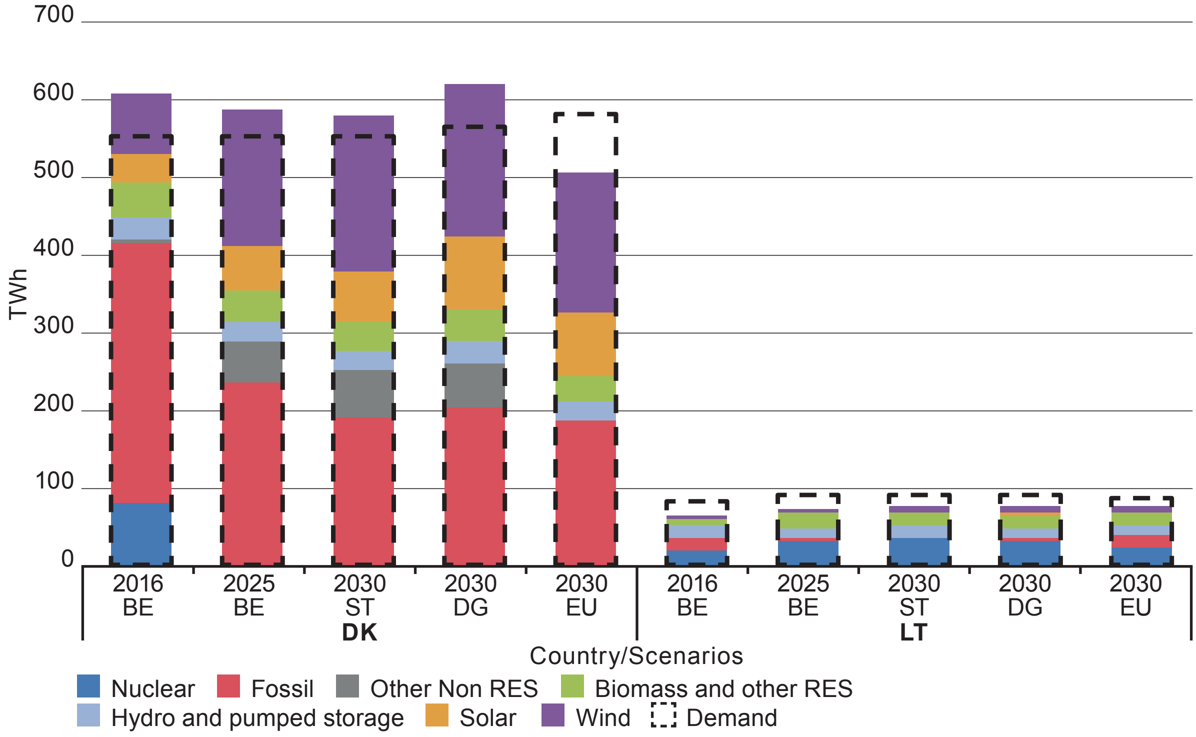


Figure 20: Generation-capacity per country and per scenario.

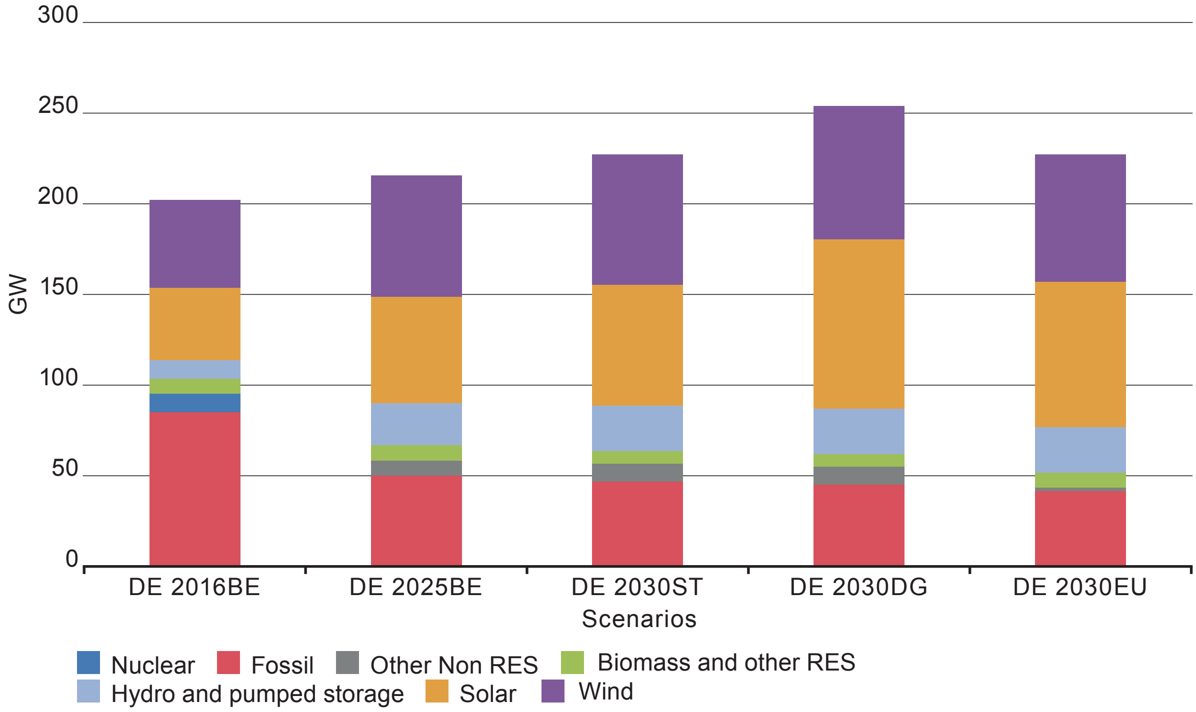
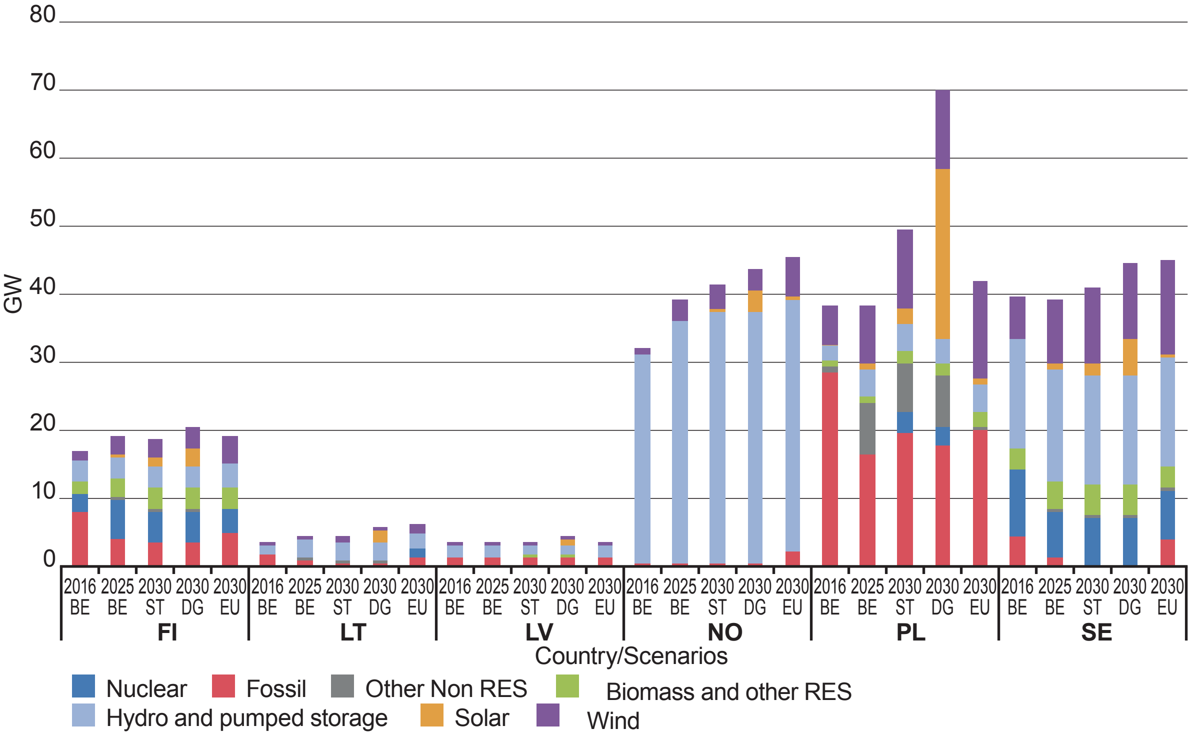
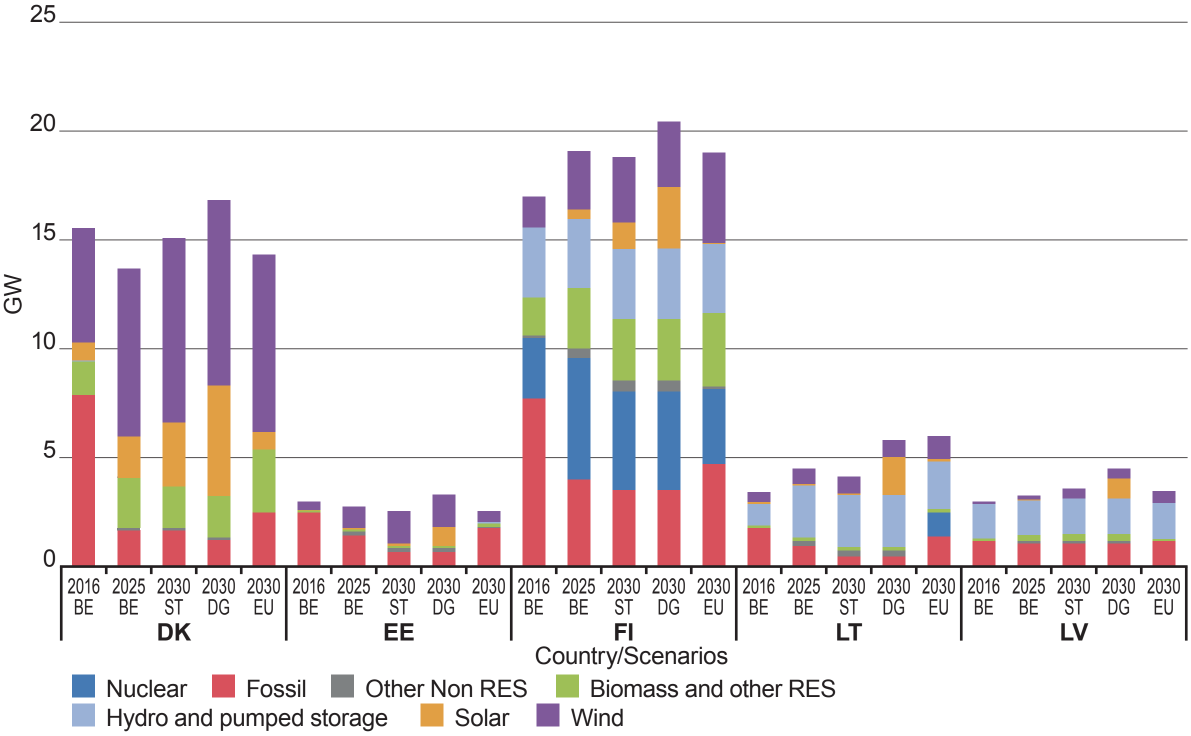


Figure 20 continued: Generation-capacity per country and per scenario.





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