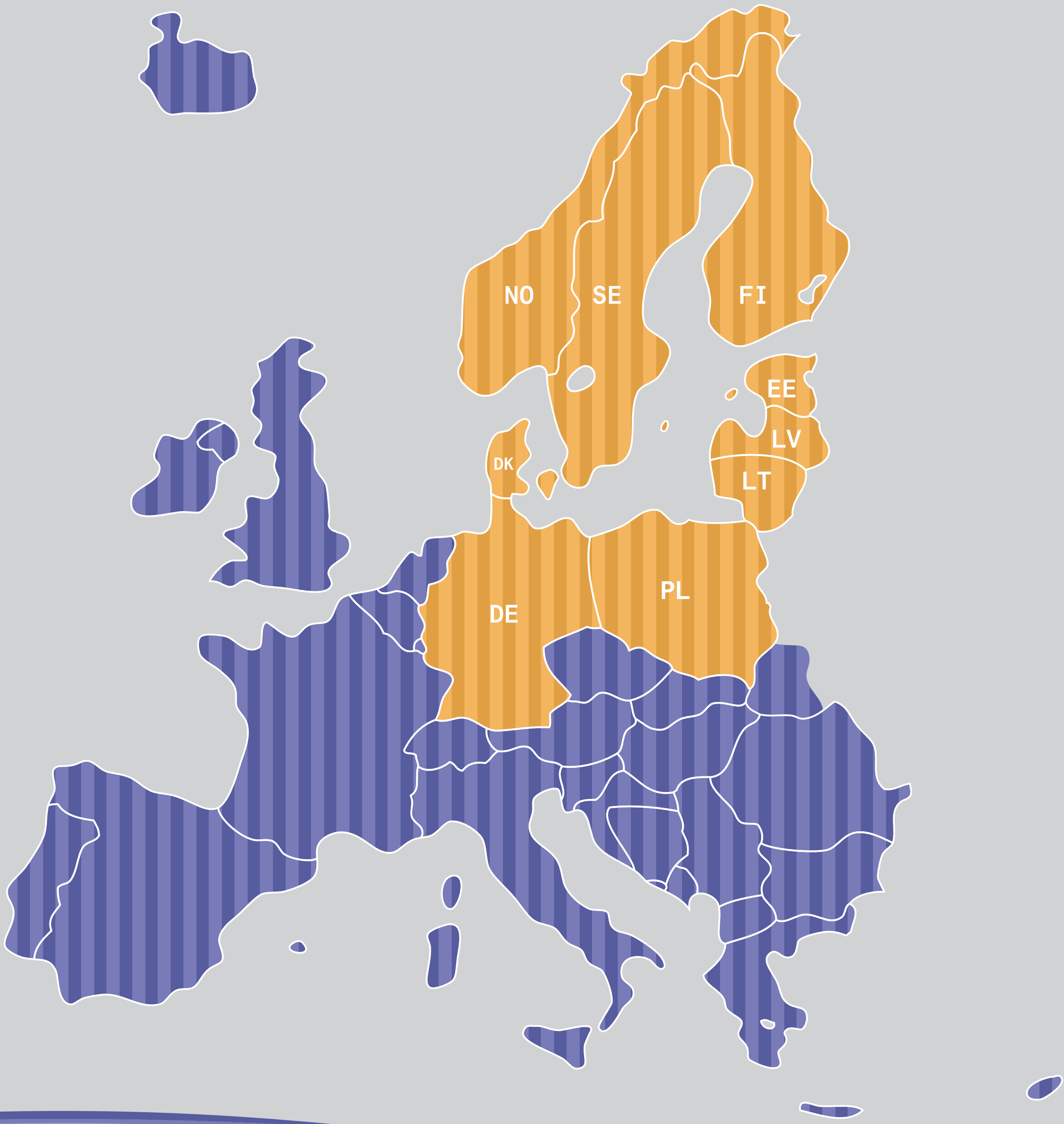
Regional Investment Plan Baltic Sea

Final



European Network of
Transmission System Operators
for Electricity

entsoe

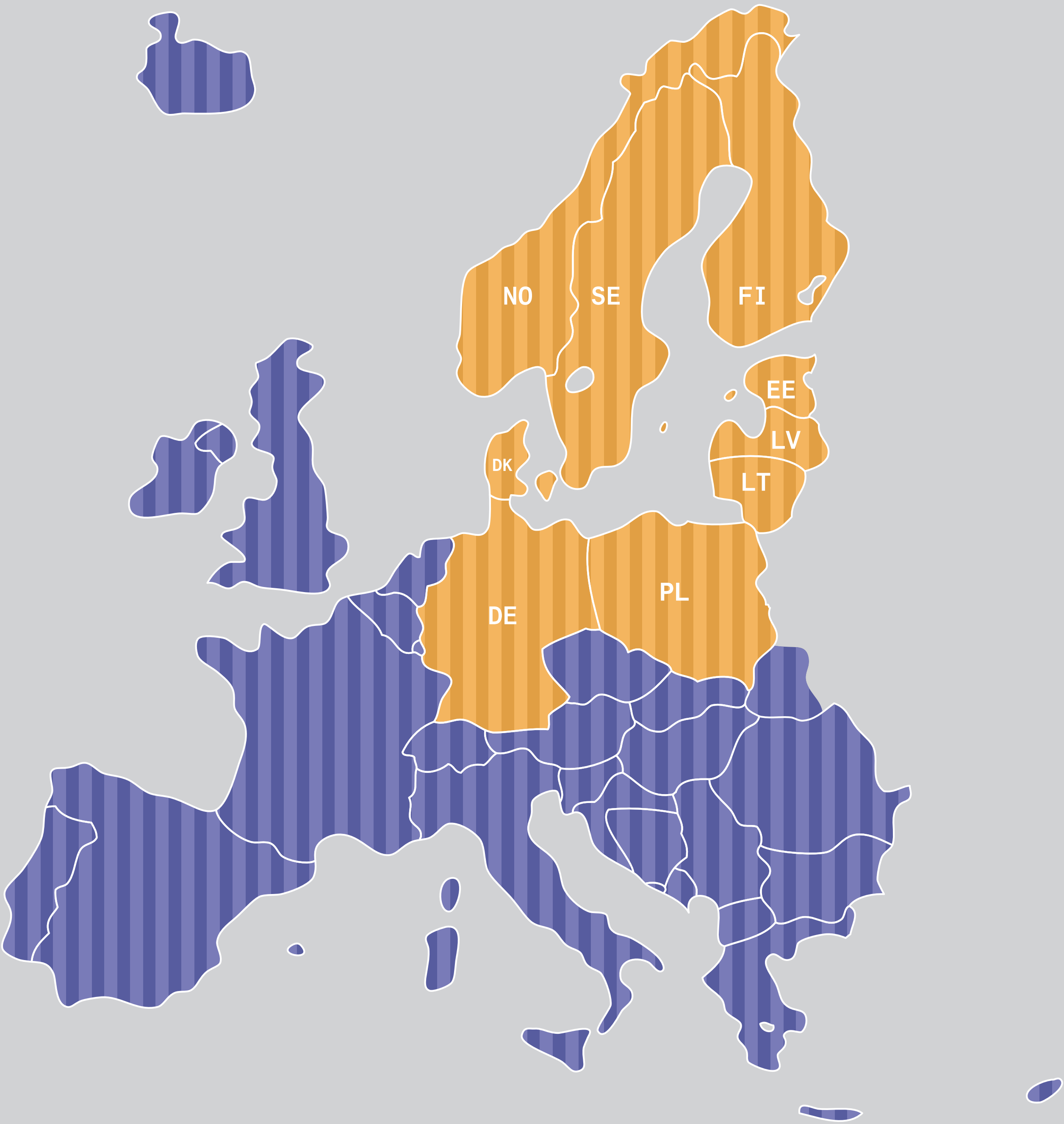
Regional Investment Plan Baltic Sea

Final

5 July 2012

Content

1 Executive Summary



Introduction

The 3rd Legislative Package for the Internal Market in Electricity entered in to force 3 March 2011. It promotes co-operation within the European Electricity Industry, the development of the Electricity Infrastructure both within and between Member States, and focuses on cross-border Exchanges of Electricity between the Member States.

In this regard, the TSOs of the Regional Group Baltic Sea within ENTSO-E present this Regional Investment Plan 2012 – 2022. The Baltic Sea region within ENTSO-E covers Norway, Sweden, Denmark, Finland, Estonia, Latvia, Lithuania, Poland and Germany.

This Regional Investment plan describes the development of the interconnected power system of the Baltic Sea region of ENTSO-E. The plan is in keeping with the continuation of the pilot pan-European Ten Year Network Development Plan (TYNDP), published by ENTSO-E in June 2010. The present plan is supported by regional and pan-European analysis, rather than by unilateral or bilateral studies.

Investment drivers

The main drivers for system evolution in the region are preservation of security of supply, increased market integration and connection of renewable and conventional generation, EU 20-20-20 targets and the priorities in the EIP (Energy Infrastructure Priorities). The integration of Baltic States to the European electricity market and further integration of the Nordic countries will make the system more robust and accommodate the integration of large amounts of wind power and other renewable energy sources (RES) within and around the region. New connections between Nordic and Continental European countries are necessary and beneficial with regards to handling the changes in generation portfolios in the Continental countries and the Baltic Sea region, as well as the Nuclear Phase Out plan of Germany. In addition to the existing and planned direct connections, the transmission system of the Baltic States, after connection to the central Europe network, will serve as an alternative route between Nordic and Continental Europe.

Scenarios 2020

This plan is founded on the first ever region-wide market and grid analysis performed in co-operation by the Baltic Sea regions TSOs. The market and grid analysis were based on two main scenarios, and several sensitivities around these.

The **EU2020 scenario** represents the national renewable action plan targets of the countries, and hence meeting the objectives of the European 20-20-20 (20 % of RES in the final energy, 20 % reduction of GHG, and 20 % increase in energy efficiency). Moreover, the World Energy Outlook of the International Energy Agency (IEA) has been chosen as a reference for gas and coal prices. This scenario is also referred to as the top-down scenario.

A second scenario has been called **Scenario Best Estimate,** or **Scenario B,** and represents the TSOs' best estimate on how the future might look like, taking practical experience into account concerning for example lead times of developments. This scenario is a bottom-up scenario.

In addition to these two scenarios, **a sensitivity analysis** was conducted with the new Nuclear Phase Out plans in Germany announced in the summer of 2011, during the analysis phase. The effect of varying CO_2 price was also studied.

These scenarios have been simulated in a market model, both to identify investment needs, as well as to analyze the benefits of the planned grid reinforcements in the region. Grid studies have been performed to assess the technical resilience of the system, with and without new investments. Power adequacy of special situations has also been studied.

Investment needs

The Baltic Sea region comprises nine countries in three different synchronously connected power systems, which are linked with HVDC connections. The Nordic system is currently linked with Continental European, the Baltic States and IPS/UPS of Russia. The Baltic States are synchronously connected to IPS/UPS of Russia, but no link yet exists directly between Baltic States and the Continental systems. Part of the region is large and scarcely populated, which causes additional challenges with regards to the transmission of electricity. Dynamic phenomena restrict the transmission capacity due to long distances between production and consumption areas.

The results of the analysis based on the scenarios above show that by 2020 there will be a high surplus of energy in the Nordic countries, and this energy must be transmitted to Continental Europe, to the UK and the Baltic States. The main transmission direction will be North-South in the Baltic and Nordic countries. Large conventional generation units are planned in Finland, Lithuania and Sweden, and also require extensive development of the transmission grid.

Strengthening the existing grid between the hydropower dominated northern part and thermal and wind power dominated southern part of the region is beneficial. The large hydro reservoirs can be utilized in order to balance the changes in wind and solar production as well as the demand fluctuations. Increased interconnection capacity is also needed to drain the expected Nordic surplus. Without new interconnector capacity, there is a risk of locked-in power in Norway and Sweden given the studied scenarios. Lack of grid capacity would most probably lead to lower investments in RES, and hence failure to achieve RES targets.

Investments, transmission adequacy and resilience

In response to the investment needs highlighted above, the Regional Investment Plan 2012 – 2022 for the Baltic Sea region includes 46 projects of Pan European significance, which are listed in Appendix 1. However, internal German and Polish projects excluding Polish internal projects relevant with Polish – Lithuanian interconnection are not included in analyses carried out by this Regional group. German and Polish internal projects are analysed in Continental Central East group of ENTSO-E. Most of the projects in this plan were presented in the TYNDP 2010, but there are also a number of additional investments in this version. Of the investments presented in TYNDP 2010, the majority remain on schedule. Some projects have changed in terms of commissioning date, status or consistency of project detail. Delays are mainly caused by time consuming permitting processes. The TSOs are proceeding to implement this plan in order to facilitate the region in meeting the EU targets for 2020 as well as targets of market integration and security of supply.

The figures 10 and 11 illustrate the projects which are expected to be delivered in the medium term (first five years), and in the long-term (last five years).

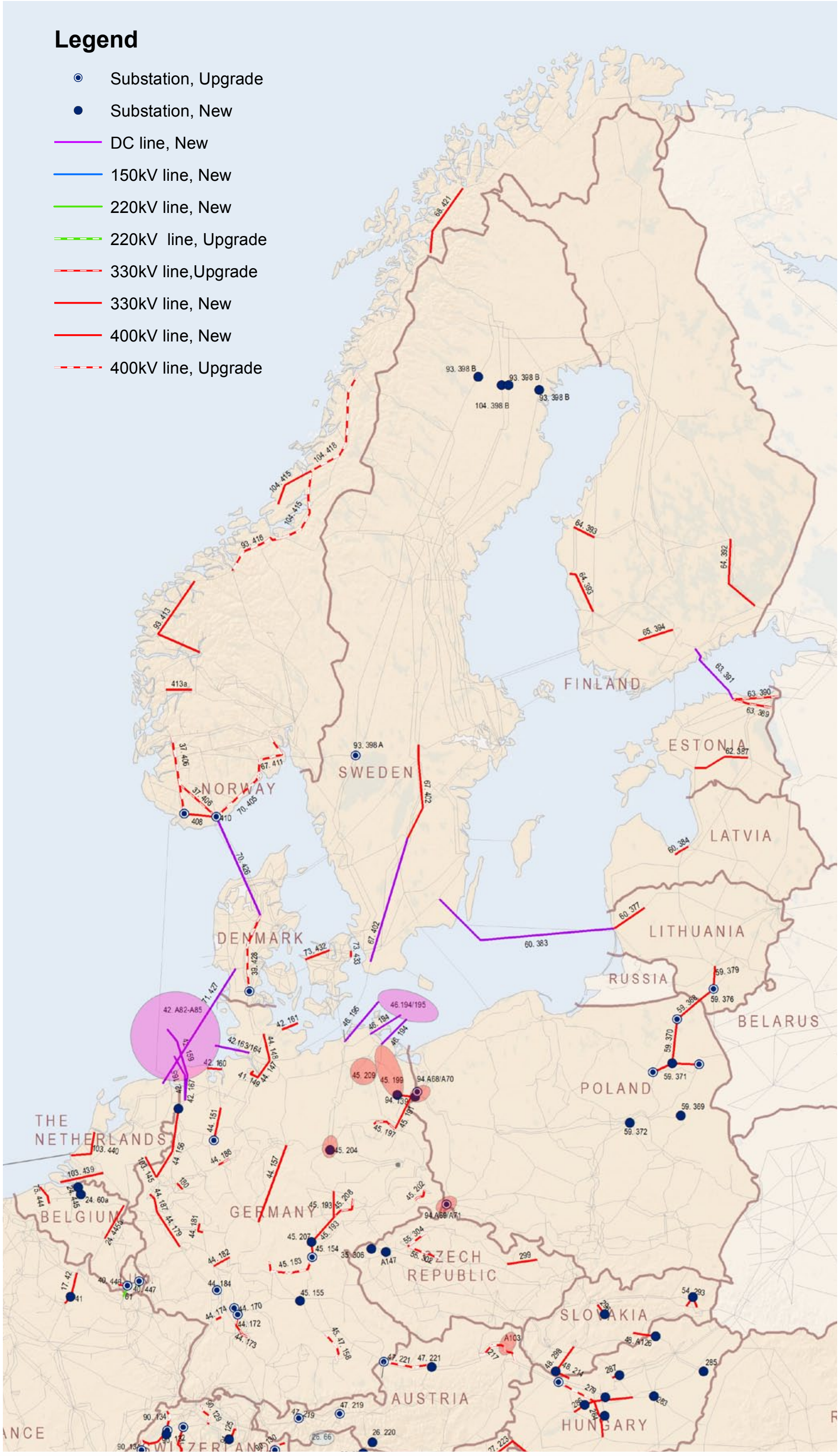


Figure 1:
Mid-term projects in Baltic Sea region

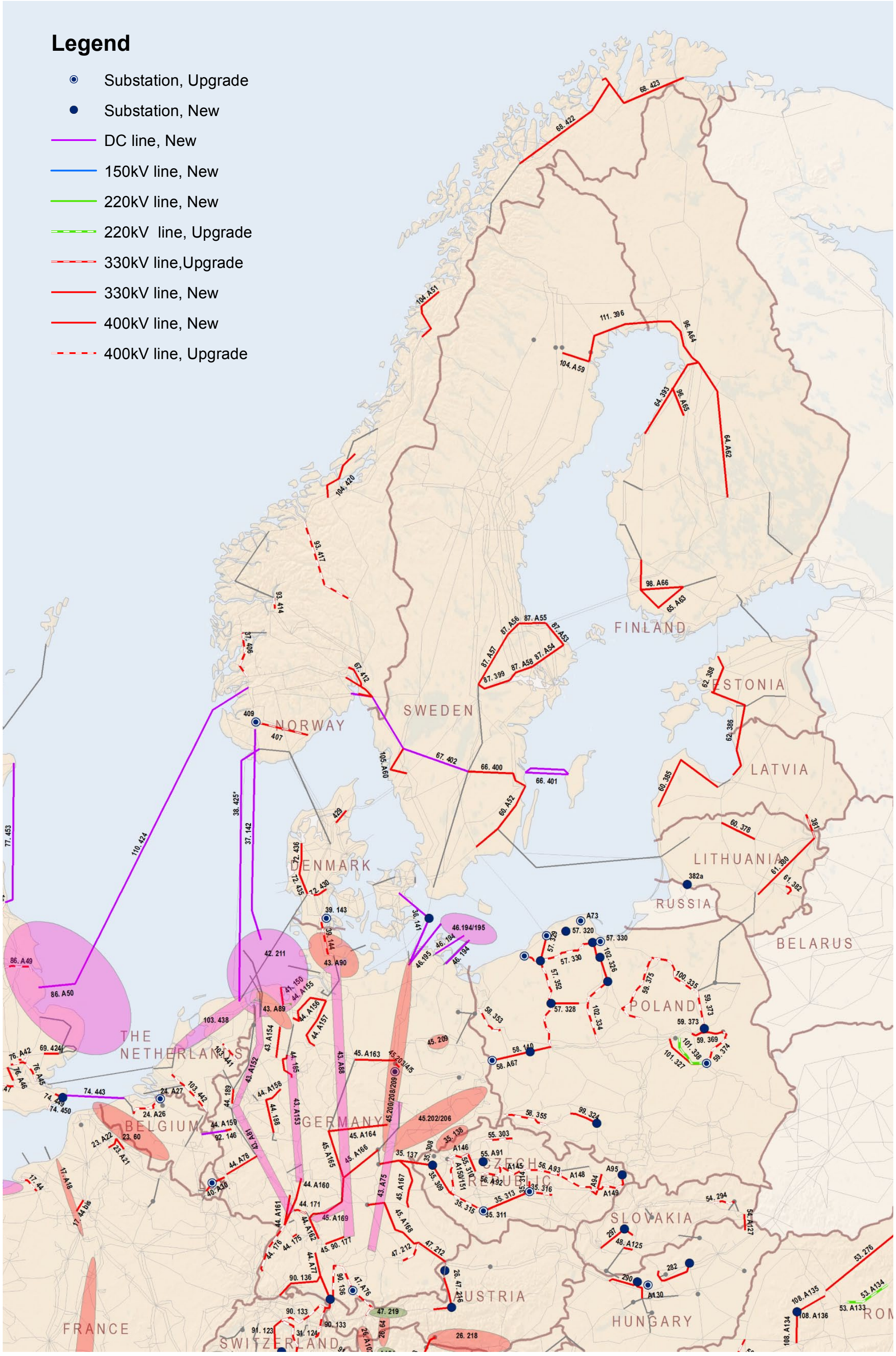


Figure 2:
Long-term projects in Baltic Sea region

The results of the analysis show that the investment portfolio presented in this plan gives flexibility and provides a sound and functional infrastructure which bodes well for the future European vision of competitive internal market and low-carbon energy. The planned investment portfolio is robust, resilient and beneficial. With the presented investment portfolio the Baltic Sea region within ENTSO-E will become more integrated with the rest of the European electricity market. Due to the high amount of wind and solar power integration it is crucial to ensure sufficient regulation of power, which could even increase the benefits of the planned investment portfolio through better-functioning markets.

For the studied scenarios the investment portfolio was found to be proper for the coming ten years. However if significant and unexpected changes occur in contrast to the assumptions made in the scenarios, more change of investments may be required.

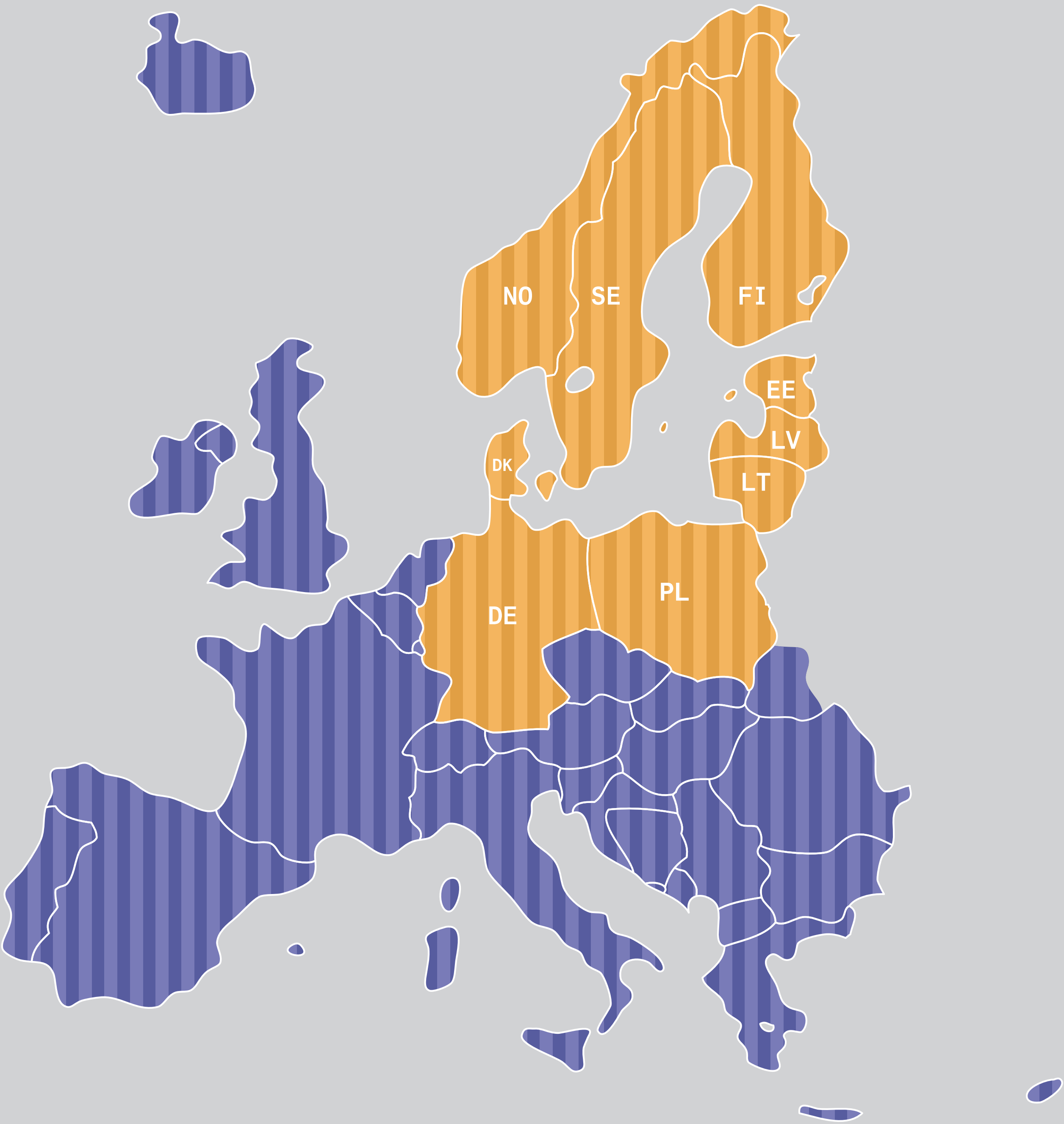
Main challenges regarding implementation

A major challenge is that the grid development may not be in time if the RES targets are to be met as planned by 2020. Permit granting procedures are lengthy, and may cause commissioning delays. If energy and climate objectives are to be achieved, it is of upmost importance to smooth the authorization processes.

The large volume of projects in some countries represents a challenge in itself, as it requires increased implementation capacity both internally and in the suppliers market. In addition, these investments will require extensive disconnections in the existing grid during construction and commissioning (especially voltage upgrading of lines and substations), which could potentially jeopardize security of supply temporarily.

There are also uncertainties regarding the market development on the EU – Russian border, as well as much uncertainty regarding the generator investments and power flows for import-export to the region.

2 Introduction



2.1 Expectations of the 3rd Legislative Package

The 3rd Legislative Package for the Internal Market in Electricity[1)] (hereinafter the 3rd Package), which entered in to force 3 March 2011, imposed a number of requirements upon the European Electricity Industry in terms of regional co-operation to promote the development of the Electricity Infrastructure both within and between Member States, and looking at Crossborder Exchanges of Electricity between the Member States.

The key requirement of the 3rd Package which forms the legislative driver for the "2012 Ten Year Network Development Plan" suite of documents is Article 8.3(b) of The Regulation, whereby "The ENTSO for Electricity shall adopt: (b) a non-binding Community-wide network development plan, … including a European generation adequacy outlook, every two years".

The specific requirements are elaborated on under Articles 8.4, 8.10 and 12.1 of The Regulation, covering the scope and content required in the publication. This includes; time frames for assessing overall generation adequacy, the relationship between National Development Plans and the Community-wide Network Development Plans, identification of investment needs and the requirement to publish Regional Investment Plans every two years.

The relevant text referred to above can also be found in the Ten Year Network Development Plan 2012 – 2022 document.

An explanation of how the TYNDP package meets these requirements can be found in Section 2.3.

2.2 ENTSO-E

ENTSO-E was established on a voluntary basis on 19 December 2008 and became fully operational on 1 July 2009, in anticipation of the entry in to force of the 3rd Package on 3 March 2011.

Today, 41 TSOs from 34 European countries are members of ENTSO-E. The working structure of the association consists of Working and Regional Groups, coordinated by three Committees (System Development, System

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1) The 3rd Legislative Package for the Internal Market in Electricity refers to Directive 2009/72/EC, Regulation (EC) 713/2009 and Regulation (EC) 714/2009.

Operations and Markets), supervised by a management Board and the Assembly of ENTSO-E, and supported by the Secretariat, the Legal and Regulatory Group, and Expert Groups. A list of countries and TSO members can be found at the end of this document.

The main purposes of ENTSO-E are:

- to pursue the co-operation of the European TSOs both at the pan-European and regional level; and
- to have an active and important role in the European rule setting process in compliance with EU legislation.

2.3 Documents in the TYNDP Package

The objectives of the TYNDP are to ensure transparency regarding the electricity transmission network and to support decision-making processes at regional and European level. The report is the most comprehensive and up-to-date European-wide reference for the transmission network. It points to significant investments in the European power grid in order to help achieve European energy policy goals.

The Ten Year Network Development Plan 2012 – 2022 (TYNDP), the Regional Investment Plans and the Scenario Outlook and Adequacy Forecast combine to meet the above aims and fulfilfulfill the requirements of Articles 8.3(b), 8.4, 8.10 and 12.1 of The Regulation as detailed in Section 2.1.

The focus of each document in the package is outlined below:

1. **Ten Year Network Development Plan 2012 – 2022:**

   The TYNDP focuses specifically on the projects of pan-European significance detailed within each Regional Investment Plan, covering those with significant contributions to cross-border flows and meeting large areas of demand. Further information on the content, methodology and selection criteria can be found in the TYNDP document itself.

2. **Regional Investment Plans:**
   [Comprising 6 individual, regional documents]

   The Regional Investment Plan documents overlap between the National Development Plans which TSOs are bound to publish to their regulatory authority every year (under Article 22 of Directive 2009/72/EC) and the TYNDP document outlined above. They provide a more focused view of the development needs and project planning for all levels of investment at a regional level within Europe (as opposed to those solely of pan-European significance in TYNDP 2012 – 2022) as per regulation Regional Investment Plans are not binding.

3. **Scenario Outlook and Adequacy Forecast:**

   The Scenario Outlook & Adequacy Forecast (SO&AF) assesses the future system adequacy at a mid- to long-term time horizon. It provides an overview of generation adequacy analyses for all of ENTSO-E, its regions, and for individual countries, including an assessment of the role of the transmission capacities and security of supply on a regional basis.

More information regarding the history and evolution of the Ten Year Network Development Plan can be found in the TYNDP document.

2.4 Regional Groups

As described in Section 2.2, co-operation of the European TSOs both on the pan-European and regional level in order to undertake effective planning is the main requirement of the 3rd package, and therefore one of ENTSO-E's key purposes. In order to achieve this goal ENTSO-E has divided itself into 6 regional groups for grid planning and system development tasks. The Member States belonging to each group are shown in Figure 3.

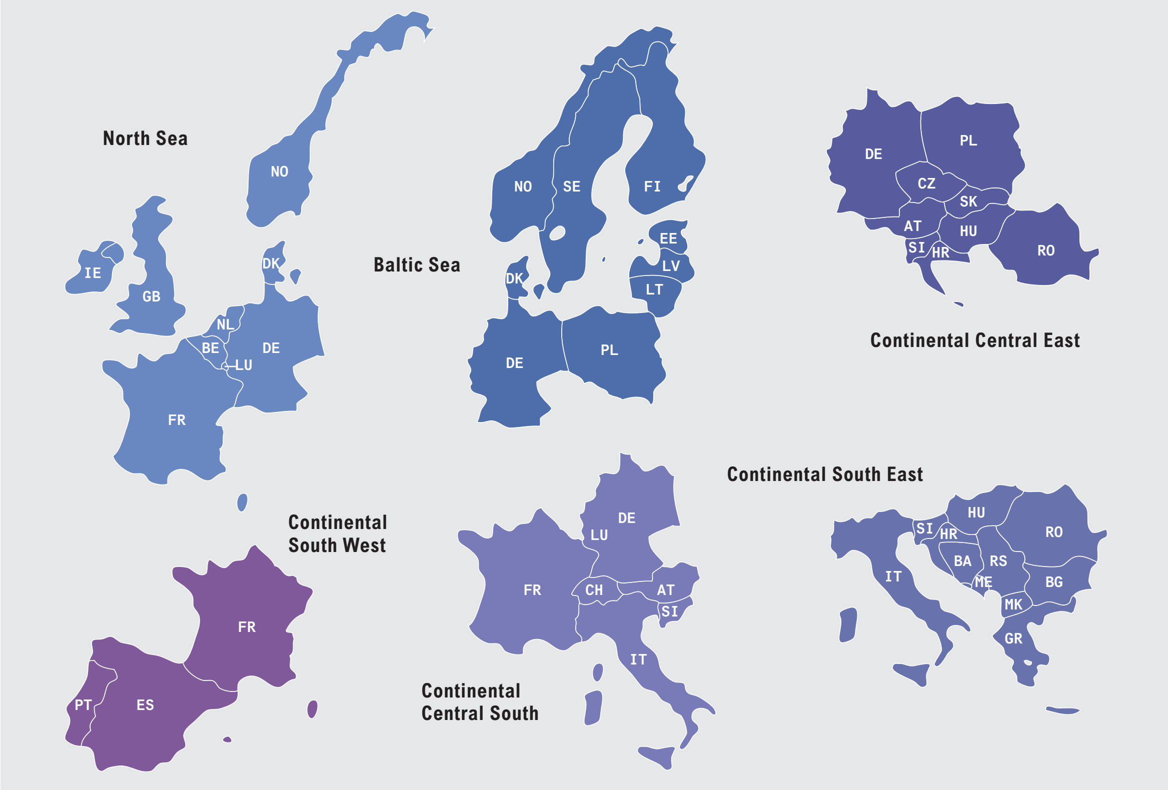


Figure 3:
ENTSO-E regions (System Development Committee)

ENTSO-E considers the regional approach to be the most appropriate framework for grid development in Europe. This is due to the fact that it contains numerous instances of overlapping to ensure overall consistency of the Regional Investment Plans.

The Baltic Sea Regional Group is formed by 9 TSOs namely:

- AS Augstsprieguma tikls, Latvia
- Elering AS, Estonia
- Energinet.dk, Denmark
- Fingrid Oyj, Finland
- Litgrid AB, Lithuania
- PSE Operator S.A, Poland
- Statnett SF, Norway
- Svenska Kraftnät, Sweden
- 50Hertz Transmission, Germany

2.5 How to Read the Document

Chapter 3 identifies and explains the main changes which have occurred in the investments including the TYNDP 2010 submission.

Chapter 4 describes the specific methods used in the regional market and network studies, giving justifications of the models utilized.

Chapter 5 explores in detail the scenarios considered in developing the Regional Investment Plan, looking at the scenarios common to all plans contributing to the TYNDP 2012 – 2022 but also highlighting any regionally specific scenarios.

Chapter 6 presents the current Net Transfer Capability of the European electricity transmission networks, looking at present congestion and experienced flows. It then proceeds to examine how this will evolve over the ten year plan period, and identifies the main challenges and needs of the region.

Chapter 7 focuses on the Projects of European significance and National projects of interest identified to meet the investment needs identified in Chapter 6. These are divided into medium-term (2012 to 2016 inclusive) and long-term (2017+) projects.

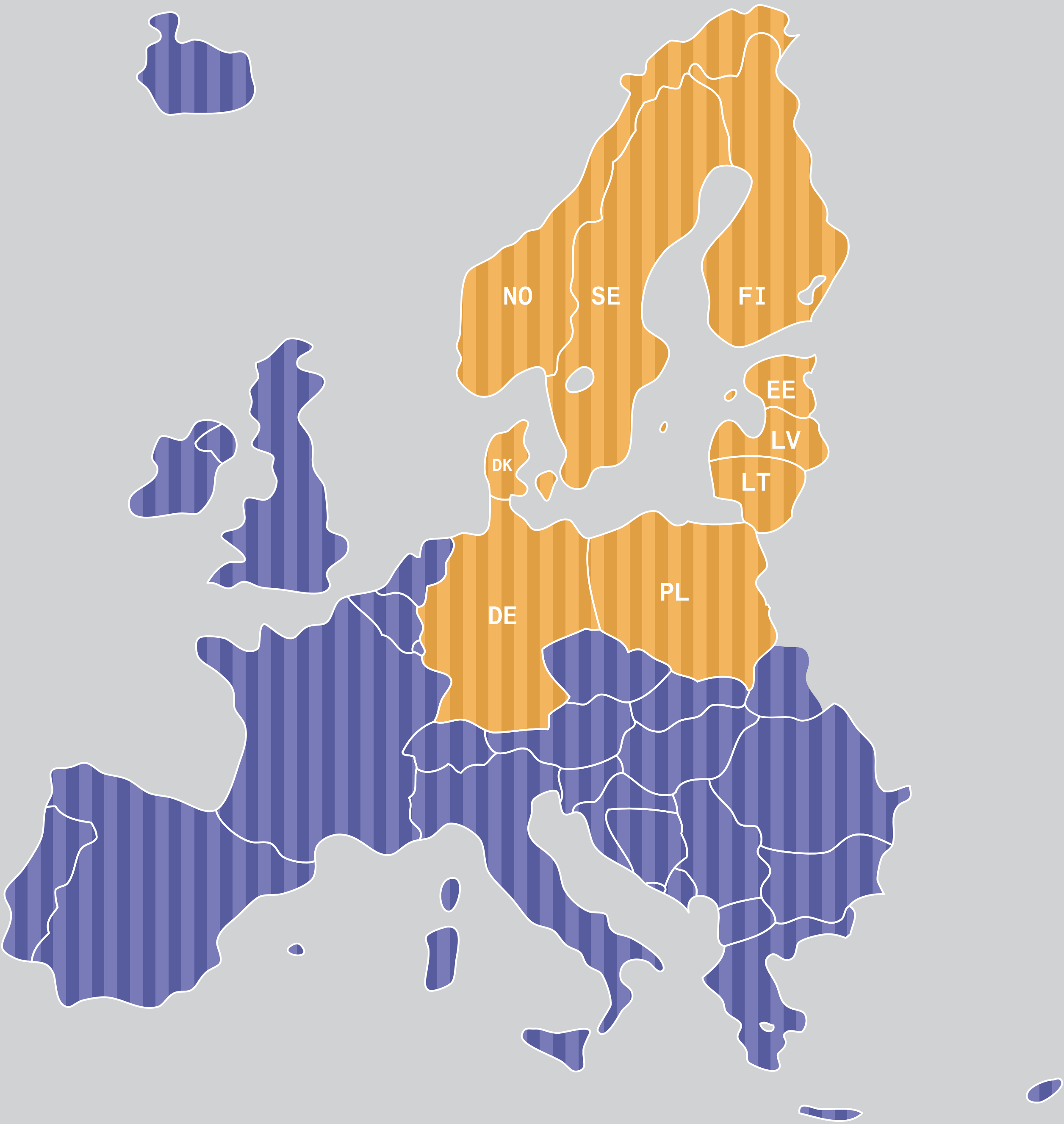
Chapter 8 then looks at the overall adequacy of the transmission network after the proposed investments, and identifies any remaining challenges.

Chapter 9, where applicable, underlines the process of environmental assessment utilized in the course of constructing the Regional Investment Plan.

Chapter 10 revisits the resilience principles highlighted in the TYNDP 2012 – 2022 and justifies the planned investments, as well as highlighting and describing the adverse scenarios which may occur in the region and which require special attention and possible future investment.

Finally, the summary presents aggregates figures and statistics for the whole Regional Investment Plan.

3 Assessment of the TYNDP 2010 (Regional Focus)



This plan includes 46 projects of Pan European significance in the Baltic Sea region, comprising investments within the Baltic Sea countries, between the countries of the Baltic Sea, or between Baltic Sea countries and neighboring regions.

This chapter presents an overview of the changes to these projects compared to the information presented in the pilot TYNDP 2010. The main changes and reasons for the changes are outlined with focus on the major projects for the Baltic Sea Region. Some of the investments are new to this plan, that is, they did not feature in the pilot TYNDP published in June 2010. Of the investments which were presented in the pilot TYNDP, the majority remain on schedule. However some investments have changed in terms of expected commissioning date, status or consistency of details. A small number have been removed from the plan or canceled. Detailed information is presented in Appendix 1.

3.1 Completed Projects

A number of significant projects have been completed (or are close to completion at the time of compiling this report) since the TYNDP 2010 was compiled. They include:

– The Great Belt 600 MW HVDC link between the two Danish synchronous AC areas, Denmark West and Denmark East (TYNDP 2010 index 434) was successfully implemented in September 2010 as planned.

– Eesti – Püssi, reinforcement of an existing single circuit 330 kV OHL in Estonia (TYNDP 2010 index 389). The preliminary estimate of commissioning time was the beginning of 2010 however the design and construction process schedule was updated, meaning that the project was actually finished at the end of 2009.

– Balti – Püssi, reconstruction of an existing single circuit 330 kV OHL in Estonia (TYNDP 2010 index 390). The preliminary estimate of commissioning time was the beginning of 2011 however the the design and construction process schedule was updated, meaning that the project was actually finished at the end of 2010.

– Fenno-Skan 2 HVDC link between Finland and Sweden (TYNDP 2010 index 395) was implemented in December 2011 as planned.

– A small number of German projects or sections of projects are completed on schedule.

- The two phase shift transformers (TYNDP 2010 index 143) at the Danish side of the Western Denmark – German boarder are completed.

3.2 Delays in Commissioning Date

The scheduled commissioning dates of some key projects of European significance have been delayed. The delays relate to problems with permitting, interactions with other projects or changes in the project scope.

- The EstLink2 HVDC cable between Püssi in Estonia and Anttila in Finland (TYNDP 2010 index 391) has been delayed by a couple of months from the end of 2013 to the beginning of 2014 due to further revision of the project timetable.
- The whole concept of the Kriegers Flak Combined Grid Solution (CGS) project (TYNDP 2010 index 141) is based on the prerequisite that offshore wind power plants will be built in the Danish and German part of the Kriegers Flak region. The progress of these offshore wind power plant projects is essential for the progress of the CGS project. In the meantime, offshore wind power plant Baltic 1 has started the operation with a capacity of 48,3 MW, in the German part. Concerning offshore wind farm Baltic 2 (former Kriegers Flak I) the project owner (the German TSO EnBW) has entered into a contract to build the platform for the offshore substation opening up the possibility of an extension to accommodate the additional cable connections for the CGS project. Baltic 2 will have an overall installed capacity of 288 MW. The political decision concerning offshore wind power plant Kriegers Flak III on the Danish part is still pending. As a consequence, the progress of the project has been delayed by one and a half years, from Q2 2016 to Q4 2017.
- The South West link project (TYNDP 2010 index 402) consists of three main parts: 1) a new 400 kV line between Hallsberg and Barkeryd in Sweden; 2) a new VSC HVDC line between Barkeryd and Hurva in Sweden and 3) a new VSC HVDC line between Barkeryd in Sweden and Tveiten in Norway forming a three terminal VSC HVDC system together with 2). In TYNDP 2010 the estimated time of commissioning was 2014. This is still correct with regards to parts (1) and (2) however part (3) is postponed until 2018 – 2020. Statnett and Svenska Kraftnät have made a joint decision to postpone part 3 due to several factors. The most important of these factors is the extra time and resources needed for parts 1 and 2 of the project in Sweden as well as the complexity and estimated time needed for voltage upgrading of the Norwegian grid near to the landing point in Tveiten.

Projects delayed due to implementation of other projects

- The Norway-Great Britain and Norway-Germany interconnector are both postponed until 2018 – 2021 because the upgrades needed in the Norwegian AC grid are more comprehensive than previously identified, and also that system operations in southern Norway have become more stressed over the last few years. The size of the HVDC links will be in the range 1,000 – 1,400 MW. Details of connection points have not yet been decided. The second Netherlands-Norway interconnector, NorNed 2, is postponed until further notice. NorNed 2 will not likely be realized during this planning period but is included in the TYNDP calculations and therefore on the project list. NorNed 2 is not included in the current Norwegian national grid development plan.
- The North – South reinforcement in Sweden (TYNDP 2010 index 403) has been postponed from a long-term project in TYNDP 2010 to 2025. The reason pertains to reprioritizations in the project portfolio.
- The schedule of the 400 kV AC line between North Finland and North Sweden (TYNDP 2010 index 396) has been postponed to 2021 due to reprioritizations in the project portfolio.
- The project Panevezys-Musa (TYNDP 2010 index 378) is postponed after investment optimization. The reason is again to do with reprioritizations.

Delays in permitting procedures

- The project Klaipeda-Telsiai in Lithuania (TYNDP 2010 index 377) has been delayed due to environmental impact assessment procedures taking more time than expected.
- A large number of German on-shore projects are delayed, largely due to permitting issues for example changes to the legal framework, local public resistance, delays in permitting processes, and so on. For the most part, the delays do not change the classification of the project from mid-term to long-term.

3.3 Earlier Scheduled Commissioning Date

- The investment Kruonis – Alytus in Lithuania (TYNDP 2010 index 379) is planned to be commissioned in 2015 instead of in 2020 as stated in the TYNDP 2010. The investment is an important support for the LitPolLink connection.
- The shunt- and series compensation projects in Sweden (TYNDP 2010 index 398) were presented as long-term projects (2016 – 2020). Now however, the estimated time of commissioning is 2015.

3.4 Changes in Project's Consistency

- On 11 January 2010 (as stated in TYNDP 2010), Svenska Kraftnät decided to withdraw from the Kriegers Flak (CGS) project (TYNDP 2010 index 141), mainly due to uncertainties concerning the construction of wind turbines in the Swedish zone of Kriegers Flak during the foreseeable future. The project is now between Denmark East and Germany with the option for a possible link to Sweden at a later stage.
- The 400 kV cable trace is changed from between Tjele and Idomlund to between Endrup and Idomlund in Denmark West (TYNDP 2010 index 436). The trace change is due to better grid-connection possibilities for future large-scale offshore wind power plants on the North Sea coast of Denmark as well as reinforcement of the back-bone structure of the western Danish transmission system; the latter of which is a result of upgrades in the system between Denmark West and Germany.

3.5 Removal from TYNDP 2012 Projects List and Maps

- A 400 kV cable connection upgrade, that is the replacement of aging 400 kV and 132 kV submarine cables with new 400 kV submarine cables, between Denmark East and Sweden (part of TYNDP 2010 index 433) has been abandoned and a new solution is currently being studied.
- A 400 kV line between Tjele and Trige (TYNDP 2010 investment ref. 431) which is part of the grid reinforcement in Denmark West is now postponed to 2025; it therefore does not appear on the TYNDP 2012 table of projects. This investment should have a relation to the establishment of a new offshore wind power plant at Læsø or to the upgrading of HVDC connections to Sweden. The investment is postponed because such activities are not expected within a timeframe of the TYNDP 2012
- North Norway – North Finland (TYNDP 2010 index 397). Based on a common (Statnett/Fingrid) study, conclusions from the more detailed studies on the project state that it can be postponed beyond 2021. The need is related to the oil/refinery and wind development in northern Norway.
- Norned2 – new HVDC link between Norway and the Netherlands. The project has been postponed until further notice, and will not be commissioned during the next ten years.
- 5th Latvia – Lithuania interconnection Visaginas – Liksna. Removed from TYNDP 2012 because installed capacity of new Visaginas NPP will not reach 2,000 MW and there is no need for additional interconnector and no need for internal reinforcements in Latvia.

3.6 Redefinition of Mid-term Versus Long-term Projects

In TYNDP 2012, the definition of mid-term projects has changed. A project which is commissioned by 2016 at the latest is now considered mid-term. In the TYNDP 2010 the year was set to 2015. Due to this change, the following projects have changed from long-term to mid-term.

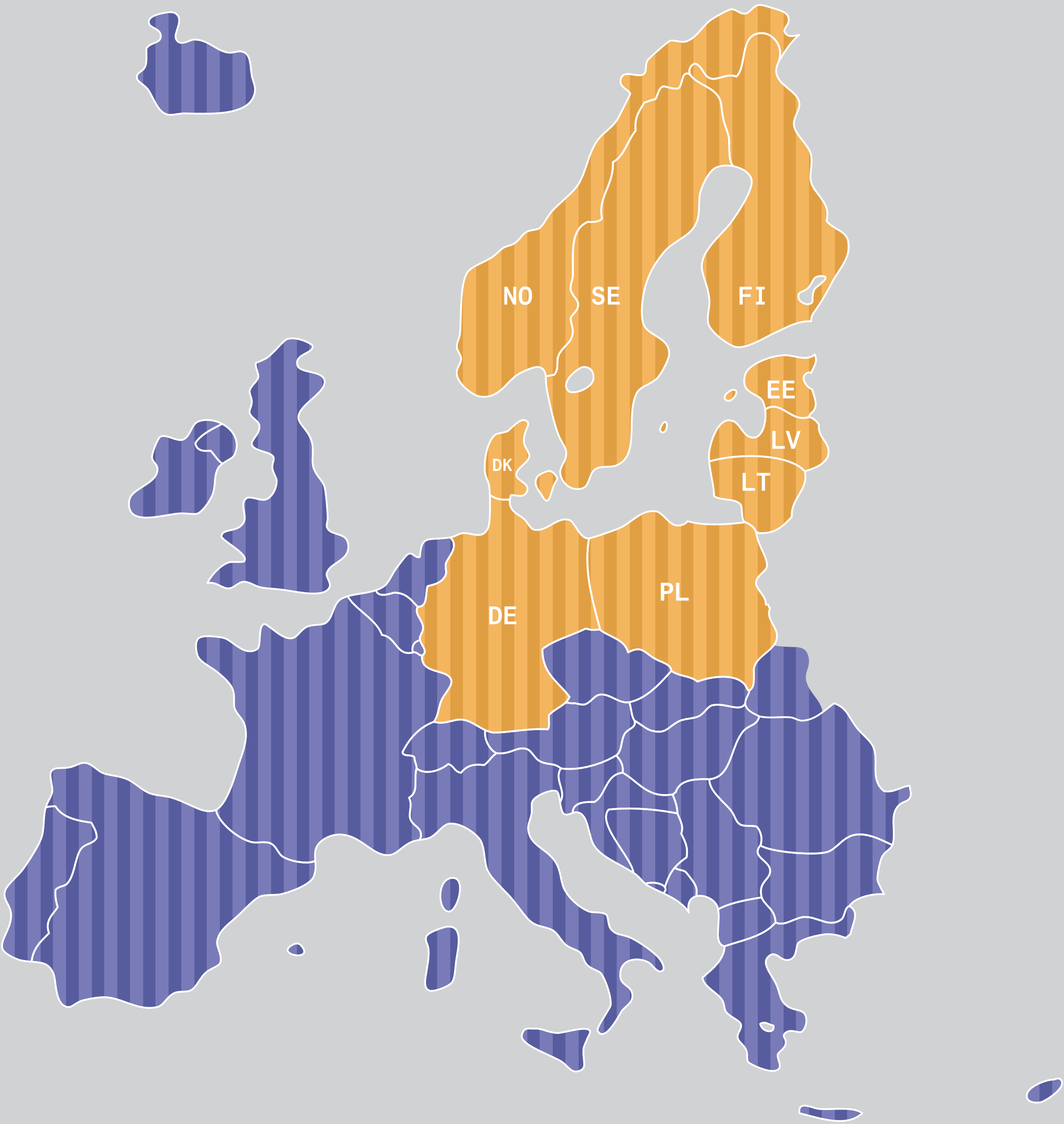
- The 400 kV line Hikiä – Forssa in Finland (TYNDP 2010 index 394)
- The Cobra HVDC VSC link between Denmark West and the Netherlands (TYNDP 2010 index 427)
- A 400 kV cable between Glentegård and H.C.Ørstedværket in Denmark East (TYNDP 2010 index 433).

3.7 More Exact Assessment of Commissioning Dates

A number of Sweden's long-term projects in TYNDP 2010 were not mature enough to have exact assessed commissioning dates. In TYNDP 2012, these projects now have the following expected commissioning dates:

- The 400 kV line Ekhyddan – Barkeryd (TYNDP 2010 index 400) is expected to be commissioned in 2017
- The DC subsea cable Västervik – Gotland (TYNDP 2010 index 400) will be realized as two links with 500 MW of capacity each; the first is expected to be commissioned in 2017 and a date for the other has not yet been fixed in time but is expected to be commissioned in the frame of Long-term projects.
- The upgrade of existing single circuit 220 kV lines to 400 kV between Lindbacka and Västerås in Sweden (TYNDP 2010 index 399) is expected to be commissioned in 2021.

4 Specific RG Methodology and Assumptions



Common main scenarios build the base of the analysis for the TYNDP and the Regional plans. These scenarios are described in Chapter 5. In addition, during the process of preparing the TYNDP and the Regional plans, a Pan European Market Database (PEMD) has been developed containing scenario supply and demand data and common data such as fuel prices.

This common data is the basis for Regional analysis; both market model analysis and network analysis.

Market study results have also been used in defining the benefits of the planned investments. Common guidelines have been defined for project assessments.

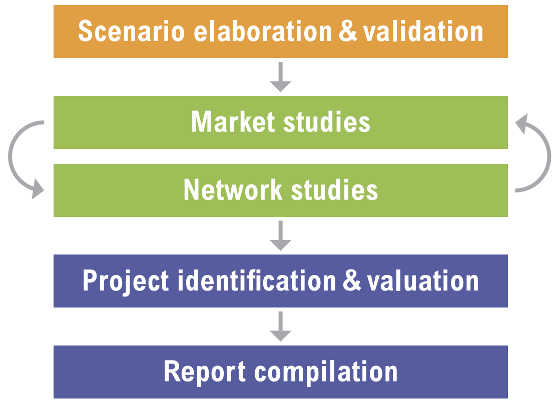


Figure 4:
Market and network study process.

Market studies have been performed at the regional level taking advantage of the existing competence and tools.

A common grid model is used to check the future grid transfer capability with the planned investments and the resilience in stressed grid situations.

A more detailed description of the common method can be found in the TYNDP 2012.

4.1 Regionally Specific Assumptions and Methods

Regionally specific assumptions and methods are described below.

The following figure gives an overview of the RGBS market modeling process.

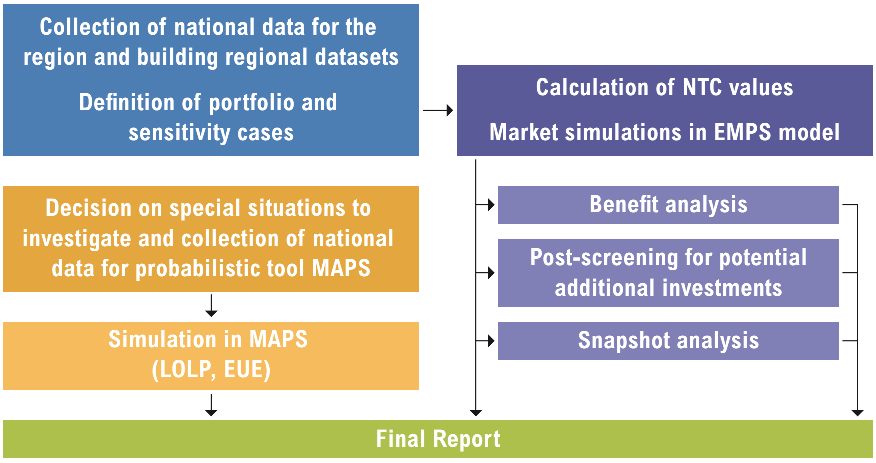


Figure 5:
Procedure of rg baltic sea's market modeling process.

Two different models were used in RGBS to simulate the energy market for the region. The EMPS-model was used to simulate the market with and without the long-term project portfolio. In contrast, the MAPS-model was used to simulate the loss of load probability (LOLP) and the expected unserved energy (EUE). Both models are described in more detail later in this chapter.

The results from the market simulations of the EMPS-model were used to investigate:

- benefits of the investment portfolio for different conditions
- possible additional investment needs
- snapshots of special situations – analyzed in a network model.

All assumptions and preconditions are described in more detail in this chapter. In Chapter 5, the results of the market modeling studies are presented.

4.2 Countries Modeled and Accuracy of Modeling

The countries modeled in the market model as well as the accuracy of modeling are shown in the following figure.

Norway is modeled as seven areas, Sweden as four areas, and Finland and Denmark as two areas each. Estonia, Latvia, Lithuania, Poland, Germany, France, Belgium, Netherlands, Czech Republic, Slovak Republic, and UK are modeled according to PEMD 1), as one area each. It is important to note that the flows between Nordic countries and Germany may be overestimated because German data does not allow internal bottlenecks in Germany to be taken into account.

Spain, Italy, Austria, and Switzerland are modeled using fixed exchanges based on time series from RG CCE Pan European market simulations. Import from Belarus and Ukraine to Poland is modeled by reducing consumption in Poland by the amount of import according to the decision of RG CCE. North-West Russia is modeled as two market areas and the same generation structure and consumption are used in both EU and B scenarios. Kaliningrad is assumed to be balanced. NTCs between the areas are presented in Appendix A4.2_1.

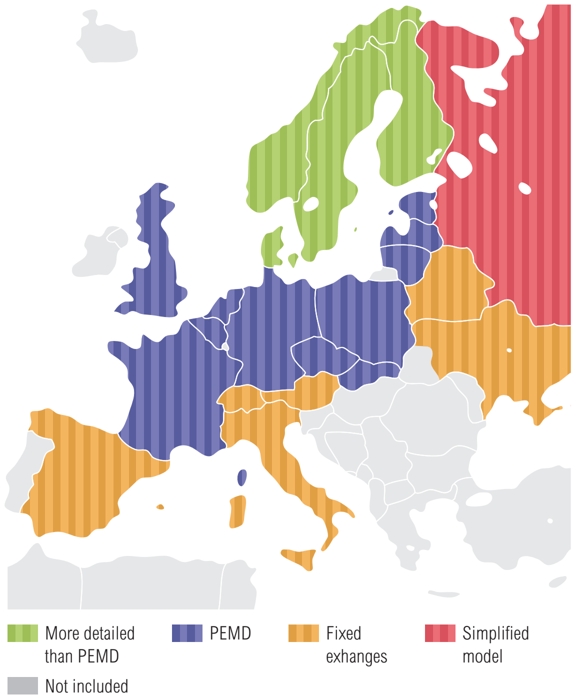


Figure 6:
Countries modeled in the market model

4.2.1 Differences between the Input Data and Current Plans

Market model studies were carried out before the project portfolio was fixed. For this reason there are some differences between the net transmission capacities used in market studies and the capacities based on current plans. The interconnections with differences are listed on the next page (capacity in market studies / capacity based on current plans):

[1] ENTSO-E's Pan-European market modeling database, data provided by TSOs

- Norway – UK in 2020: 1400 MW / 1,000 MW
- Norway – Germany in 2020: 1400 MW / 1,000 MW
- Norway – Netherlands in 2020: 1400 MW / 700 MW
- Denmark – Netherlands in 2015/2016: 600 MW / Up to 700 MW

Due to these differences, flows from North to South will be lower than market studies indicate. The CO_2 emissions will probably increase and the electricity market benefit of the investment portfolio could also be affected.

4.2.2 Modeling of Hydro Power

Modeling of hydro generation in Nordic countries is more detailed than in PEMD. The model used for market studies in Baltic Sea region exploits historical inflow series. In the studies, 36 historical hydro years were used for Nordic countries. Hydro generation in an average of all hydro years was adjusted to be consistent with PEMD values. Hydro modeling in other countries is based on PEMD hydro energy series. Pure pump storages are not modeled because it was assumed that pumping energy demand and generation are equal. Pure pump storages exist only in three RGBS countries; Germany, Poland, and Lithuania.

For countries with detailed hydro modeling, namely Nordic countries, automatic water value calibration was applied. Water values can be seen as the "marginal cost" for hydro power generation and can be adjusted ("calibrated") by the model user. An automatic water value calibration tool calibrates water values with the aim of to maximizing electricity market benefit in the region. In other countries hydro was expected to be the must-run generation according to the PEMD hydro inflow series.

4.2.3 Modeling of Nuclear Power

Historical running hours were used to estimate the availability of nuclear power in Finland and Sweden. In other countries standard availability for nuclear power from PEMD guidelines was utilized. Nuclear power generation was modeled as annual energies, that is, nuclear power capacities were converted to annual energies taking into account the availabilities in each country.

Modeling of Wind Power

Annual wind power generation in each country was modeled according to the wind energy series from ENTSO-E secretariat. Hourly wind series were used for all ENTSO-E countries modeled, with the exception of Norway. For Norway a resolution of 10 periods in a week was used.

4.2.4 Other Assumptions

- Solar power was modeled as must-run generation according to PEMD.
- No start-up costs for thermal power plants were modeled.
- Subsidized generation, which is defined as must-run in PEMD was obliged to generate regardless of the market price. Otherwise generation subsidies were not taken into account.
- Some flexible loads in Nordic countries, namely electric boilers were modeled according to the data from Nordic TSOs. Demand in other areas was assumed to be independent of the market price.
- The market model used has ten sub weekly categories ("load periods") and did not use hourly resolution.

4.3 Analysis

In the following subchapters the analysis methods are described. The benefits are calculated for projects which affect NTC capacities and will be commissioned between 2015 and 2020. Projects planned for implementation in 2021 – 2022 are not considered in market studies. Screening was performed to find interconnections which might require additional capacity mostly after 2020. Finally, grid studies were conducted with grid situation 2020 to assess technical resilience.

4.3.1 Benefit Analysis

Benefits of the investments which increase net transfer capacities (NTCs) between market model areas were calculated in two different ways:

1. Savings in generation costs (official indicator for TYNDP projects)
2. Electricity market benefit; consisting of electricity producer and consumer surplus as well as congestion rents

The electricity market benefit has been the method used to calculate benefits in Nordic studies. It was calculated without taking into account savings in generation costs. This was in order to be consistent with how benefits have been calculated in previous plans in the Nordic area.

The reference grid situation in market simulations was 2015 because investments to be completed up until 2015 are already in progress. Investments between 2016 and 2020 were studied together in order to demonstrate how they improve functioning of the European electricity market, accommodate integration of RES, and contribute to achieving the EU targets. In benefit analysis the benefits were assessed by calculating the generation costs/electricity market benefit in both grid situations (2015 and 2020) and comparing the results, that is, calculating the change due to the investment portfolio. NTCs with and without the investment portfolio are presented in Appendix A4.2_1. The "portfolio concept" used for estimating the impact of the investment portfolio is described more thoroughly in Appendix A4.3_1. The calculation of savings in generation costs and electricity market benefit is described in more detail in Appendix A4.3_2.

4.3.2 Screening Process

The aim of the screening process was to assess transmission capacity needs in the 2020 scenarios, to identify interconnections where additional capacity might be needed after 2020 and to identify potential new projects for future analysis. Scenarios EU2020 and B2020 and net transfer capacities for 2020 were used in screening.

The screening methodology is described below:

1. Loading of each modeled interconnection was studied based on marginal benefits, congestion hours, congestion rents per MW of capacity and power flow levels in order to pinpoint the locations where additional capacity might be needed.
2. Based on the analysis, the interconnections with highest additional investment needs were selected as they were deemed worthy of further investigation.

4.3.3 Grid Analysis

Grid studies have been performed in order to investigate how the power system behaves in the EU2020 scenario with the planned grid investments in operation. Each TSO involved has been responsible for the contingency analysis which has been conducted according to ENTSO-E standards. The studies have covered n-1 analysis, load flow (overloads) and voltage collapse simulations. Grid studies have been conducted for the Regional Investment Plan with the following intentions:

a) Analyze the power system during strained situations in order to assess the quality of the system
b) Verify previously assessed NTC values

4.3.3.1 Strained situations

To ensure that relevant situations are analyzed, the market model has been used to find situations and snap shots with high power flow in certain grid sections. Ten different snap shots relevant to different countries were selected from the market model as described below. The generation mix and demand in each modeled area of the market model (see map below) as well as the power flow between areas for each snap shot can be found in Appendix A4.3_3.

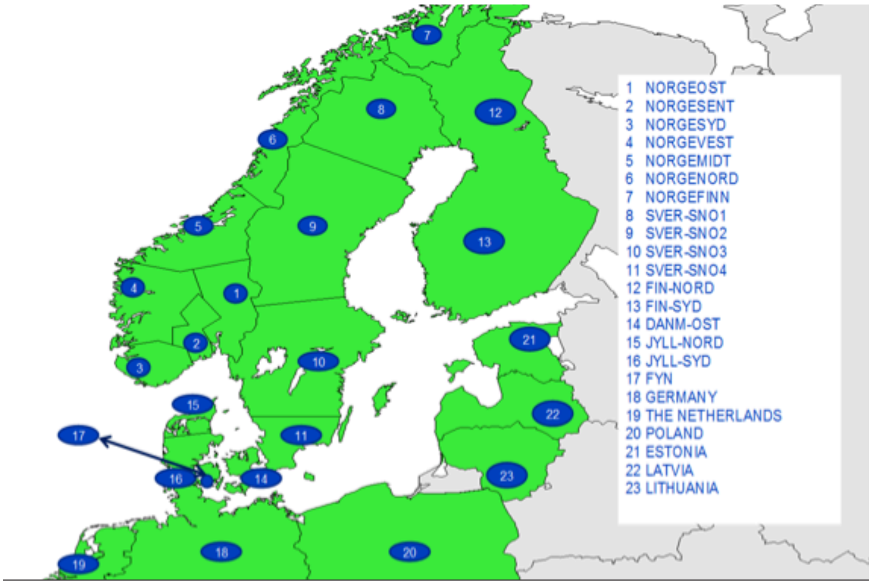


Figure 7:
Areas in the market model

1. Sweden and Norway 1: Highest power flow North-South (between the areas A6-A5, A9-A10 and A5-A9)
2. Sweden and Norway 2: Highest power flow from Norway to Denmark, Germany and Netherlands
3. Denmark and Norway: High wind in Denmark and highest power flows from South Norway to other areas in Norway
4. Finland: Highest power flow between A12 and A13
5. Finland and Sweden 1: Highest power flow from Sweden to Finland
6. Finland and Sweden 2: Highest power flow from Finland to Sweden
7. Baltic countries 1: Maximum power flow on DC links
8. Baltic countries 2: Maximum absolute transit in Baltic countries
9. Baltic countries 3: Max simultaneous energy surplus in Baltic countries
10. Baltic countries 4: Max simultaneous energy deficit in Baltic countries

4.3.3.2 Verification of previously assessed NTC values

In order to verify the accuracy of previously assessed NTC values used in the market model calculations, NTC calculations have been performed by each TSO.

4.3.4 Transmission Losses

Transmission losses change when the generation portfolio changes, location of generation changes, load changes or if the impedance of the system is altered. New transmission lines lower the impedance, but when the transmitted power grows the losses also grow. For loss calculation, two different models were available for the TSOs in the Baltic Sea group. For the Nordic countries a model called Samlast was available. This model is especially suited for the analysis of grid utilization and for calculating losses in a power system dominated by hydropower. Two situations were analyzed; one before the integration of new RES generation and new transmission lines and one situation with new RES generation and the related grid development. The results will then show the combined impact of RES integration and transmission grid development.

The change in Baltic transmission losses was studied in an alternative way by calculating the losses in 2015 and 2020 with the reinforcements and without them, not taking into account the restrictions it would cause on integration of new power plants or power plants or system security. The short description of methodologies used, how the calculations were performed, and the results are described in Appendix A4.3_4.

4.4 Models

The models and tools which were used for the analysis are described below.

4.4.1 EMPS Model

EMPS model (EFI's Multi Area Power Scheduling) is a stochastic model for optimal scheduling and simulation of system performance in hydro-thermal power systems. The model is best suited for systems with a significant portion of hydropower [1].

A more detailed description of the EMPS model can be found in Appendix A4.4_1.

4.4.2 Samlast Model

Samlast is a combined market model and grid model analysis tool. Samlast model is based on the EMPS model, but it also performs load flow calculations using EMPS market solution as a starting point. Due to historical reasons, only the Nordic grid part is currently modeled in Samlast which restricts the use of the program for the whole region [2] [3].

4.4.3 MAPS Model

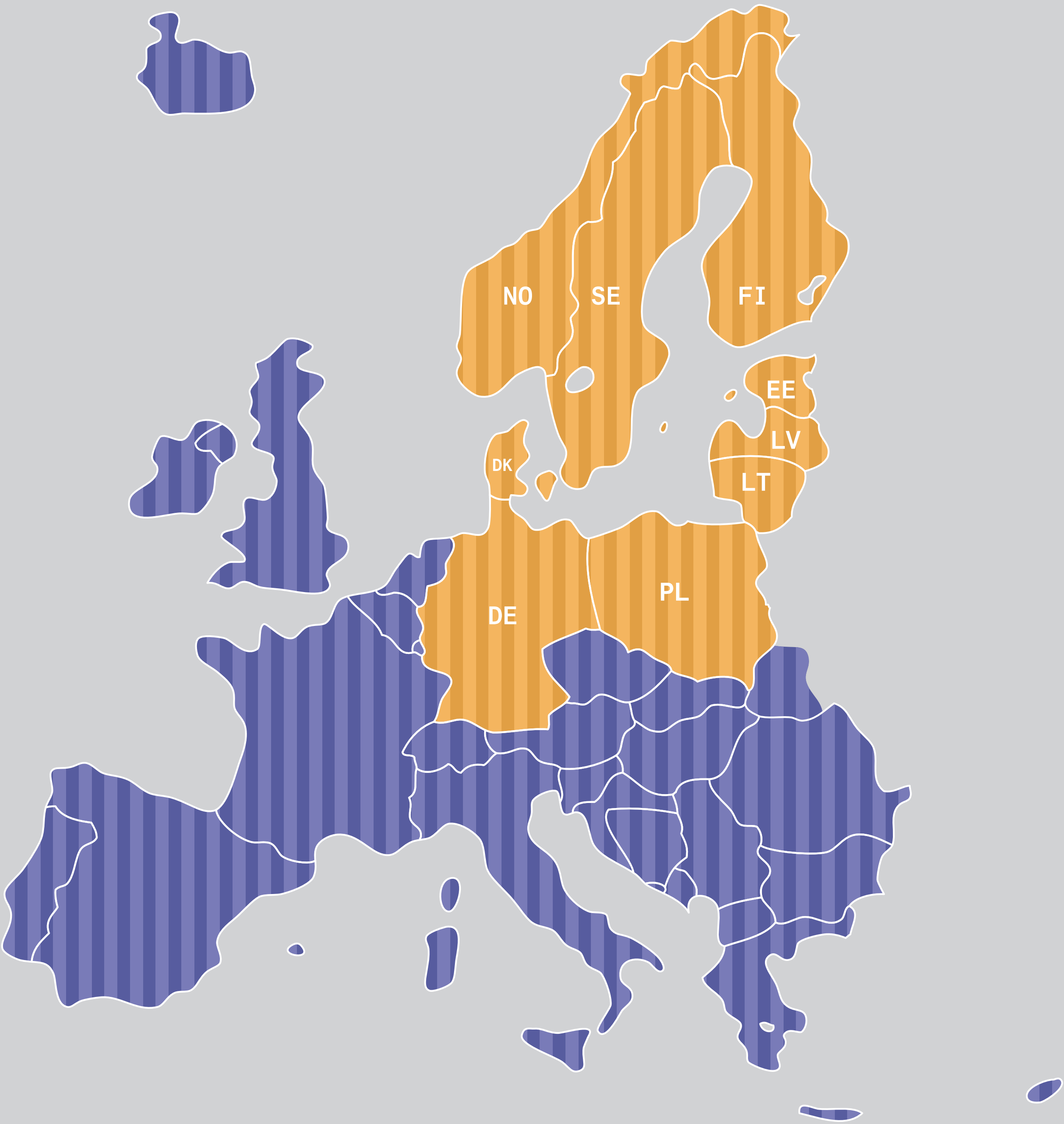
In order to assess Loss of Load Probability (LOLP) and Expected Unserved Energy (EUE) in strain situations, the MAPS model (Multi Area security analysis of large scale electric Power Systems) was used. It was developed by Vattenfall at the beginning of the 90s.

A more detailed description of the MAPS model is available in Appendix A4.4_2.

4.4.4 PSS/E

For grid studies the widely used program PSS/E was applied.

5 Scenarios and Market Study Results



In this chapter the scenarios used in the Regional Investment Plans and the market simulation results are described. The chapter starts with a description of the two scenarios which were used within all ENTSO-E Regional Groups. In addition, the scenarios specific for the Regional Group are addressed. Finally the market simulation results and conclusions are presented.

5.1 Description of the Scenarios

Two different scenarios have been simulated for the whole region, both for the year 2020. They represent different possibilities of the main variables involved in the behavior of the systems and thus, the markets.

- A first scenario has been referred to as the **"EU 2020"**, and represents a context in which all of the European 20-20-20 objectives are met (20 % of RES in the final energy, 20 % reduction of GHG, and 20 % increase in energy efficiency).
  - Assumed efficiency measures result in low growth in demand in all countries.
  - The prices of the main fuels, gas and coal, are taken from the reference scenario of the International Energy Agency in its World Energy Outlook. CO_2 price is higher, and CCGT units are generally cheaper than coal plants, except for the coal with "must-run" conditions.
  - The installation of power from RES is optimistic, according to the National Renewable Energies Action Plans sent to the European Commission.
- A second scenario has been referred to as **"Scenario Best Estimate"**, or **"Scenario B"**, and represents the best estimate conditions of the TSOs, regardless of whether or not European objectives are globally met.
  - Higher demand growth rates result in significantly higher demands all over the simulated region.
  - The prices of CO_2 emissions used are the central forecasts of the IEA, and result in lower variable generation cost for most coal plants in Europe (particular efficiencies of coal or CCGT plants sometimes invert this merit order).
  - The installation of power from RES is the central forecast of the TSOs, and is generally (but not always) lower than the national targets.

In addition to these two scenarios, a sensitivity analysis "Nuclear Phase Out

(NPO)" was carried out. During this analysis, part of the nuclear units in Germany will be shut down (the total phase out is expected for 2022).

For both scenarios and the Nuclear Phase Out analysis, similar data with standard format has been shared among TSOs through the Pan-European Market Database (PEMD), in order to allow a simplified modeling of the entire European region. Some additional information is shared among TSOs of one RG when more detail is needed for the simulated region (must-run constraints of specific units, ramp rates, min time ON/OFF, hourly NTCs between neighbor systems etc.).

For a more detailed description of scenarios and the history of scenarios the reader is referred to the Ten Years Network Development Plan 2012.

5.2 Regional Additional Market Study Scenarios Simulated

Apart from the common ENTSO-E scenarios, a further sensitivity study with different CO_2 prices was carried out. In the sensitivity study CO_2 prices were switched between the two main scenarios, EU2020 and B. The purpose of the sensitivity study was to investigate the impact of CO_2 prices on the results. Results of the sensitivity are presented in Appendix A5.2_1.

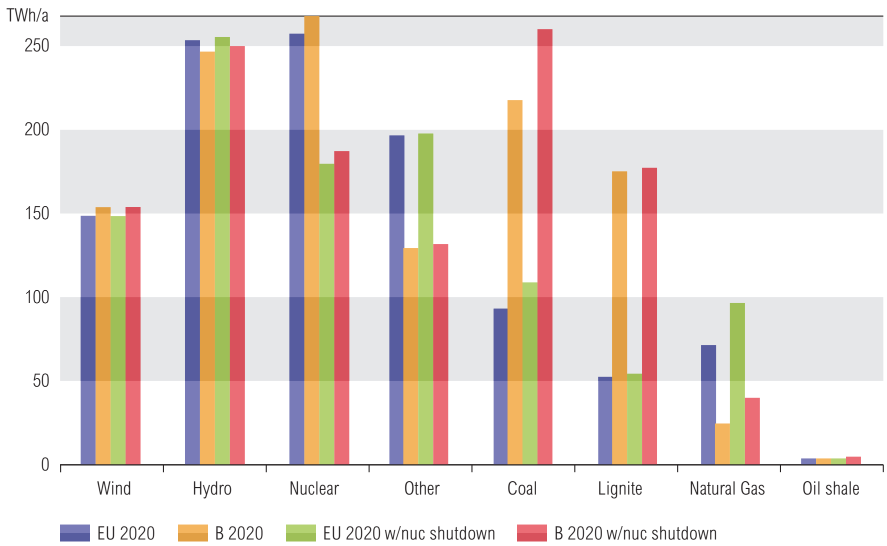
5.3 Regional Market Study Results

While reaching for EU 2020 targets, the Nordic countries are expected to become a surplus area. New investments in interconnectors between the countries will be beneficial to utilize this surplus. New domestic reinforcements will also be necessary to be able to supply the new interconnectors and avoid bottlenecks with negative impacts on the obtainable electricity market benefit. The investment portfolio and the Nordic power surplus will result in an increased North-South flow. With new interconnectors the prices in the Baltic Sea region will converge and the electricity market benefit will increase. In addition the new RES generation will enable substitution of carbon-intensive power generation. The electricity market benefit of the investment portfolio is substantial in all investigated scenarios. A closer integration between the Nordic, Baltic countries and Continental Europe will generate added value through utilization of natural resources in a viable and sustainable way.

5.3.1 Balances and Net Flows

Productions per each generation type, installed capacities, balances, and net flows in the Baltic Sea region in 2020 are presented in this subchapter. The figures show the situation in scenario EU2020, scenario B, scenario EU2020 with Nuclear Phase Out in Germany, and scenario B with Nuclear Phase Out in Germany. The figures are based on market model simulations in an average hydrological year. Balances and net flows in extreme hydrological years are presented in the Appendix A5.3_1.

The following graph shows the energy produced per each generation type in RGBS in different scenarios. Figures are based on market studies of the 2020 grid. Wind and hydro make up approximately a third of the total generation in each scenario. The share of nuclear power is about a quarter of the total generation in base EU2020 and B scenarios and around a sixth of the total generation in EU2020 and B with Nuclear Phase Out. The share of coal and

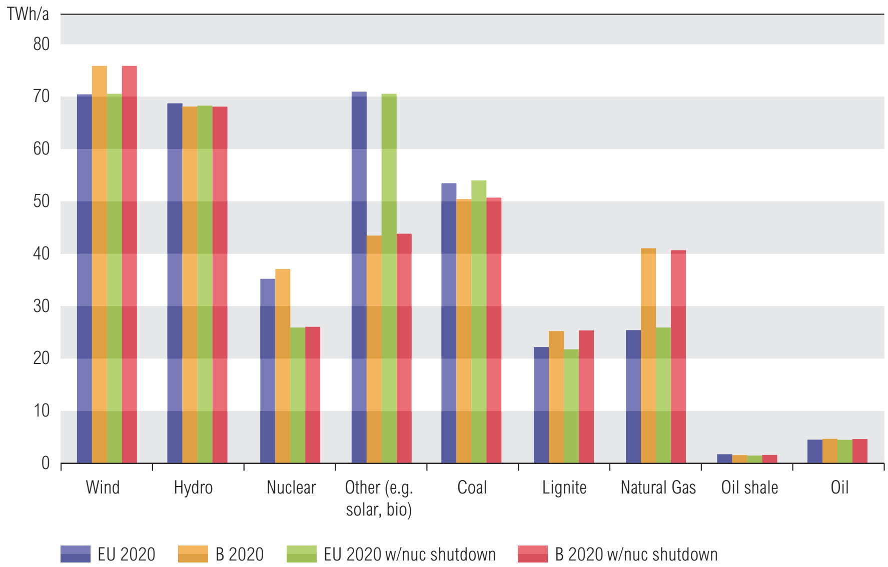


	Wind	Hydro	Nuclear	Other	Coal	Lignite	Natural Gas	Oil shale
EU 2020	148,6	253,0	257,6	197,4	92,0	52,9	70,2	2,2
B 2020	154,0	246,8	268,8	129,2	217,5	175,5	24,1	2,8
EU 2020 w/nuc shutdown	148,6	255,7	179,8	198,2	107,9	52,9	97,8	2,2
B 2020 w/nuc shutdown	154,0	248,4	187,8	130,5	260,9	178,3	39,4	3,6

Figure 8:
Energy produced in RGBS in different scenarios with 2020 grid (TWh/a)

lignite generation is remarkably higher in B scenarios than in EU2020 scenarios because of the lower CO_2 price. However, the share of CO_2 neutral generation, that is wind, hydro, nuclear and most of the generation in other categories (e.g. solar and biomass), is well over 50 % in each scenario.

The generation capacities installed in the Baltic Sea region are presented below.



	Wind	Hydro	Nuclear	Other (e.g. solar, bio)	Coal	Lignite	Natural Gas	Oil shale	Oil
EU 2020	70	68	35	70	53	22	25	1	4
B 2020	75	67	37	43	50	25	40	1	4
EU 2020 w/nuc shutdown	70	68	24	70	53	22	25	1	4
B 2020 w/nuc shutdown	75	67	26	43	50	25	40	1	4

Figure 9:
Installed generation capacities in RGBS in 2020 (GW)

5.3.1.1 EU 2020

In scenario EU 2020 there is a huge surplus of energy in Norway and Sweden due to the high amount of renewable and nuclear production. The main direction of energy flows in the Baltic Sea region is from North to South and from West to East. The Baltic countries, Germany, and Poland will import more due to the inexpensive generation in Nordic countries. The Baltic Sea region is a net importer in this scenario.

The energy balances shown for each country are the resulting balances after the import/export which occurs in the market model due to the differences in prices. A negative value does not necessarily indicate a shortage of nationally available production capacity, only that cheaper imported production is used.

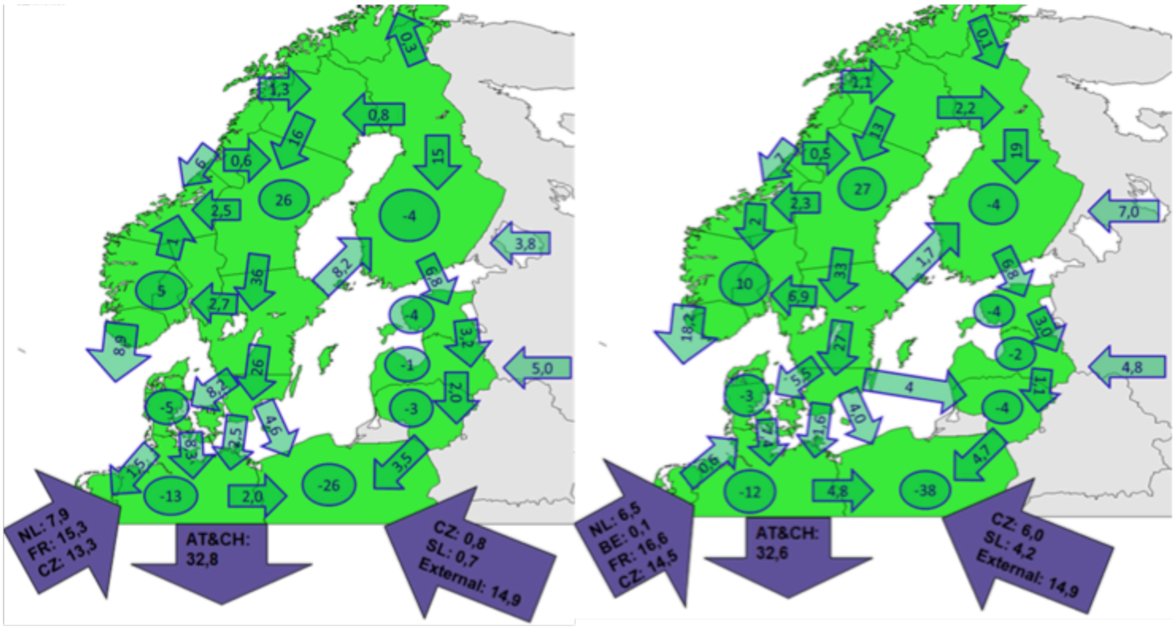


Figure 10:
Net flows and balances in Scenario EU 2020 with 2015 grid (left) and 2020 grid (right) (TWh/a)

5.3.1.2 Scenario B

In scenario B the surplus of energy in Nordic countries is moderate compared to scenario EU2020. The deficit of energy in Poland is significantly lower than in scenario EU2020 and Germany is showing a surplus of energy. This is due to a smaller share of renewable generation in Nordic countries and a lower CO_2 price which makes lignite and coal generation more competitive. In scenario B the main energy flows in the Baltic Sea region are from North to South and from East to West. RGBS is a net exporter in this scenario. Interconnection of the Baltic system with the Nordic and Central European system allows for the establishment of alternative transmission route possibilities between Nordic and Central Europe.

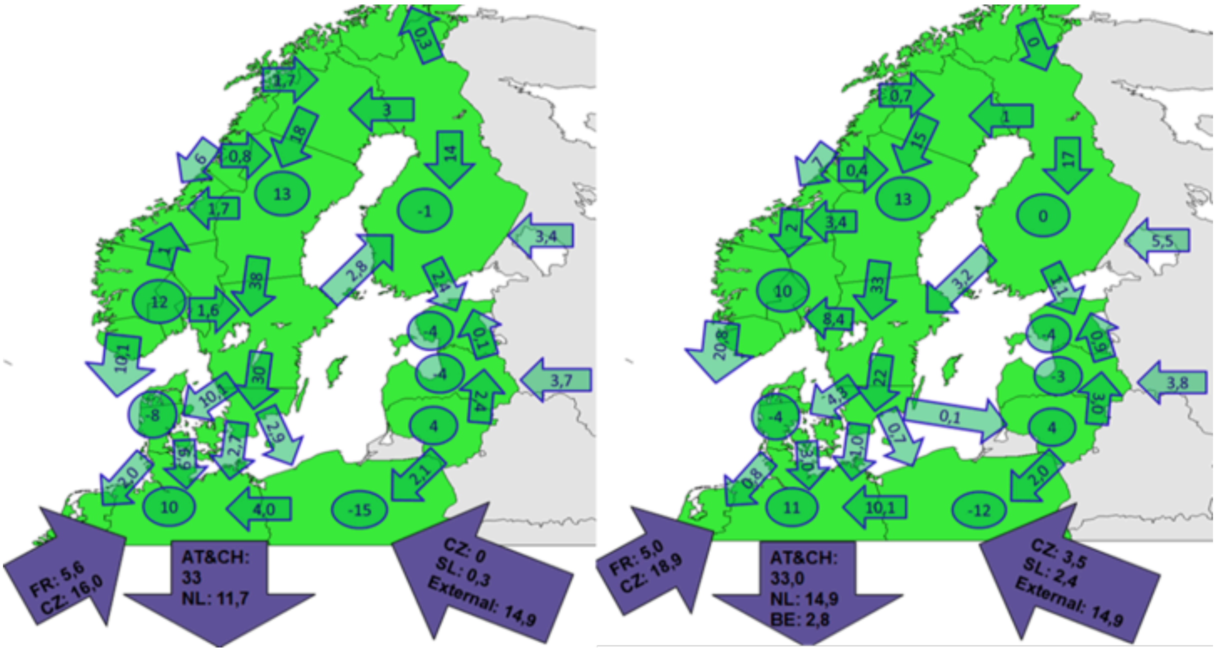


Figure 11:
Net flows and balances in scenario B with 2015 grid (left) and 2020 grid (right) (TWh/a)

5.3.1.3 EU2020 and scenario B with nuclear phase out

The following two maps show the changes in net flows and balances after the Nuclear Phase Out in Germany compared to the base scenarios presented above. The figures show the difference between the case with Nuclear Phase Out and the base case, both including the investment portfolio. As the figures show, the flows from East to West and North to South increase in the Baltic Sea region after the Nuclear Phase Out. Import to the Baltic Sea region increases and RGBS is a net importer in both scenario EU2020 and scenario B with Nuclear Phase Out.

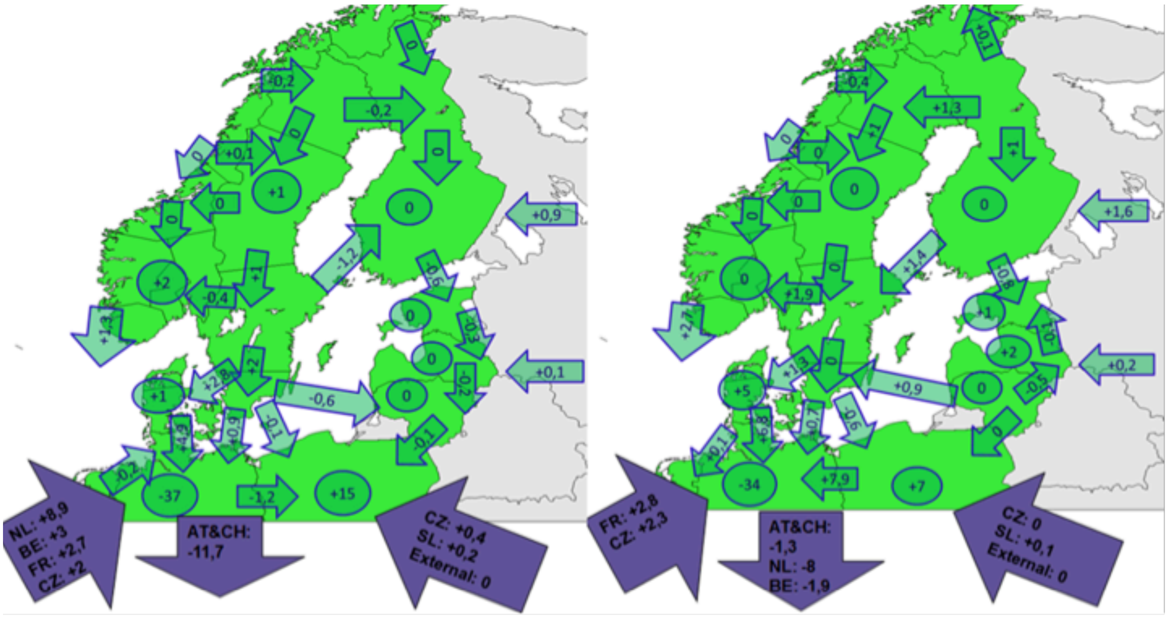


Figure 12:
Net flows and balances in scenario eu2020 with nuclear phase out in germany with 2020 grid (difference from the base eu2020 scenario with 2020 grid; twh/a; left); net flows and balances in scenario b with nuclear phase out in germany with 2020 grid (difference from the base b scenario with 2020 grid; twh/a; right)

5.3.2 Price Convergence

Average prices in EU2020 and scenario B with and without the investment portfolio are presented in the following figures. Prices are based on marginal generation costs and the figures show the price difference in each country from the consumption weighted average price in the Baltic Sea region. Zero level represents the average price in each case. As the figures show, prices in the Baltic Sea region converge due to the investment portfolio. Investment portfolio decreases the standard deviation of the prices from 22 % to 8 % in EU2020 and from 5 % to 3 % in scenario B which means that investment portfolio increases the efficiency of the electricity market.

In EU2020 with 2020 grid the average price in Germany is lower than in Nordic countries, despite the fact that net energy flow is from Nordic countries to Germany. This is because prices in Germany are generally higher than in Nordic countries but when prices are lower they are significantly lower due to a high proportion of RES which leads to a lower average price.

To be noticed: The basis for the presented charts are marginal costs and any fixed costs or support or feed-in tariffs are not taken into account. These should not be interpreted as the effect on the market price and do not in any way refer to the change in market price between today's situation and the future 2020 situation. The meaning is to show the effect with and without the long-term investments. The presentation does not take into account the possible effect on the dynamics of the generation investments either; it merely shows the difference between the case with and without the lines in the same generation/consumption scenario.

Figures showing the price convergence in EU2020 and scenario B with Nuclear Phase Out are presented in Appendix 5.3_2.

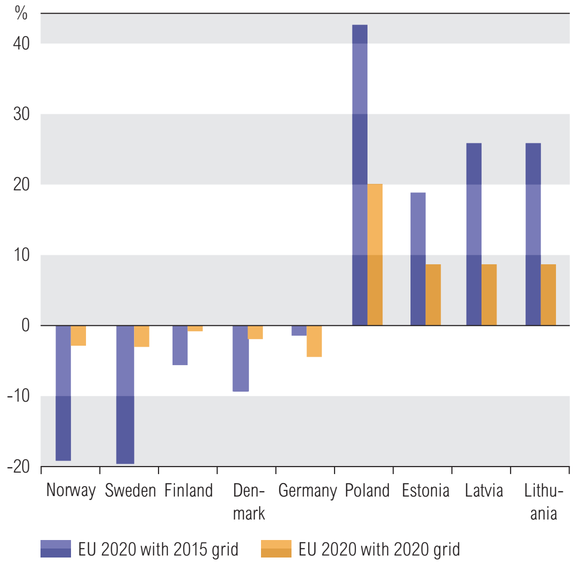


Figure 13:
Average price differences from the consumption weighted average prices in RGBS region in scenario EU2020

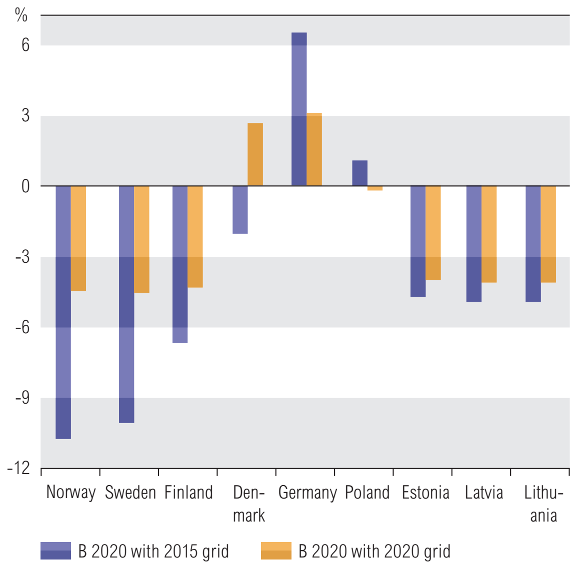


Figure 14:
Average price differences from the consumption weighted average prices in RGBS region in scenario B.

5.3.3 Electricity Market Benefit and Savings in Generation Costs

Electricity market benefits and savings in generation costs in the Baltic Sea region are presented in the following table. The figures show the difference between the situation with the grid investment portfolio and without the grid investment portfolio in each case. The generation portfolio and consumption is unaltered when calculating the difference in electricity market benefit or savings in generation cost due to grid investments. When calculating the benefits and savings in generation costs, only marginal generation costs are taken into account. Generation subsidies and investment costs are not considered in this calculation. Savings in generation costs and total electricity market benefit are not directly comparable but represent two different approaches with regards how to calculate the benefit for the society. Savings in generation costs only takes into account the change in generation costs which is experienced by producers. In general, lower generation costs also lead to lower consumer prices. Total electricity market benefit takes into account the changes in producer surplus, consumer surplus and congestion rents. With increased transmission capacity it is anticipated that expensive production in one area is substituted by cheaper production in another area, thereby contributing to a cheaper and more efficient generation mix.

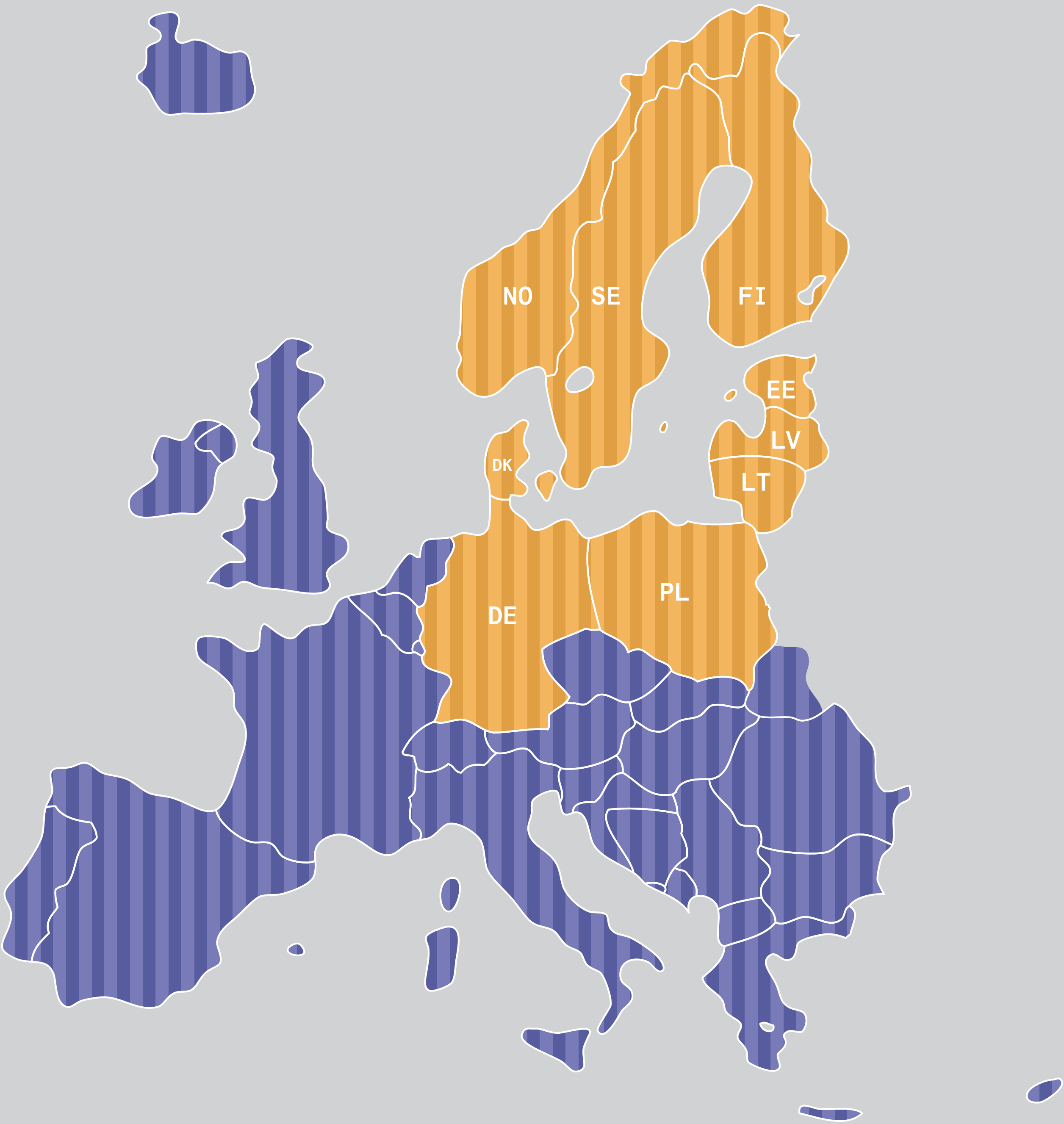
The investment portfolio shows a high total electricity market benefit for the Baltic Sea region in all studied scenarios. Looking at the components of electricity market benefit, producer surplus increases while consumer surplus and congestion rents decrease as a result of increased interconnector capacity. The table also shows that in the EU2020 scenario the benefits of the grid investment portfolio are substantially higher than in scenario B. This means that the EU2020 scenario has as higher utilization of the grid than Scenario B. The same conclusion can be drawn from the calculation of savings in generation costs.

Savings in generation costs are significant in scenario EU2020 and scenario EU2020 with Nuclear Phase Out. In scenario B and scenario B with Nuclear Phase Out savings in generation costs are negative which means that generation costs increase. The reason for increased generation costs in base scenario B is increased export from RGBS to other regions. In scenario B with Nuclear Phase Out the reason for increased generation costs is decreased import to RGBS. Even though generation costs in the Baltic Sea region in scenario B increase due to the investment portfolio, generation costs at the European level decrease. More expensive generation in other regions is replaced by cheaper generation from the Baltic Sea region and thus total generation mix is cheaper.

	EU2020	Scenario B	EU2020	Scenario B
			with nuclear shutdown	
Electricity market benefit	750	265	530	350
Savings in generation costs	1,960	-210	1,870	-150

Table 1:
Electricity market benefits and savings in generation costs in RGBS due to the investment portfolio; difference between the situation with the investment portfolio and without the investment portfolio (M€/a)

6 Investment Needs



6.1 Present Situation

The Baltic Sea Region comprises nine countries in three separate synchronous systems: Denmark East, Finland, Norway and Sweden comprise the whole Nordic System, while the Baltic countries Estonia, Latvia and Lithuania comprise the IPS/UPS system and Denmark West, Germany and Poland make up the Continental European system. The Nordic system is separated geographically from the Baltic and Continental systems by the Baltic Sea and in the West by the North Sea. A total of nine subsea HVDC cables currently connect the Nordic system to the Continental system and one subsea HVDC cable connects the Baltic and Nordic systems. The Nordic system is already a very integrated electricity market and as Figure 15 shows, the Baltic countries also have high transfer capacities to neighboring countries compared to their maximum load.

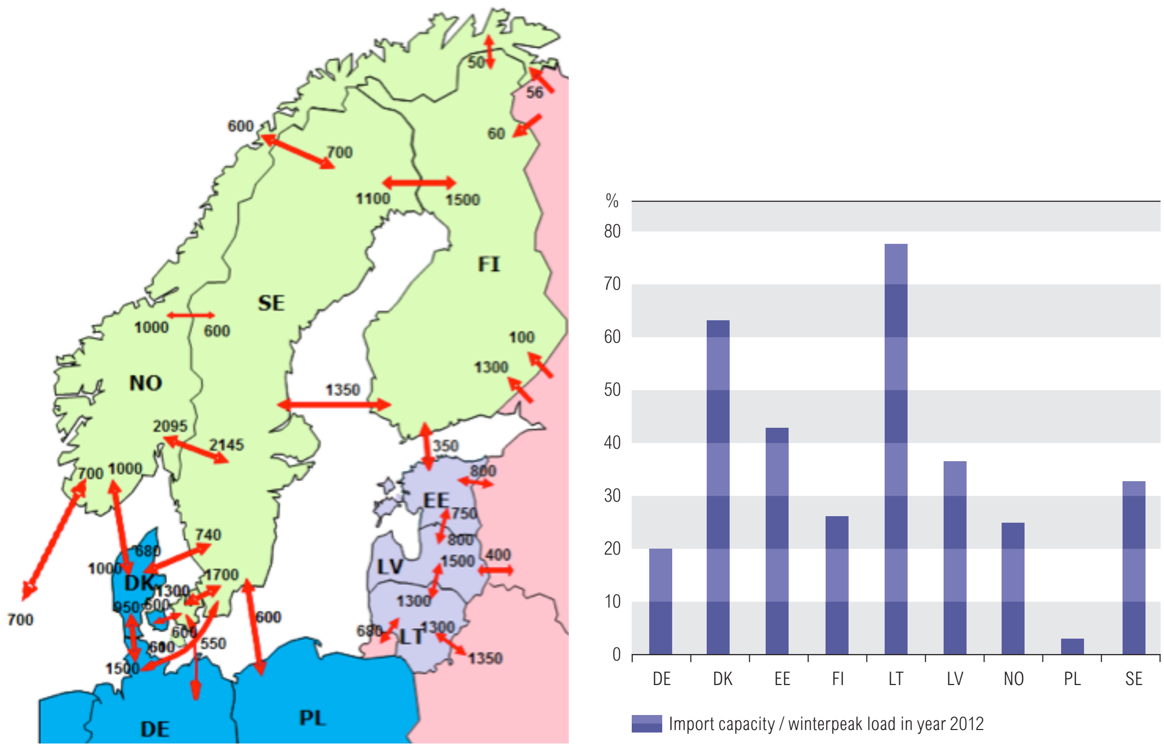


Figure 15:
The three synchronous systems of Baltic Sea region, maximum cross border capacities and cross border net import capacity of each country compared to country's winter peak load in year 2012

The total yearly consumption in the RGBS region excluding Germany and Poland is approximately 400 TWh. The peak load is much higher in winter than in summer due to cold winters and large amounts of electric heating. Large industry accounts for approximately 35 % of the consumption. Main consumption areas are located in southern parts of the Nordic system and more evenly in other parts of the region. Consumption and production of electricity in the Baltic and Nordic countries are shown in Figures 16 and 17.

The Nordic power system is hydropower dominated with most of the hydropower plants located in Norway and northern Sweden. The continental system and the Baltic States are currently thermal power dominated areas. Denmark stands out with a high share of wind power. The energy constrained Nordic hydropower system has a very flat price structure over the day, and over shorter periods compared to the power constrained thermal systems. The difference of energy balance of countries in the region between wet and dry year is significant. During an average year Finland and Lithuania have a large energy deficit while other countries in the region are more balanced. Finland is the only country in the region which is dependent on import during peak load hours.

The main power flow is during the day from the hydro power plants in northern Scandinavia to the South all the way to Central Europe. During the night, flows are from Central Europe and Baltic States to Nordic countries. After the shutdown of Ignalina NPP in 2009 the power flow in the Baltics has primarily been to Lithuania from Latvia or all the way from Estonia through Latvia.

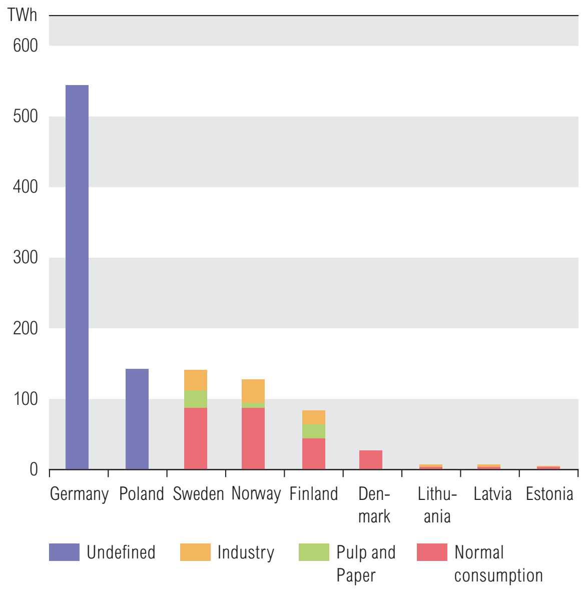


Figure 16:
Consumption of electricity in Baltic sea region countries 2010

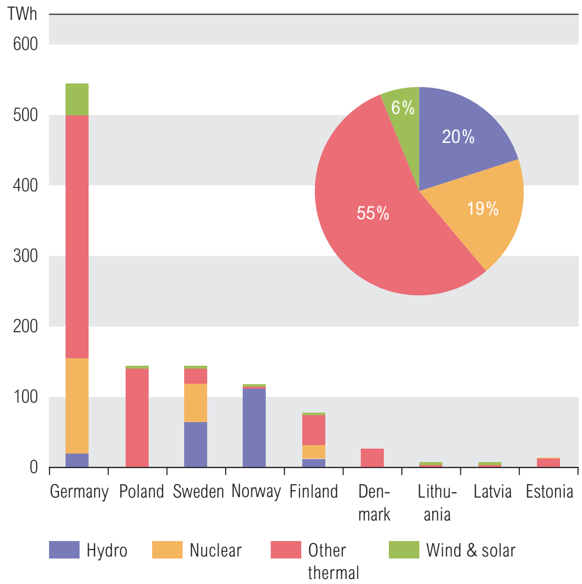


Figure 17:
Generation of electricity from different sources in Baltic sea region countries in 2010

6.2 Drivers of System Evolution

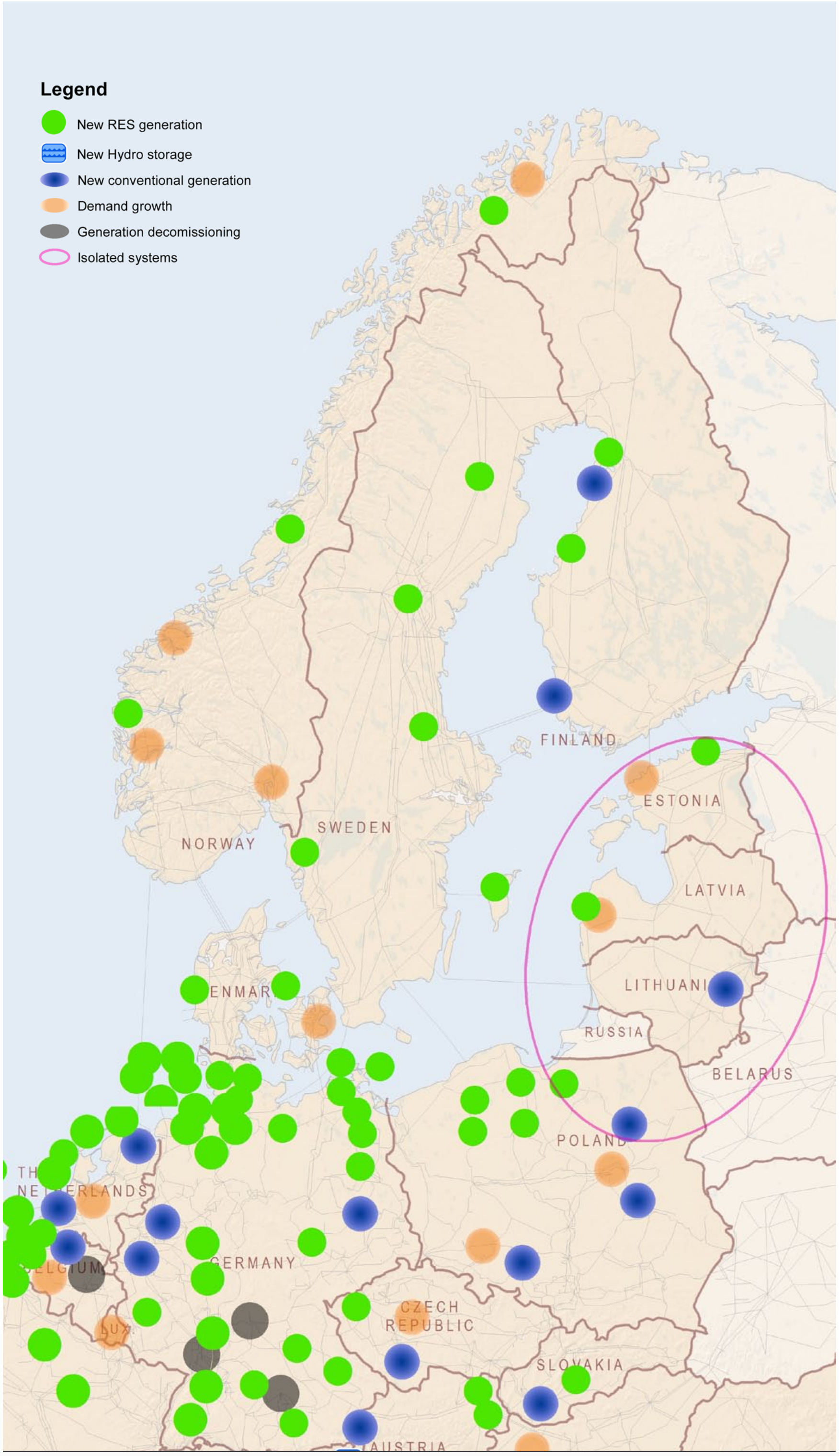


Figure 18:
Map of main drivers in Baltic Sea region

The three main drivers for system evolution in the Baltic Sea region are market integration, RES and conventional generation integration and security of supply. These drivers are followed by the refurbishment of aging equipment, environmental issues and synchronous connections of Baltic States. One of the biggest challenges regarding the main drivers is that there is a large uncertainty regarding the generator investments. On the EU – Russian border there is also uncertainty regarding the market development. Until now the direction of flow has been steady from Russia without electricity price impact, but in future with more equal prices due to generation portfolio, CO_2 and fuel price changes, there may be less import or even export when the electricity price is higher in Russia or low in Baltic Sea region. In the South-East part of the region the integration of Baltic countries with the Nordic and European electricity market can also have an impact on the border transfer between Russia and the neighboring countries.

In Germany with the recent decision of a nuclear phase-out by 2022 the structural changes in generation obviously also result in the generation pattern changes which affect the whole region.

6.2.1 Market Integration

In the medium term market integration is the key driver for grid investments in the Baltic Sea region. More capacity is needed between the Baltic States and the European energy market to thoroughly integrate the Baltic States with the Nordic and European energy market. While a strong connection already exists between the Nordic countries, further integration is required in order to fully utilize the benefits of the countries' diverse generation type portfolios. Bottle necks currently still exist between the hydropower dominated areas of Norway and North Sweden and the thermal production dominated South Finland, South Sweden and Denmark.

More capacity between Nordic and Continental Europe is vital to serve the expected change in transmission patterns due to the increase in wind power in Continental Europe and the change in power balance in Germany. In the long-term the connection of the Baltic area directly to Central Europe via a new connection from Lithuania to Poland is a driver for cross Baltic investments.

In 2011 the three Baltic TSOs together with ENTSO-E started a feasibility study on the interconnection variants for the integration of the Baltic States (Lithuania, Latvia and Estonia) with the EU internal Electricity market. One of the main objectives and outputs of the study will be the optimal variant and scenario identification with detailed analyses of the process and steps needed for full synchronous interconnection of the Baltic States' power system with the Continental European power system. The study will be finalized and results will be available by TYNDP2014.

6.2.2 RES and Conventional Generation Integration

In the long-term integration of new renewable generation and new or upgraded nuclear power plants are the main drivers of system evolution in the Baltic Sea region.

New wind power plants are planned to be built almost all around the region, but mainly concentrating on the coastal areas and the highlands in the North of the region. A new small scale hydro is planned to be constructed particularly in Norway. The new wind and hydro generation in the northern areas which already have a high surplus of energy balance requires a strengthening of North-South connections in Sweden, Norway and Finland.

The new wind power plants in the coastal areas of Estonia and Latvia need connections to the transmission system, but also strengthening of inter-area connections due to expected change in the power flow patterns.

In Finland there are plans and decisions-in-principle to build two new large nuclear power units and in Sweden there are plans to replace and/or upgrade the existing aging nuclear power units. In the South-East part of the region a nuclear power plant is to be built in Lithuania which requires not only internal reinforcements in Lithuania but also new interconnection to Latvia including local transmission network reinforcement in Latvia.

6.2.3 Security of Supply

Security of Supply is a driving force for investments in the Arctic region especially in the northern most part of Norway due to increased consumption of the oil industry and new mining sites. The area has weak security of supply even today.

In the Baltic countries the capacity of wind generation is expected to rise whilst the use of conventional generating technology is expected to decrease, meaning that security of supply would become an issue without the planned transmission investments.

There are also some restricted areas in the region where investments are needed to secure the supply especially when old assets are dismantled.

6.2.4 Aging Transmission Assets and Environmental Issues

Aging of the network equipment is a driver for investments in all of the countries in the region. Joined together by a need for more capacity, the old assets are frequently replaced with equipment which boasts a higher transfer capacity. More transmission capacity is achieved with minimal environmental impact when old assets are replaced with higher dimensioned equipment.

In Sweden and Denmark there is a political urge to minimize the use of overhead lines in urban areas which could lead to extensive funds with which to build new cable connections.

6.3 Bulk Power Flows in 2020

The figure shows main load flow from North to South.

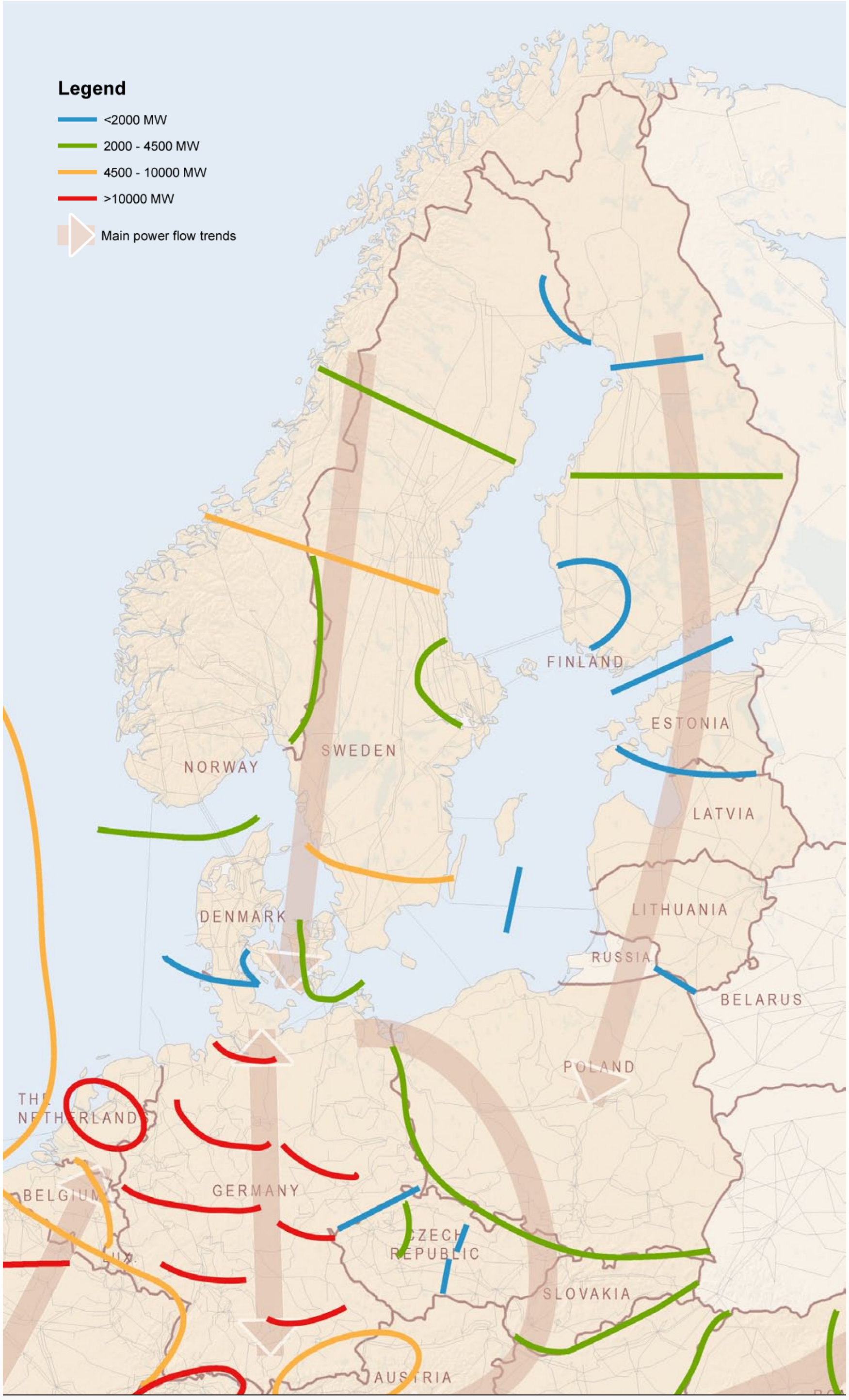


Figure 19:
Bulk power flows and the market flows in MW range for RGBS region in 2020

6.3.1 Duration Curves

Duration curves for Nordic-Continent, Nordic-Baltic and Baltic-Continent flows in EU and B scenarios with both 2015 and 2020 grid are presented below. Nordic-continent shows the sum of simultaneous flows in all interconnections between Nordic countries and continent. As the figure shows, flows in both directions increase significantly after the investments are made. The main direction of flows in both scenarios is from North to South. As the figure shows, there are no simultaneous bottlenecks in all lines between Nordic and continent. However, there are considerable bottlenecks in certain individual lines and adding capacity to those lines brings benefits, although the total capacity would already seem to be sufficient.

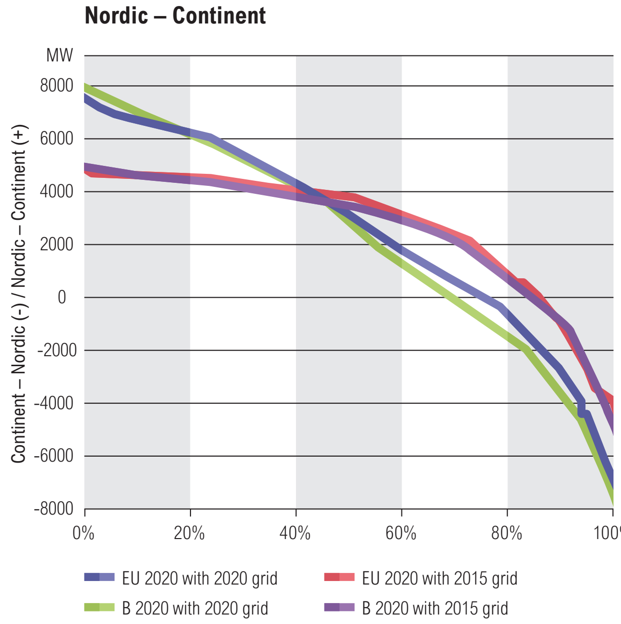


Figure 20:
Duration curves showing simultaneous flows from Nordic countries to continent

The Nordic-Baltic figure shows the sum of simultaneous flows in all interconnections between Nordic countries and Baltic countries (Finland – Estonia and Sweden – Lithuania). Flows are mostly from Nordic countries to Baltic countries in both scenarios. In the EU scenario there are bigger flows whilst at the same time interconnections are fairly congested, as the figure shows. In B scenario power flow levels are lower and there are no simultaneous bottlenecks in interconnections after the investments are made.

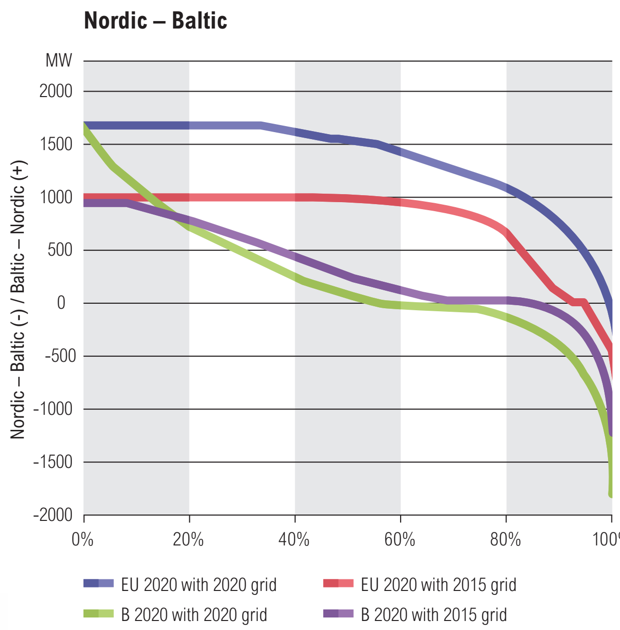


Figure 21:
Duration curves showing simultaneous flows from Nordic countries to Baltic countries

Baltic-Continent shows the flows between Lithuania and Poland. With 2015 grid transmission is only possible in one direction, from Lithuania to Poland. In addition, with the 2020 grid the direction of flows is mainly from Lithuania to Poland. There is a great deal of congestion between Baltic and continent, especially in the EU scenario.

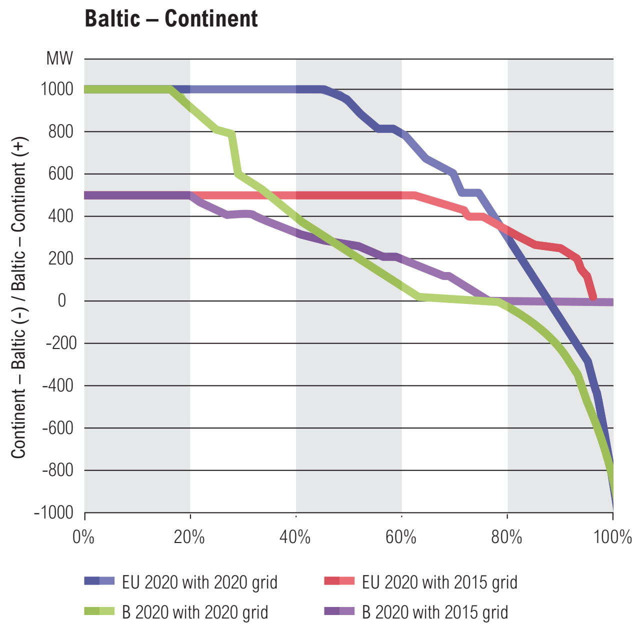
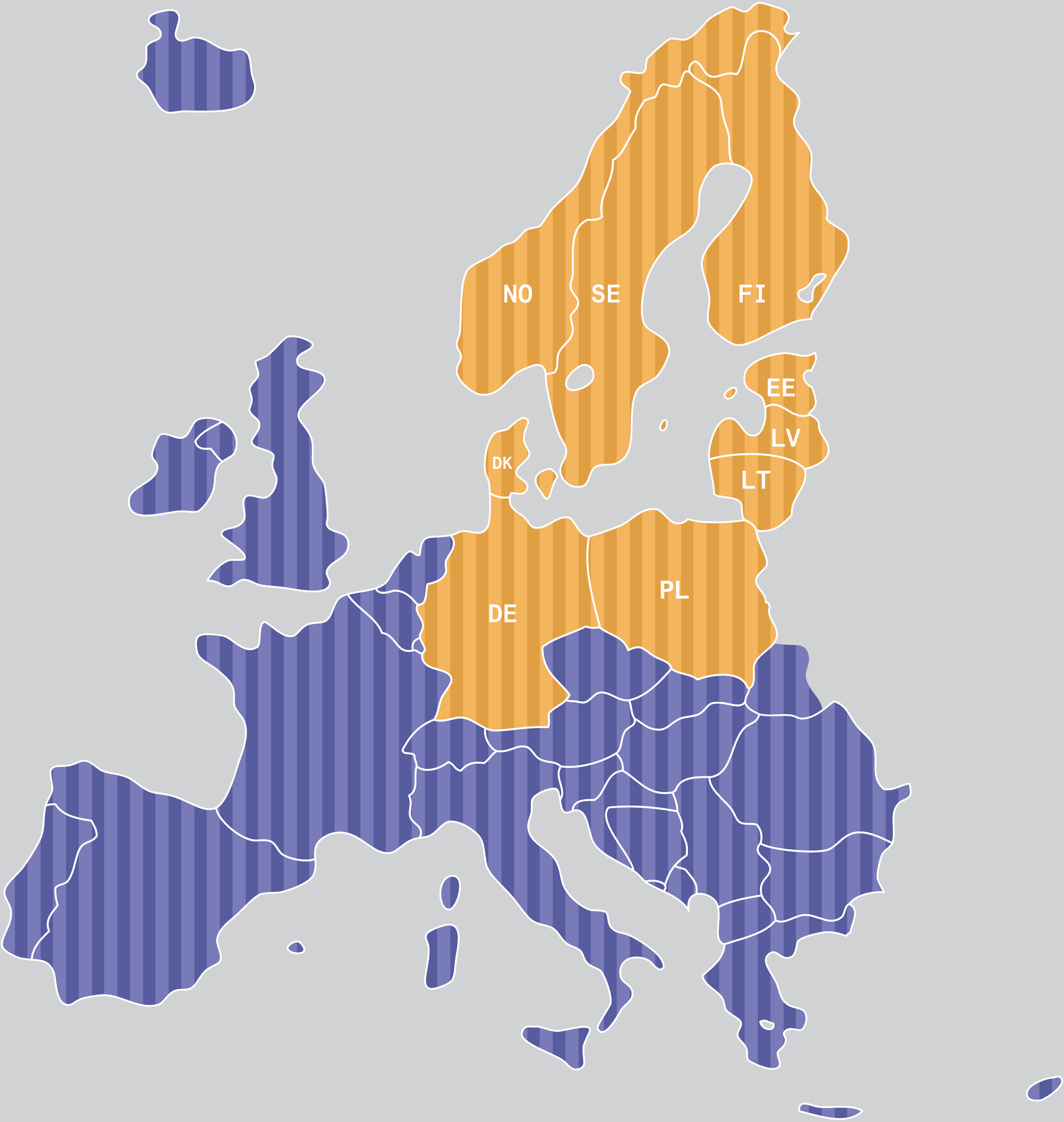


Figure 23:
Duration curves showing simultaneous flows from Baltic countries to continent

7 Investments



The main drivers for investments in the Baltic Sea area are described in Chapter 6.2. As a result of these drivers, projects are now being developed for market integration, RES and conventional generation integration and security of supply. Both mid-term and long-term projects are being built for increasing power transmission from the Baltic Sea area towards Continental Europe. Particularly, several large HVDC projects are planned for this purpose. As a consequence, internal grid reinforcements become necessary. Examples of such projects are voltage upgrades on existing transmission lines and new transmission lines.

The projects presented in this plan are those of Pan-European significance and some Regional significance projects. In addition, all the TSOs have a number of other investments planned or in consideration, which are of National importance. These investments are included in the National development plans. These national projects are also not included in any of the statistics and figures relating to this plan.

A regional benefit assessment of the projects was conducted for the entire project portfolio including the projects to be commissioned between 2015 and 2020. In addition an assessment was carried out for each project based on the common ENTSOE criteria.

Each project was assessed based on the 9 agreed common criteria:

- Grid Transfer Capability increase MW
- Social and economic welfare indicator
- RES indicator
- SoS
- Losses variation
- CO_2 indicator
- Technical resilience
- Flexibility
- Social and environmental indicator

The summary of the projects assessment according to those criteria above is presented in 11.1 Main Statistics chapter.

7.1 Criteria for Including Projects

A **Project of Pan-European Significance** is a set of Extra High Voltage assets, matching the following criteria:

- The main equipment is at least 220 kV if it is an overhead line AC or at least 150 kV otherwise and is, at least partially, located in one of the 32 countries represented in TYNDP.

- Altogether, these assets contribute to a grid transfer capability increase across a network boundary within the ENTSO-E interconnected network (e.g. additional NTC between two market areas) or at its borders (i.e. increasing the import and/or export capability of ENTSO-E countries vis-à-vis others).
- An estimate of the abovementioned grid transfer capability increase is explicitly provided in MW in the application.
- The grid transfer capability increase meets at least one of the following minimums:
  - At least 500 MW of additional NTC; or
  - Connecting or securing output of at least 1 GW/1,000 km^2 of generation; or
  - Securing load growth for at least 10 years for an area representing consumption greater than 3 TWh/yr.

7.2 Projects of Pan European Significance (A)

In this chapter a general description of the projects at regional level for the entire Baltic Sea region is presented. Particular reference will be made to the most important issues and targets which the new investments are contributing towards. A higher level presentation of the projects of pan-European significance with a brief description of each project is given in Appendix 1.

7.2.1 Mid-term (2012 – 2016)

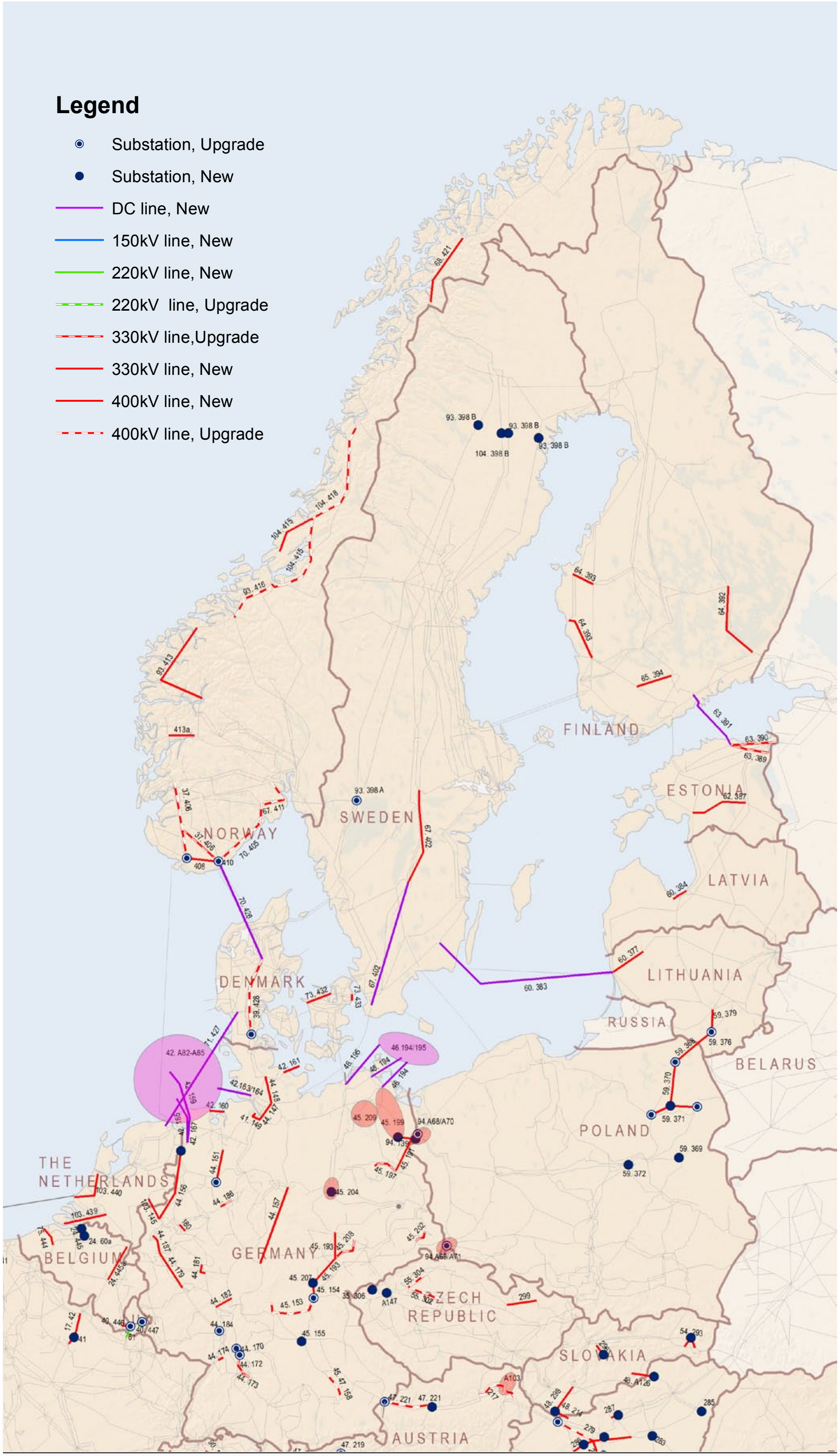


Figure 23:
Map of Medium Term Projects in the Baltic Sea Region

Figure 23 illustrates the projects which are expected to be delivered in the Baltic Sea region in the first five-year period of the ten year plan, that is, between 2012 and 2016. A number of important projects will be completed during this period, three of which involve offshore HVDC technology.

The mid-term projects are mainly driven by the increase of transmission capacity in the North-South direction due to RES integration both in the Northern part of the region and in the Southern part of the region. However, projects seldom have only one driver; for instance, the projects affecting the NTC greatly improve the possibility of renewable integration in the region and also in the neighboring regions.

The projects recognized in the **Baltic Energy Market Interconnection Plan** are included in this regional plan. Integrating the Baltic States with the rest of the EU electricity market is a priority for the Baltic States and EU. This plan presents links from the Baltic States to Finland, Sweden and Poland. A number of internal grid reinforcements are also needed to utilize these interconnections both in the three Baltic States and in Poland.

EstLink 2, a new HVDC (450 kV) connection, will be built between Estonia and Finland. On the Finnish side, a 14 km DC overhead line will be built to a new substation, namely Anttila. On the Estonian side, an 11 km DC cable line will be built to an existing substation, namely Püssi. The length of submarine cable is 140 km. The capacity of the new HVDC link will be 650 MW. Together with the existing link, the total transmission capacity between Estonia and Finland will increase to 1.000 MW. The project also includes reinforcement of two existing 330 kV OHLs in Estonia thus enabling connection to the HVDC line on the Estonian side. The expected commissioning date is 2014.

NordBalt; Is a planned 300 kV VSC HVDC subsea cable between Lithuania and Sweden (440 km) with a capacity of 700 MW. The project will connect the Baltic grid to the Nordic and will, together with the Estlink connection, integrate the Baltic countries with the Nordic and European electricity market. The Project also includes AC grid reinforcements in Lithuania, Latvia and Sweden which are needed in order to use the capacity of the DC connection. The expected commissioning date is 2015.

LitPol; Interconnection of Lithuania and Polish transmission grids by building a new double circuit 400 kV interconnection line Ełk – Alytus with 2 x 500 MW back-to-back convertor station and strengthening internal high voltage transmission grids in Poland and Lithuania in order to utilize the capacity of the HVDC link. The capacity increase in mid-term is 500 MW and the expected commissioning date is 2015.

Improving the North-South transmission corridor in the region

The Nordic power system is dominated by hydropower, and the variations in annual generation are extensive. Interconnectors to thermal systems are therefore important to balance out these variations. There is a high RES potential in the northern parts of Sweden, and in the northern, middle and western parts of Norway. Increased RES generation in these areas must be transmitted southwards to areas with high consumption and interconnectors. Interconnectors to the continent and UK will facilitate the integration of RES in Norway and Sweden, ensuring security of supply in years with low hydropower generation. Storage capabilities will also be provided in the form of the country's hydro power reservoirs.

In the mid-term, one new interconnector will be built; the Skagerrak 4, which is a subsea HVDC link between Norway and Denmark (127 km), in parallel with the three existing links. The project includes a voltage upgrade of the so-called eastern corridor in the internal Norwegian grid. The capacity is 700 MW, and the expected commissioning date is 2014.

North-South in Scandinavia; There are several projects in Norway which aim to upgrade the existing 300 kV into 400 kV, and to establish a new 400 kV ac line from western to mid-Norway in order to secure the security of supply in mid-Norway. These projects will also integrate large volumes of RES generation. The capacity increase is divided between mid- and long-term. Shunt compensation and series compensation of existing lines in northern Sweden will be used to increase the transmission capacity in a North-South direction.

The North-South part of the South-West link; the South-West link will consist of a three-terminal VSC HVDC link which will connect the Oslo region in Norway to southern Sweden with a terminal midway in Sweden. Connecting to that terminal a 400 kV AC line will be used to strengthen the grid northwards. The AC line and the Swedish part of the DC link together provide a strengthening of the North–South capacity in the Swedish grid and they are planned for the mid-term with an expected commissioning date of 2014. The DC part connecting to Norway falls under Long-term investments. The DC part of the South-West link will have a maximum capacity of 1400 MW.

Due to the strong increase in RES generation, it is necessary to meet the goals of the European and especially German energy policy with new connections between areas with high installed capacities of RES and areas with high consumption and storage capabilities. For this reason the development of new North-South and Northeast-Southwest electricity transmission capacity in Germany is necessary. For the mid-term time horizon the necessary grid development in Germany is covered by common projects Western and Eastern corridor.

The German West corridor starts in the North-West of Germany, an area with high surplus of RES production (planned and existing) and connections with Scandinavia (planned and existing). It continues to the Rhine-Ruhr area (high consumption and a vast amount of conventional power generation).

The German East corridor begins in the North-East of Germany, an area with high RES generation (planned and existing), conventional generation and connections with Scandinavia (planned and existing). Both corridors end in the South of Germany, an area with high consumptions and connections to Austria and Switzerland (transit to Italy and pump storage in the Alps).

North-South in Finland, several 400 kV AC lines are planned in Finland to increase the North-South transmission capacity thus enabling the integration of new renewable and conventional generation in northern Finland and to compensate the dismantling of the obsolescent existing 220 kV lines. The commissioning of the lines is scheduled to take place in segments both in mid- and long-term.

In addition, all mid-term projects listed in BEMIP are contributing to increased transmission capacity between the North and South parts of the BS region by forming additional bridges between the generation surplus and deficit areas.

Installation of PSTs on two existing lines (Krajnik-Vierraden and Mikułowa-Hagenverder) on the PL/DE border (Ger-Pol Improvements) together with necessary investments provides additional NTC of 500 MW in terms of import and 1,500 MW export after commissioning in 2014.

Denmark/Germany; The upgrading of the 400 kV back-bone transmission system in Denmark West and 400 kV connections to Germany will increase the grid transfer capacity from Denmark to Germany. The project is divided between mid-term and long-term

Cobra; is a 700 MW HVDC 320 kV link between Denmark West and Netherlands. The capacity increase is 700 MW. The project will allow for the exchange and integration of wind energy and will increase the value of renewable energy in the Dutch and Danish systems whilst also increasing the security of supply in both countries. The expected commissioning date is 2016

There is a fairly huge interest concerning the integration of large scale wind power into power systems of Baltic States, especially near the coastline of the Baltic Sea. Many of the projects involved with Baltic States are related directly to the possibilities of integration of new wind power units in this particular region. The estimated additional wind power which can be integrated, is approximately 400 to 900 MW. The long-term influence on RES is even bigger.

Some mid-term projects are significantly improving security of supply in the eastern part of the Baltic Sea region. The Lit-Pol link is strongly related to SoS issues in northern Poland. Projects also help to improve the level of SoS in western parts of Baltic States and capital areas of Estonia.

7.2.2 Long-term (2017 – 2022)

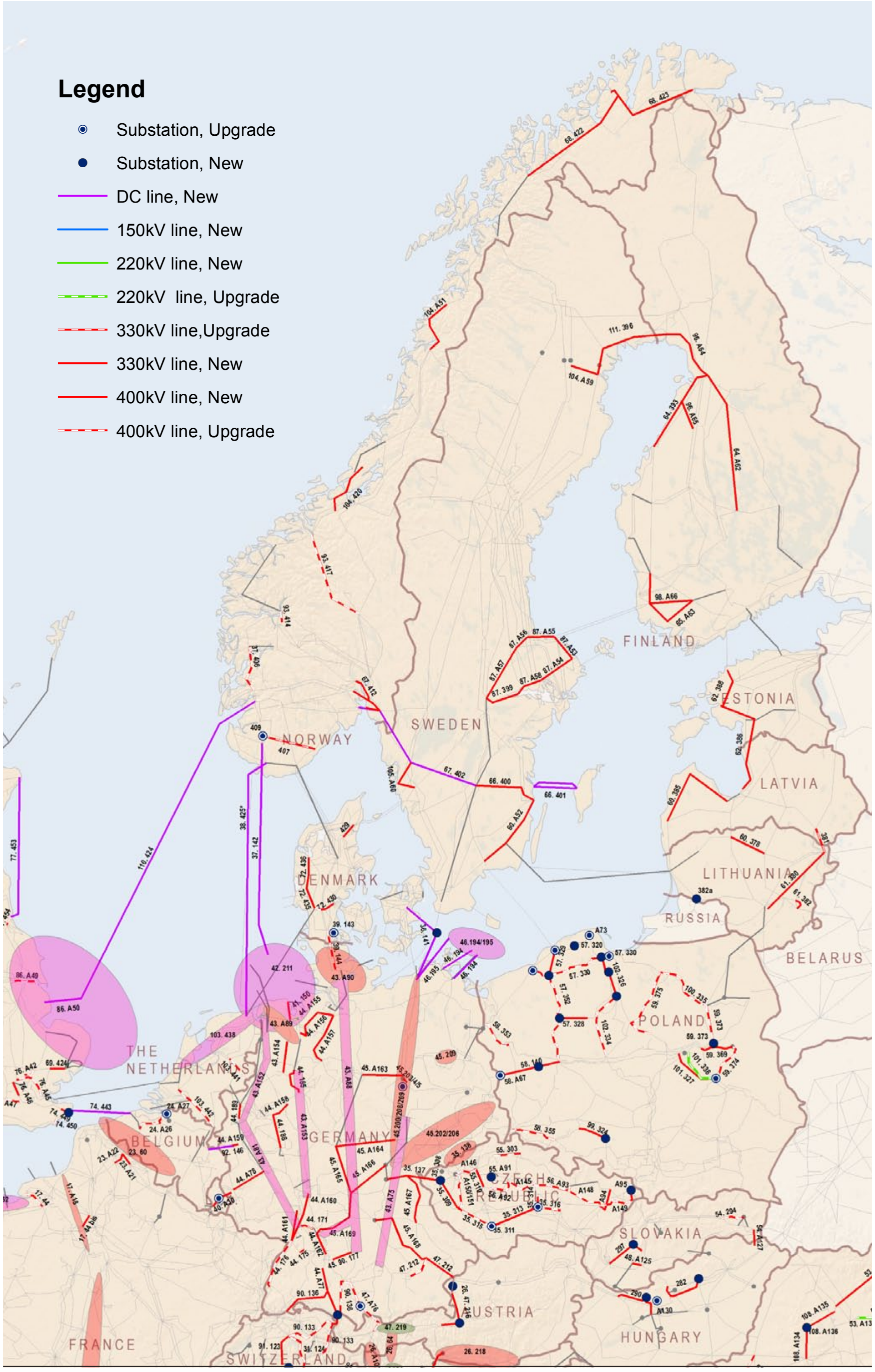


Figure 24:
Map of Long-term Projects in the Baltic Sea Region

Figure 24 illustrates the projects which are expected to be delivered in the Baltic Sea region in the second five-year period of the ten year plan, that is, between 2017 and 2022. This period will see a significant number of new transmission line projects completed. These new links will further reinforce the Baltic Sea grid. The plan in its totality will enable greater market integration and will create a larger market for the region's renewable energy generation, while actualizing a strong grid around the Baltic Sea.

Market integration is the main driver for most of the projects, but as for the mid-term projects, the renewable integration is also made easier in the whole system with increased capacity between the Nordic, Baltic and continental systems. Some projects are related to the security of supply (Arctic region) and some directly with RES integration. There are also some projects related to integration of large conventional generation (Nuclear units planned in Finland and Lithuania).

Some of the transmission capacity will be added gradually from the mid-term, since additional internal reinforcements will be finished within the long-term timeframe

Baltic Energy Market Interconnection Plan

For the long-term more internal Polish grid reinforcements are expected and the capacity of the LitPol connection can be utilized up to 1,000 MW.

North-South transmission direction in the region

Large investments in RES generation are expected towards 2020 throughout the Baltic Sea region. Reinforcements in the internal grids as well as increased interconnector capacity are needed to integrate more RES. Increased surplus and more interconnectors will lead to a stronger North-South flow in the Baltic Sea grid, and domestic reinforcements are especially needed in this direction.

For the long-term time horizon the foreseen RES generation (especially wind) in northern Germany, the increasing geographical imbalance between generation and consumption, as well as the long distances separating generation and consumption regions would require additional grid extension inside Germany. The needs for transportation over long distances, as well as the need to improve the grid stability regarding dynamic and static voltage play in favour of HVDC technology. For this reason, the German TSOs are considering several DC-connections, allowing the North-South and Northeast-Southwest power flow and enhancing the grid stability. The project is being considered in order to enable future evolutions of the generation and consumption patterns

South-West link; the western part of the South-West link expands the Swedish North-South VSC HVDC-link from mid-term investments to Norway. This substantially increases the trading capacity between the southern part of Norway and mid/South Sweden answering the future need for more efficient utilization of hydro power in southern Norway as well as the need for higher trading capacity. If all goes according to plan, the western part of the South-West link will be put into operation in 2019.

Several projects are planned to increase North-South capacity in Norway and Sweden. These include new AC-lines in northern and mid-Norway, voltage-upgrading between mid- and southern Norway. Increased capacity between Norway and Sweden in the northern or mid areas will support more North-South flow, but more studies are needed in order to identify actual projects.

The North-South direction will also be reinforced with internal grid reinforcements in Finland and the Baltic States. After commissioning the projects forming the Baltic Energy Interconnection Plan together with Estonia-Latvia 3rd interconnection the reinforced Baltic States transmission system and its connections to Nordic and Central Europe can also serve as an alternative route for exporting Nordic surplus to the Central European power system.

HVDC links out of Norway have been postponed and first interconnections after the Skagerrak 4 are planned to be commissioned in 2018 and the second cable in 2021. It has not yet been decided whether the first cable will go to the UK or to Germany. The planned capacity for these links is 1,000 – 1,400 MW. NorNed 2 (700 MW) is postponed until further notice and will not be commissioned within the next ten years. The project has been taken out of the Norwegian national grid development plan.

Denmark West/Germany Interconnection upgrade; The upgrading of the 400 kV back-bone transmission system in Denmark West and the 400 kV connections to Germany will increase the grid transfer capacity from Denmark West to Germany by 1,000 MW and from Germany to Denmark West by 1,550 MW. The projects involve the transmission system upgrade in the two countries and have regional importance for integration of wind power in Denmark and Germany, improving the security of supply and better integration of the market for electricity. The expected commissioning date is 2017.

Kriegers Flak CGS is considered to be a pilot project to build, utilise and demonstrate a multi-vendor, multi-terminal HVDC VSC offshore system interconnecting different countries and integrating offshore wind power. This will be a full-scale prototype of future European HVDC super grids, e.g. offshore transmission systems in North Sea and Baltic Sea, placing the Kriegers Flak CGS among the projects of Pan-European significance and has been awarded a grant from the EEPR.

The construction of a new (third) interconnection between Polish and German systems (Ger-Pol Power Bridge) increasing market integration between member states – additional NTC of 1,500 import and 500 MW export on PL-DE/SK/CZ synchronous profile – compared to current situation (0 MW import and 1,000 export). The projects of set of high voltage investments allowing connection in Poland of new RES (wind) and conventional generation (Wind Integration and Power Evacuation North) and also allowing connection of planned off-shore super-grid to the rest of the network of central Europe and transit RES (wind off- and on-shore) to consumption centrescenters in central Europe. After commissioning of the project it will be possible to build second DC link to Sweden and transit RES energy from Scandinavian power system to consumption centrescenters in continental Europe. The projects of a set of high voltage investments allowing connection of new conventional generation for the supply of Wroclaw and Warsaw agglomeration areas as well as North-eastern Poland (PE_ KOZ, PE_DBN, PE_OST).

The total amount of estimated long-term wind power integration in Baltic States coastal areas including possible off-shore wind parks, together with mid-term projects can reach from 900 up to around 2,500 MW. Thereby the preconditions to accommodate such a huge amount of additional power into transmission network are full commissioning of the projects Nord-Balt, Estonia-Latvia 3rd interconnection and Estlink 2. Essentially the internal projects directly connecting the wind power plant with the rest of the network will be additional projects.

A number of long-term projects are focused on significantly improving security of supply in the Baltic States generally and especially western part of Latvia.

Finland/Sweden, third 400 kV AC line between North Finland and North Sweden is under consideration. Strengthening of the AC connection between Finland and Sweden is necessary due to new wind power generation, larger conventional units and decommissioning of the existing 220 kV interconnector. The estimated capacity increase is 700 MW and the planned commissioning date is 2021. The project and timetable are under evaluation.

In the long-term large conventional generator integration will also become necessary in the Baltic Sea region. The plan is to build large nuclear units in Finland and Lithuania as well as other conventional units in Poland and Germany.

7.2.3 3rd Parties Promoted Projects

In order to deliver the most comprehensive and up-to-date outlook of the electricity grid by 2020 and beyond, ENTSO-E, based on the stakeholders' feedback regarding the 2010 pilot TYDNP, elaborated and made available in February 2011 a process for the inclusion of the third party projects in the 2012 release of the TYNDP:

https://www.entsoe.eu/system-development/tyndp/tyndp-2012/.

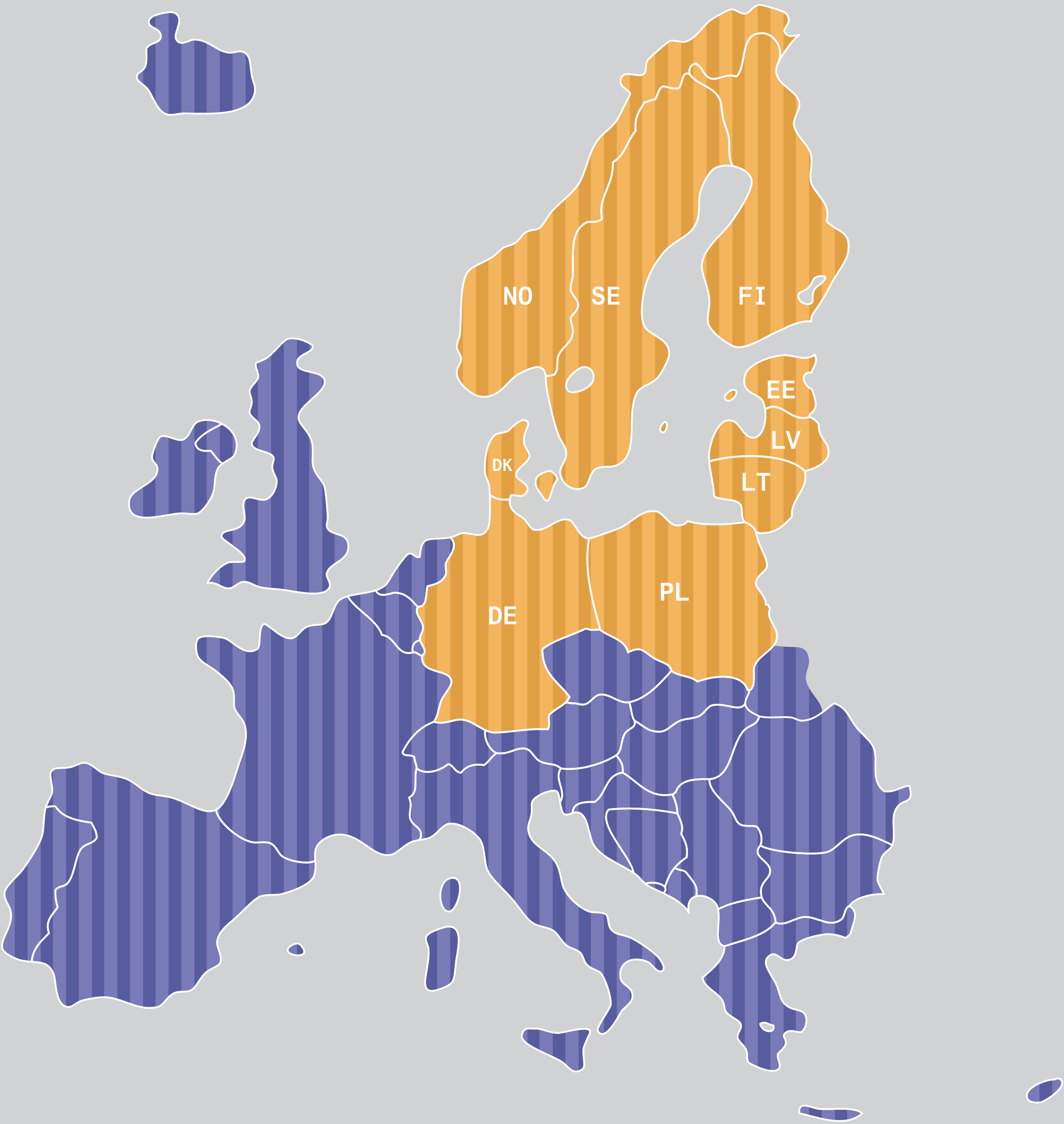
As result, ENTSOE- received 2 submissions related to the Baltic Sea region as presented in the table below.

Each of these projects failed to demonstrate evidence of a transmission licencelicense or an exemption for such licencelicense granted by the relevant national regulatory authorities and EC, as required by the ENTSO-E process. The non-discrimination principle (especially with regard to similar projects which may not have applied for inclusion for this reason), makes it inappropriate for these projects to be incorporated in the table of projects of the TYNDP 2012 package.

Country A	**Country B**	**Technology**	**Technical description**	**Regulatory and legal criteria fulfillment**	**Brief benefits for the project**
GB	NO	HVDC	Yes	No	"The project is market driven. The additional benefit is the possibility to balance the high RES (especially wind in the UK with the storage capacity in NO)".
RU	PL and LT	OHL+HVDC	Yes	No	"The project is market driven. The proposed lines/cables have as purpose the evacuation of the new nuclear generation in the Kaliningrad area".

Table 2:
Third party projects submitted in Baltic Sea region.

8 Transmission Adequacy



Transmission Adequacy shows how adequate the transmission system is in the future in the analyzed scenarios, considering that the presented projects are already commissioned. It answers the question: "is the problem fully solved after the projects are built?"

Three categories have been considered in the transmission adequacy showing that needs are solved in every situation, in almost every situation or that the need is not completely solved:

– light purple: unlikely that with all projects in the plans, in the span of scenarios considered in the plans, further measure is reported related to the boundary;
– purple: possibly, with all projects in the plans, in the span of scenarios considered in the plans, certain rare developments could trigger further measures on the boundary although sufficient transmission capability is provided for the vast majority of the situations ;
– dark purple: most likely that in the span of scenarios considered in the plans, additional measures are needed on top of all projects in the plans to cope with congestion on the boundary.

The following map (see figure 25) displays the overall picture:

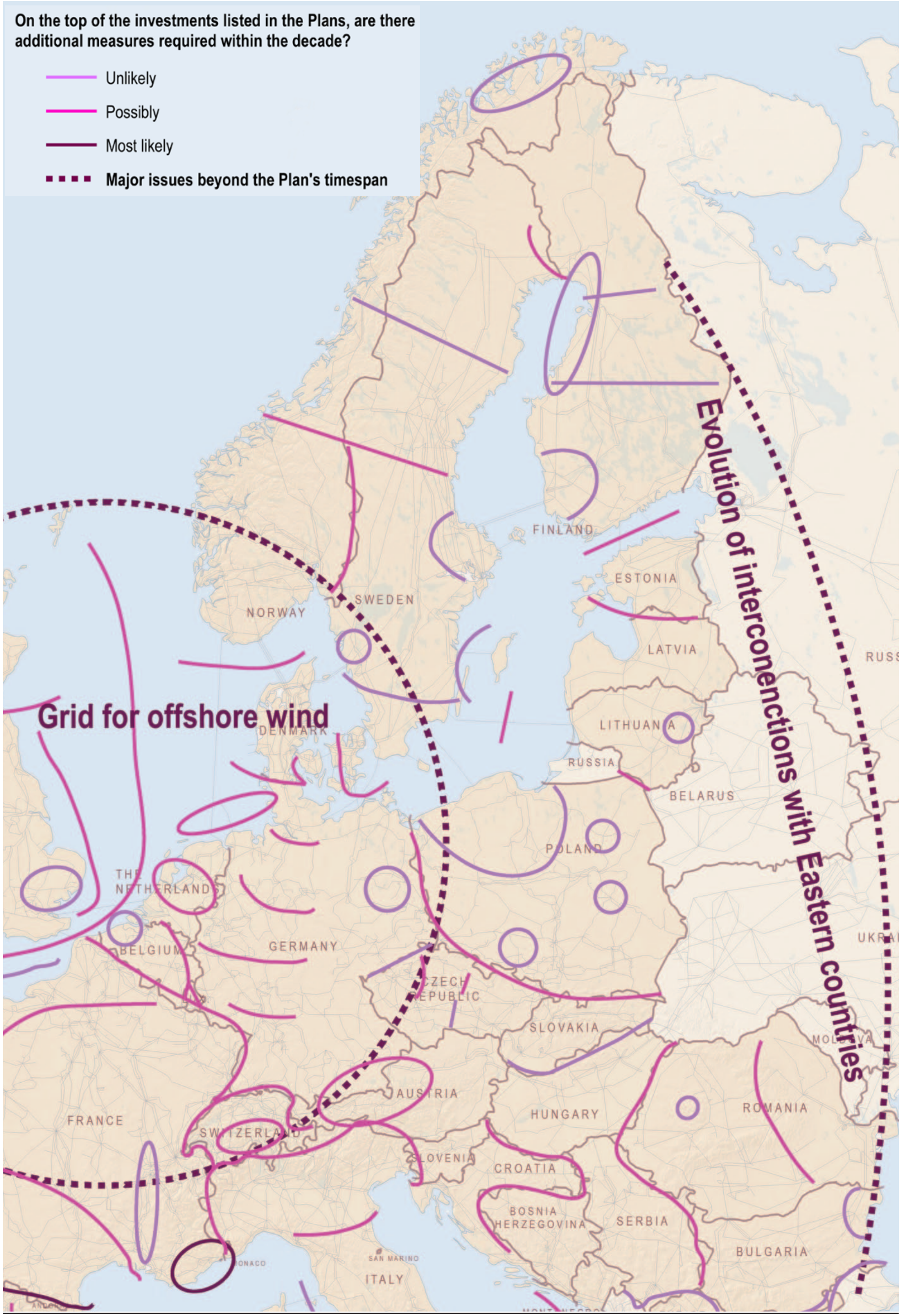


Figure 25:
Transmission Adequacy Map of Regional Group Baltic Sea.

Results of the analysis show that the investment portfolio presented in this plan gives flexibility and provides a sound and functional infrastructure on the track towards Europe's future vision of competitive internal market and low-carbon energy. With the presented investment portfolio the Baltic Sea region within ENTSO-E will become more integrated with the rest of the European electricity market.

For the studied scenarios the investment portfolio was found proper for the coming ten years, but if significant and unexpected changes occur which are out of line with preliminary assumptions and forecasts, more change of investments may be required.

Grid development will be needed beyond the investment listed in the Plans to meet challenges coming by 2030 and beyond: grid development to integrate offshore wind, the Mediterranean solar plan, further interconnection with the East, etc.

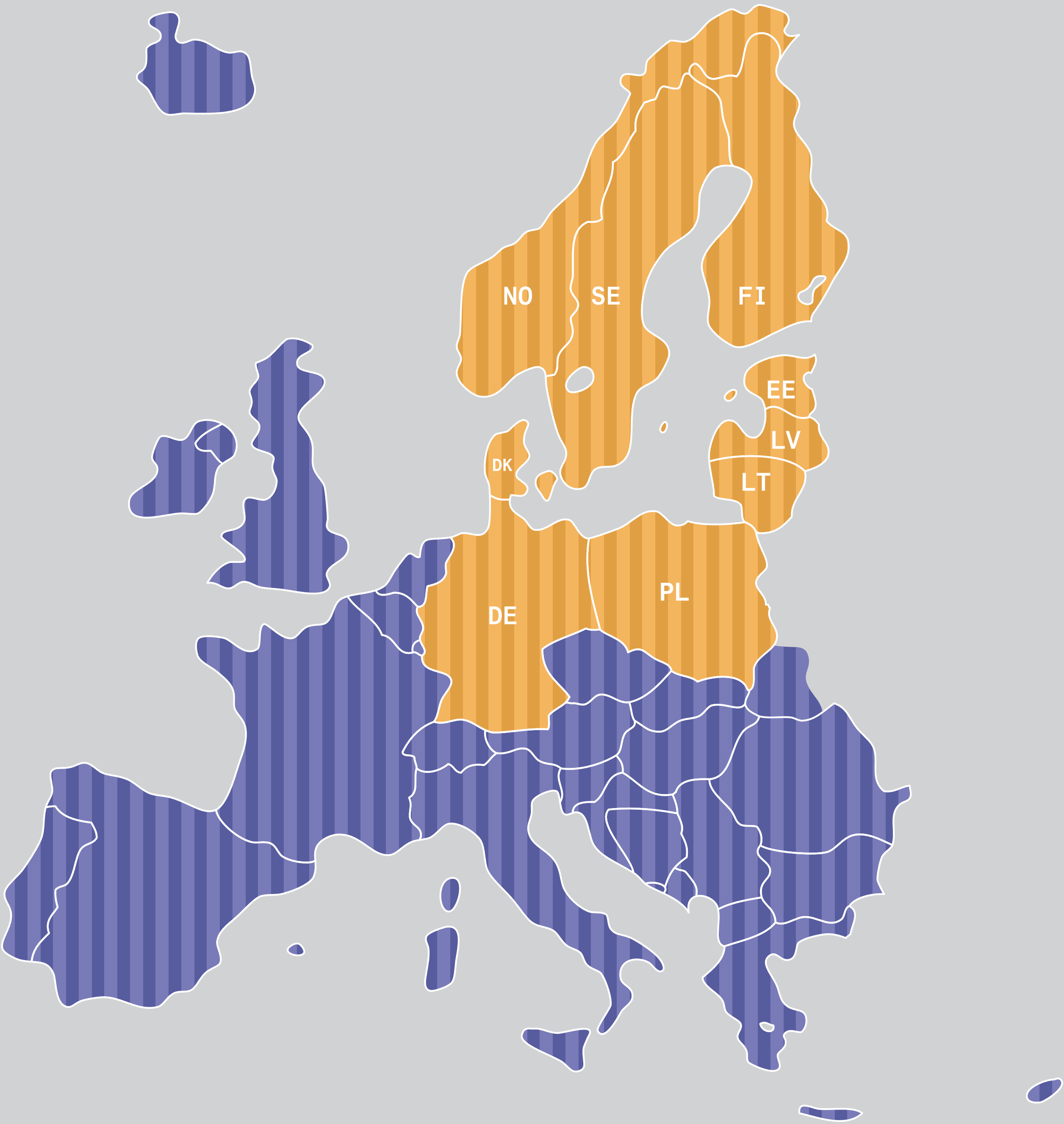
8.1 Screening Results Beyond 2020

Results from the screening for additional capacity studies beyond 2020 are presented in the following map. Interconnections where increased capacity may still be beneficial are marked with dark blue and light blue color. The impact on the national power systems has not been studied, and the direct investment costs and required additional investments in the domestic grid, are not taken into account in this consideration. The dark blue interconnections were identified in both EU2020 and scenario B whereas interconnections marked with light blue were identified in one of the above mentioned scenarios. All other interconnections which were studied are marked with grey colourcolor.

The interconnections which should be focused on in future studies are Sweden-Poland, Sweden-Germany, Sweden-Denmark West, Norway-UK, Norway-Germany, Norway-Netherlands and Lithuania-Poland. Other potential interconnections for future studies are Norway-Denmark West, Sweden-Denmark East, Germany-Poland, Sweden-Lithuania and Finland-Estonia. Additionally, if capacities for the above mentioned interconnections are increased, investments in internal grids will most probably be needed.

Figure 26:
Results from the screening process – Map of possible new interconnections in the Baltic Sea Region beyond 2020 to be further analyzed.

9 Environmental Assessment



Environmental indicators related to the regional investment portfolio and scenarios EU2020 and B are presented in the following subchapters. Indicators include grid expansion in terms of length of new lines, change in CO_2 emissions, increase in load, and increase in RES.

9.1 Grid Expansion

The graph shows grid expansion in terms of length of new lines in kilometers. All of the projects in this regional investment plan are taken into account. Around over 59 % of the new lines will be AC lines, 29 % DC lines, and approximately 12 % AC line upgrades. AC line upgrades do not have a considerable impact on the environment because they will be built mainly in existing corridors.

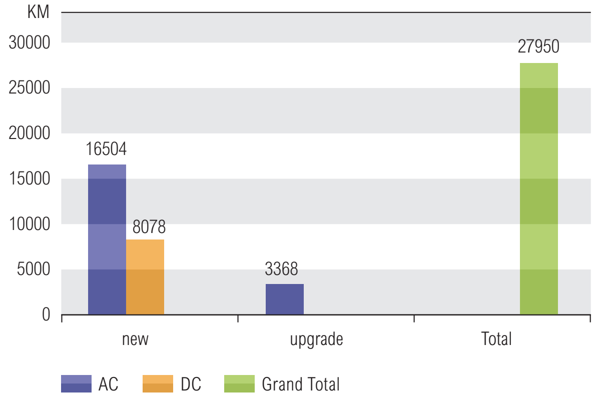


Figure 27:
Length of new lines in RG Baltic Sea by type [km].

9.2 Change in CO_2 Emissions

Changes in CO_2 emissions in EU2020, scenario B, EU2020 with Nuclear Phase Out and scenario B with Nuclear Phase Out are presented below. CO_2 emissions are based on market model studies. Emissions were calculated in each scenario with and without the investment portfolio and the figures show the difference in CO_2 emissions between the two grid situations. A negative figure indicates that CO_2 emissions have decreased and a positive figure indicates that CO_2 emissions have increased due to the investment portfolio. In EU2020 and EU2020 with Nuclear Phase Out, CO_2 emissions decrease due to the investment portfolio. In the respective B scenarios, where CO_2 price is lower, emissions increase due to the investment portfolio. In scenario B emissions increase because export from RGBS to other regions increases due to the investment portfolio. In scenario B with nuclear shutdown import from other regions to RGBS decreases due to the investment portfolio which in turn increases the generation and emissions in the Baltic Sea region.

To get an overview of the magnitude of changes in CO_2 emissions; the European average rate of CO_2 emissions from electricity and heat generation between the years 2007 and 2009 was equal to 0,356 ton CO_2 per MWh and the emissions from the Danish electricity sector today are approximately 10 Mton/a.

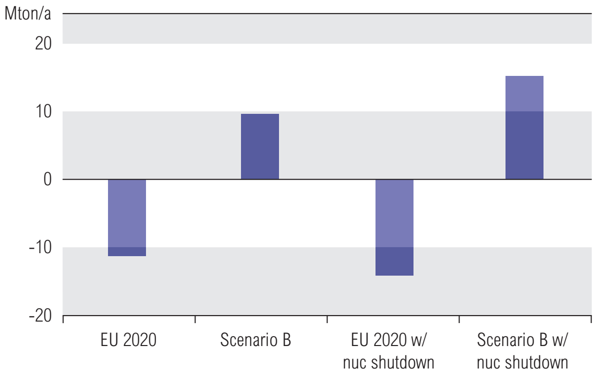


Figure 28:
Change in CO_2 emission in RG Baltic Sea due to the investment portfolio [Mton/a].

9.3 Increase in Load and RES in Mid-term and Long-term Scenarios

The following figure shows the change in load and RES in EU2020 and scenario B. Grid expansion in terms of length of new lines as discussed in subchapter 9.1.1 is also included in the figure. The blue bar shows the increase in percentages from 2011 to 2016 and the yellow bar the increase in percentages from 2017 to 2020.

As the figure shows, load in the Baltic Sea region increases slightly in scenario B and remains constant in EU2020. Increase in RES is significant in both scenarios, especially in EU2020. In order to meet the requirements of significant RES increase and possible load increase new transmission lines are needed.

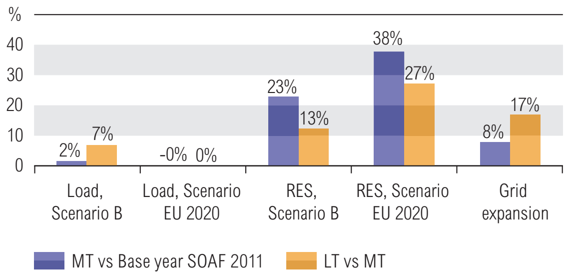
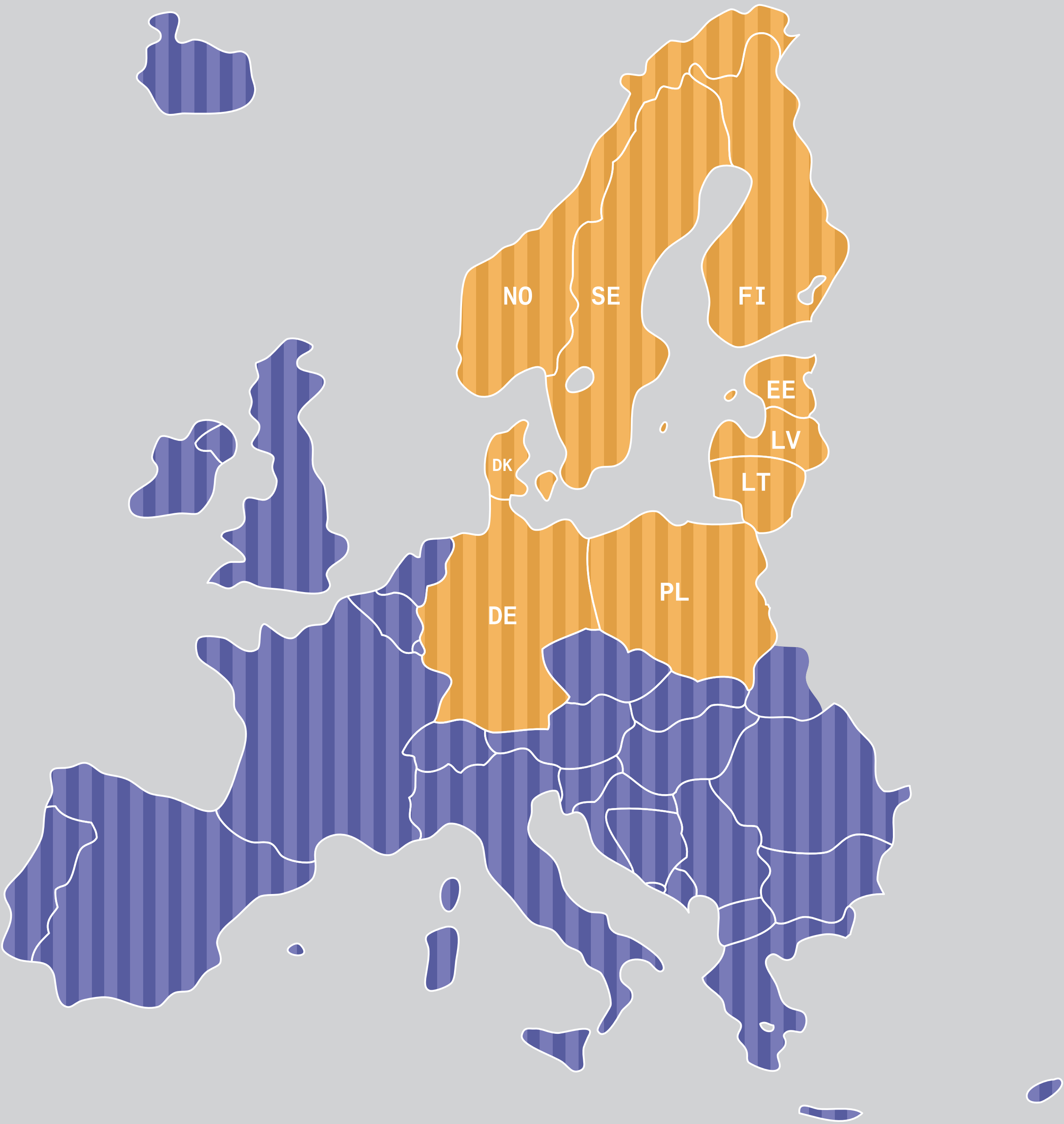


Figure 29:
Increase in load and RES, and grid expansion in RG Baltic Sea

10 Assessment of Resilience



Transmission system investments are expensive infrastructure projects, with a long lifetime (some more than 40 years), setting precedence for coming projects. In order to both avoid stranded costs and to meet grid users' expectations on time with appropriate solutions, TSOs assess the resilience of their investment projects. They assess the resilience of the system for whatever situation it may realistically have to face: high/low demand growth, different generation dispatch and exchange patterns, adverse climatic conditions, severe contingencies, and so on.

Transmission grid is designed for future needs

- The transmission system is planned to cope with future needs, and thus the target is not only to fix problems which are encountered now. The projects have been studied to cope with a range of scenarios and grid situations which could occur in the future.

Two main scenarios (e.g. scenarios EU2020, B) and sensitivity cases (Nuclear Phase Out, different CO_2 price) are considered. Based on the scenario results a number of grid situations were also studied with high transmission flows. In addition, different hydro years are included in the studies, and special focus is placed on the very low hydro and high hydro years.

Extreme situations are assessed

- Some particularly extreme situations have been studied both by performing grid studies and power adequacy studies. Some results are presented later in this chapter.

Benefits are assessed

- The projects proposed are estimated to have positive electricity market benefit for the whole region.

New Technology solutions and long-term visions are taken into account

- In the proposed projects for the Baltic Sea region a range of new VSC HVDC technology links are chosen. In addition, a novel solution for combined grid solution is proposed for Kriegers Flak.
- While studying the future with a range of scenarios, the goal remains to ensure that the projects are contributing to the even farther reaching visions of the EU regarding the High Voltage grid Electricity Highways and the modular development plan. Projects presented and planned now should not hinder the development of the grid in the long run.
- TSOs are also developing scenarios for linking the Ten Year Plan timeframe more smoothly to the long-term visions of 2050.

10.1 Technical Resilience Evaluation of the Grid

The Baltic Sea region contains 3 different synchronously connected power systems which are connected with each-other via HVDC links. With this in mind, the assessment of resilience in the transmission network of the Baltic Sea region might be more complicated than in the regions with a united synchronous area.

On the first hand, resilience was evaluated mainly by means of operational security and stability under different operational conditions, scenarios and stresses. Technical resilience under extreme conditions was based on the snapshots from market study results. It was important to investigate the entire area as one united system and on the other hand in each country separately to meet operational criteria in all probable conditions. The criteria were defined by each TSO and the whole region was observed to meet the determined criteria in normal operation and under severe N-1 contingencies.

To ascertain the most stressful conditions for the system, the most critical operations were determined for each part of the region. The description for selecting critical snapshots and the methodology is described under Chapter 4.3.

10.1.1 Conclusions of Technical Resilience in Baltic Sea Region

The results of the grid studies and observations can be found in Appendix A10_1. The results are structured for certain concentrated parts of the system in the Baltic Sea region and the determination of the areas takes into account the geographical aspects and is also driven by the diversity synchronous areas:

- North and West part of the Baltic Sea Region
- South-West part of the Baltic Sea Region
- East and East-South part of the Baltic Sea Region

The grid study results demonstrate that the transmission network is adequate with regards to meeting different operational conditions and is stable under different probable operational regimes derived from the market simulation results. For each part of the Baltic Sea region planning cases were developed to represent stressed operational conditions faced by the transmission system in an appropriate concentrated area. According to the grid studies all of the operational requirements were fulfilled in normal operation and under severe N-1 contingencies. However, it is kept in mind that the analyzed operational conditions are received from the probabilistic-approach market models, that is, they do not necessarily represent the worst-case operation conditions of the countries' transmission systems.

10.2 Impact on Grid Losses

As described in Chapter 4.3.1 the change in losses in Nordic and Baltic transmission systems were analyzed. Indeed, it is of interest to have an estimate of transmission grid losses due to the fact that the grid is developed and the production system changes. Because of the different methodology used in studying the losses in Baltic and Nordic countries the results are not directly comparable.

The results illustrate the mechanism. Even though the grid is developed with more interconnectors and lower impedance, the increased transmission of power will increase the main grid losses. A reason for this is the long distance between production and consumption and connections to neighboring countries. As Figure 30 shows, the losses in Baltic countries are much lower than in Nordic countries due to the smaller size of the system. In Baltic countries the grid losses are expected to decrease from the year 2015 to 2020 as a direct result of investments.

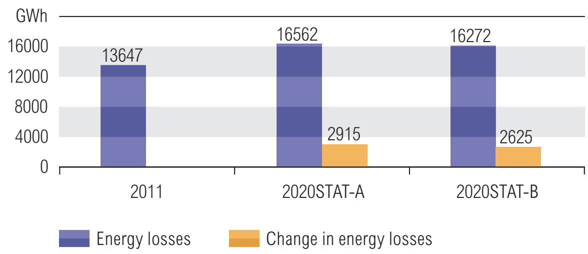


Figure 30:
Estimate annual transmission grid losses in Sweden, Norway, Finland and Denmark before and after the investment portfolio.

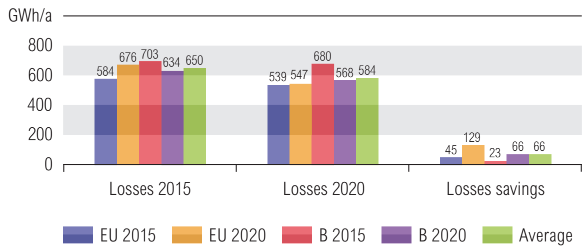


Figure 31:
Estimated sum of annual transmission grid losses in Estonia, Latvia and Lithuania in years 2015 and 2020.

10.3 Studies of Power Adequacy Assessments of Special Situations in MAPS

Simulations of the MAPS-tool (described in Chapter 4 and Appendix A4.4_2) showed a positive impact of the investment portfolio for the probability of loss of load. Implementing the proposed projects reduces the LOLP both in scenario B, EU2020 and in special simulated cases such as the shutdown of nuclear BWR-power stations and gas restricted situations.

Studies were conducted for the Scenarios EU2020 and B. In addition to the base scenarios, two additional situations were investigated:

- BWR-type failure (boiling water reactor) which assumes that all nuclear reactors of BWR-type are out of service
- Gas restriction, which assumes that a number of gas fired units are out of service in Finland, Estonia and Lithuania.
- Load was varied between severe load to normal load and import was varied with no-import to half import.

Conclusion: Simulations with the MAPS-tool show that the increased capacity by the investment portfolio improves security of supply and with the grid in 2020 the LOLP-criterion is met for all areas. The criterion was met even when severe load, no wind and no-import from the surrounding countries was assumed.

Without the projects with only the 2015 grid some problems emerge in the analysis:

- Arctic area in Norway is not meeting the criteria, shows as red or yellow in the studied base scenario cases EU2020 and B.
- South Sweden/Finland is not meeting the criteria for BWR failure case
- South Finland also yellow for Gas restriction case combined with severe load

Figure A:
Showing EUE in GWh for EU2020/B2020 without investment portfolio, half import and severe load

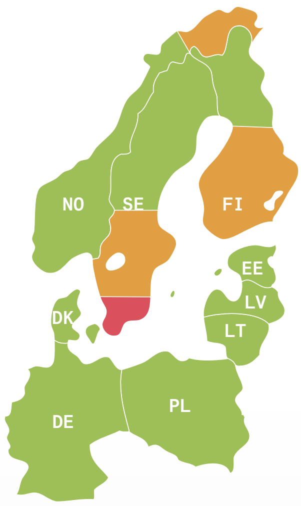


Figure B:
Showing EUE in GWh for EU2020, nuclear BWR-reactor shutdown without investment portfolio, half import and normal load

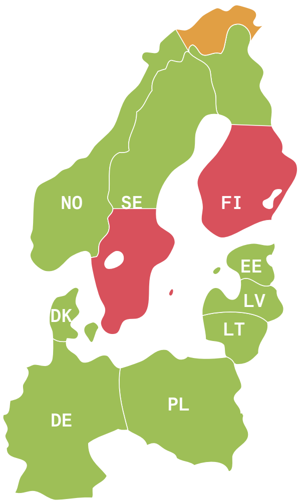


Figure C:
Showing EUE in GWh for B2020, nuclear BWR-reactor shutdown without investment portfolio, half import and normal load

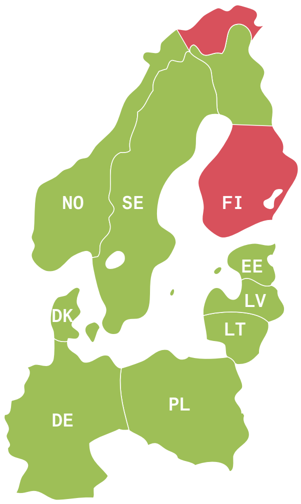
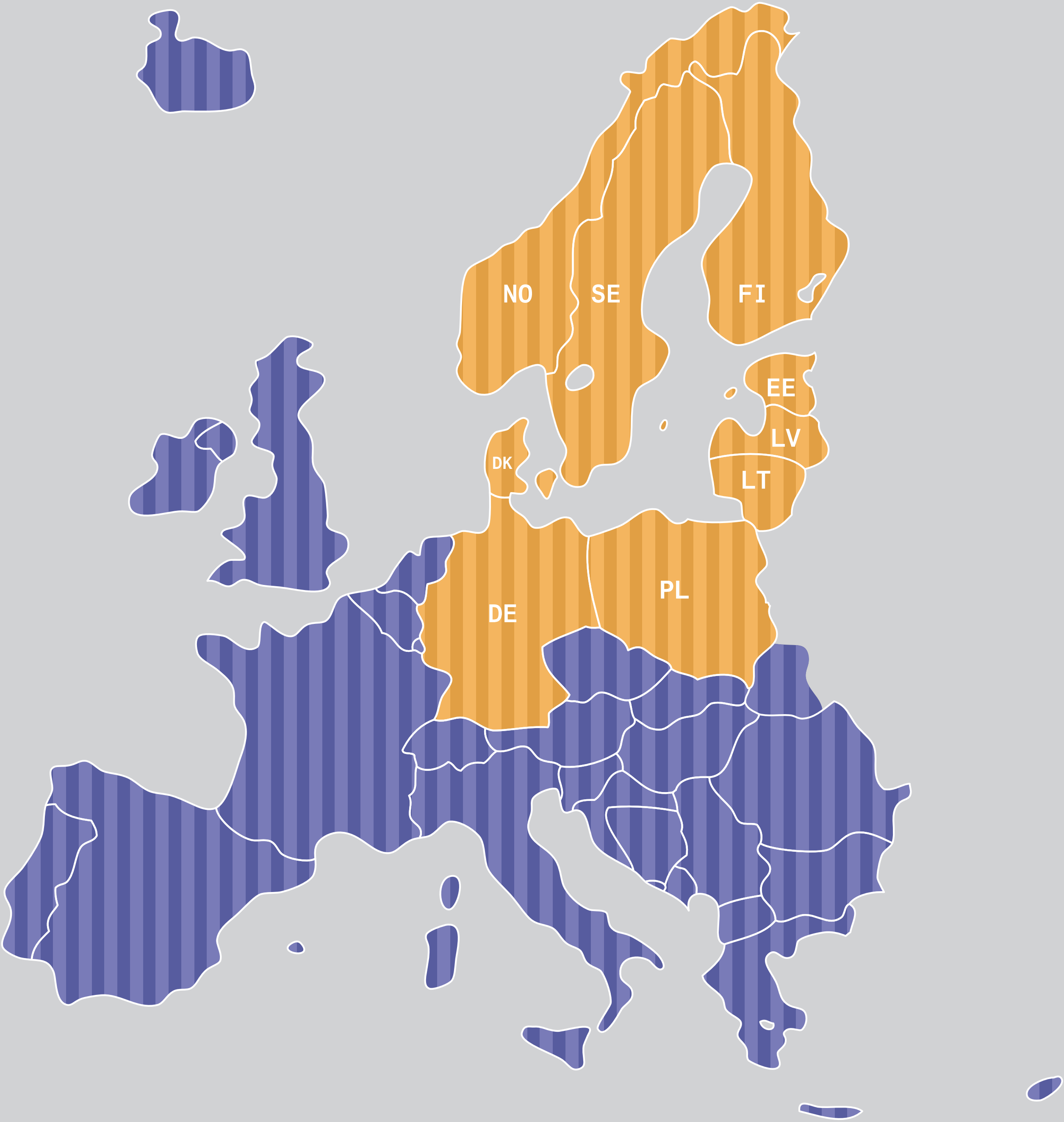


Figure D:
Showing eue in GWh for EU2020, gas restricted, without investment portfolio, no import and severe load

11 Summary/ Conclusion



This investment plan describes the development of the interconnected power system of the Baltic Sea region of ENTSO-E. The Baltic Sea region comprises nine countries in three different synchronously connected power systems, which are linked with HVDC connections. Currently the Nordic system is linked with Continental European and Baltic systems. However, no direct link yet exists between Baltic and Continental systems. The region is large and scarcely populated, which causes additional challenges in transmission of electricity. A dynamic phenomenon restricts the transmission capacity due to long distances between production and consumption areas.

This plan is founded on the first ever region-wide market and grid analysis to be performed in co-operation with the Baltic Sea regions transmission system operators. The market and grid analysis were based on a number of scenarios and sensitivities. The EU2020 scenario represents the national renewable action plan targets of the countries and scenario B represents the transmission system operators' outlook. In addition, a sensitivity analysis was conducted with the Nuclear Phase Out in Germany as the decisions were made when the analyses were already on-going. The effect of varying CO_2 price was also studied.

The main drivers for system evolution in the region are preservation of security of supply, increased market integration and connection of renewable and conventional generation, as well as EU 20-20-20 targets and the priorities in the EIP (Energy Infrastructure Priorities). The integration of Baltic States with the European electricity market and further integration of the Nordic countries will make the system more robust and accommodate the integration of large numbers of wind power and other renewable energy sources (RES) within and around the region. New connections between Nordic and Continental European countries are necessary and beneficial in order to handle the changes in generation portfolios in the Continental countries and the Baltic Sea region, as well as the Nuclear Phase Out plan of Germany. In addition to the existing and planned direct connections, the transmission system of the Baltic States, after connection to the central Europe network, will serve as an alternative route between Nordic and Continental Europe. Strengthening the already strong connection between the hydropower dominated northern part and thermal and wind power dominated South part of the region is beneficial. The large hydro reservoirs can be utilized in order to balance the changes in wind and solar power as well as the demand fluctuations.

Results of the analysis show that the investment portfolio presented in this plan gives flexibility and provides a sound and functional infrastructure on the track towards Europe's future vision of a competitive internal market and low-carbon energy. The planned investment portfolio is robust, resilient and beneficial. With the presented investment portfolio the Baltic Sea region within ENTSO-E will become more integrated with the rest of the European electricity market. Due to the increasing wind and solar power integration it is crucial to ensure sufficient regulating power, which could even increase the benefits of the planned investment portfolio through more functional markets.

For the studied scenarios the investment portfolio was found proper for the coming ten years, but if large unexpected changes occur which are out of line with preliminary assumptions and forecasts, more change of investments may be required.

A major challenge is that the grid development may not be in time if the RES targets are met as planned by 2020. Permit granting procedures are lengthy, and may cause commissioning delays. If energy and climate objectives are to be achieved, it is of upmost importance to smooth the authorization processes.

The large volume of investment in some countries represents a challenge in itself, as it requires increased implementation capacity both internally and in the suppliers' market. In addition these investments will require extensive disconnections in the existing grid during construction and commissioning (especially voltage upgrading of lines and substations), which could possibly jeopardize security of supply temporarily.

There are also uncertainties regarding the market development on the EU-Russian border, large uncertainty regarding the generator investments and power flows for import-export to the region.

11.1 Main Statistics

The total cost of investments in the Baltic Sea region according to the current plan is approximately 45 billion Euros. All the projects of the Baltic Sea region shown in the development plan are also considered as projects of Pan European relevance. In terms of planning time horizon, 47 % of the investments (21,1 billion Euros) are expected to be completed by the end of 2016 and are classified as mid-term projects whilst the remaining 53 % (23,9 billion Euros) of investments are classified as long-term projects and will be completed by 2022.

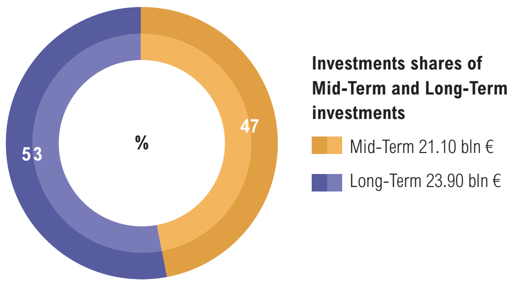


Figure 32:
Costs share of investments in Baltic Sea region

The total length of the power lines, defined in the regional investment plan is 27 950 km. The prevailing technology of new or upgraded lines and interconnections is high voltage AC technology, followed by high voltage DC lines. The exact shares of new and upgraded AC and DC lines are shown in the table below.

Sum of Length	AC	DC	Grand Total
New	16504	8078	24582
Upgrade	3368	0	3368
Grand Total	**19872**	**8078**	**27950**

Table 3:
The length of AC and DC power lines [km] to be constructed or upgraded

Table 4 represents more information about the shares in % from total length of mid-term and long-term projects by their constructional and technological features.

		DC	AC HV	AC MV
Upgrade		0,0 %	11,7 %	0,3 %
New	OHL	7,9 %	55,7 %	0,4 %
	US	20,7 %	1,4 %	0,1 %
	UG	0,4 %	1,3 %	0,2 %
Totals		**28,9 %**	**70,1 %**	**1,0 %**

Table 4:
Project length shares in % from total length (27,950 km) distributed by construction technology

Compared to the previous Baltic Sea region investment plan issued in 2010, approximately 21 % of the projects are new. 53 % of the projects are on schedule and 33 % of the projects are delayed due to rescheduling and reprioritization of the projects. The changes are presented in Figure 33 and the reasons are presented in Chapter 3.

The summary of the contributions of the projects are presented in the figure below. Most of the projects contribute heavily to RES integration and Social and Economic Welfare whilst at the same time demonstrating very high Flexibility and Transmission Resiliency. The figures describe the rating of the projects regarding different areas of contribution and indicators.

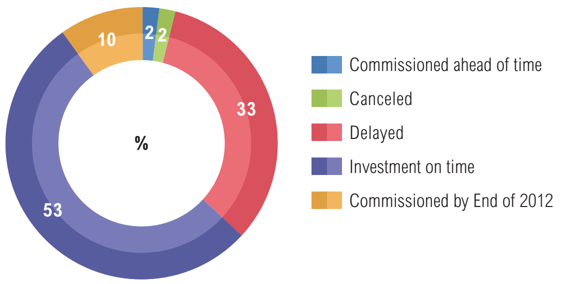


Figure 33:
Status of projects in 2012 compared to planned 2010

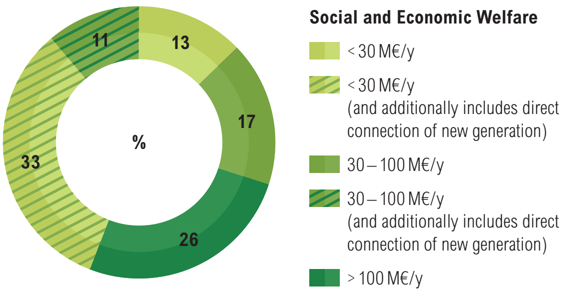


Figure 34:

Assessment of projects regarding Social and economic welfare.

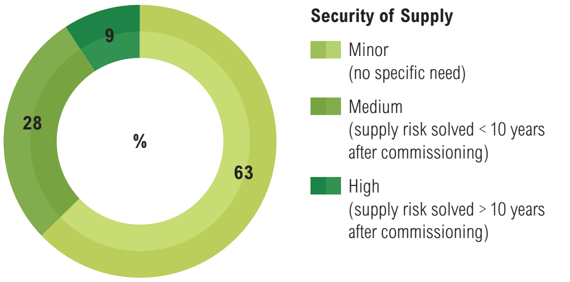


Figure 35:

Assessment of projects regarding Security of Supply.

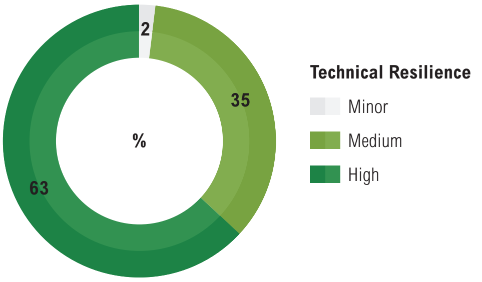


Figure 36:

Assessment of projects regarding Technical resilience.

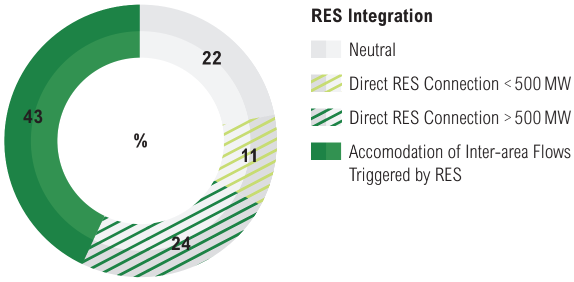


Figure 37:

Assessment of projects regarding RES integration.

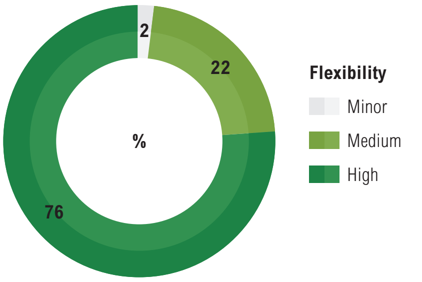


Figure 38:

Assessment of projects regarding Flexibility.

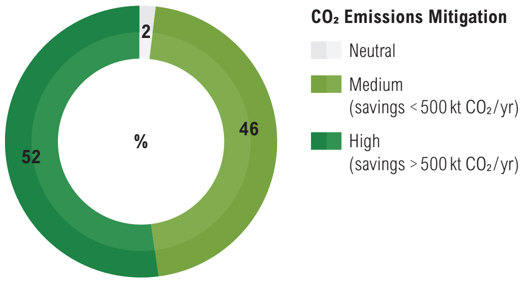


Figure 39:

Assessment of projects regarding CO_2 mitigation.

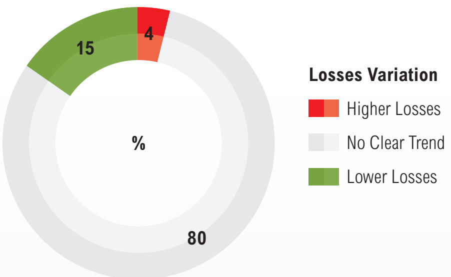


Figure 40:

Assessment of projects regarding impact to losses.

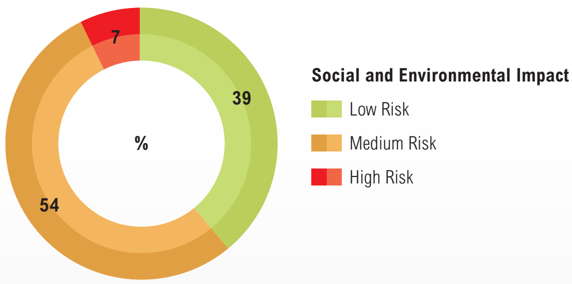
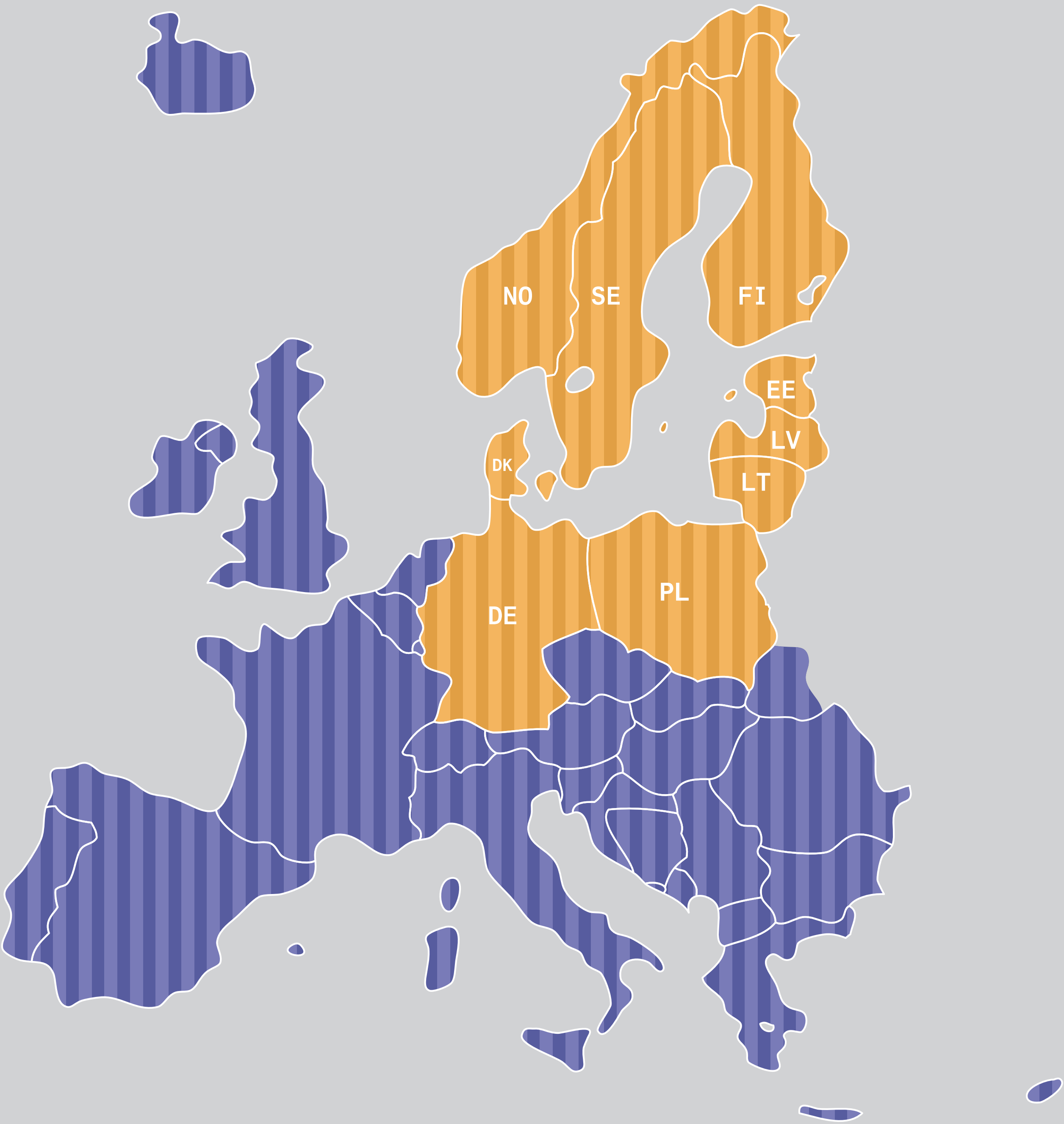


Figure 41 :

Assessment of projects regarding environmental impact.

12 Appendix 1: Table of Projects of Pan European Significance



The following table provides some brief synthetic information regarding the projects mentioned in Chapter 7 of the main document. It gives a synthetic description of each project with some factual information as well as the expected projects impacts and commissioning information.

Project & investment items

A project in the TYNDP package 2012 can cluster several investment items. Every row of the table in Appendix 1 to the TYNDP or Regional Investment Plan report corresponds to one investment item. The basic rule for the clustering is that an investment item belongs to a project if this item is required to develop the grid transfer capability increase associated to the project. A project can be limited to one investment item only. An investment item can contribute to two projects; in this case it is depicted only once in the table of projects, in one of the projects (and only referred to in the other project: no technical description, status, etc. are repeated).

Labeling

Projects of pan-European significance are numbered from 1 to 112. Investment items' labels have the following structure: project_index.investment_index. They are displayed on the projects maps in Chapter 7 and in the table of projects below.

Investment items which were present in the TYNDP 2010 have the same index in the TYNDP 2012 package. Indices of investments items which were not present in the TYNDP 2010 start with "Axxx".

Examples:

- 79.459 designates an investment item, already present in TYNDP 2010 (under the label 459) and contributing to project 79;
- 42.A86 designates a new investment item, not present in TYNDP 2010, contributing to project 42.

Projects develop grid transfer capability across the boundaries as displayed on the following map (see map of GTC increase). The numbers attached to every boundary on the following map correspond to the projects' indices relieving the constraints across that boundary:

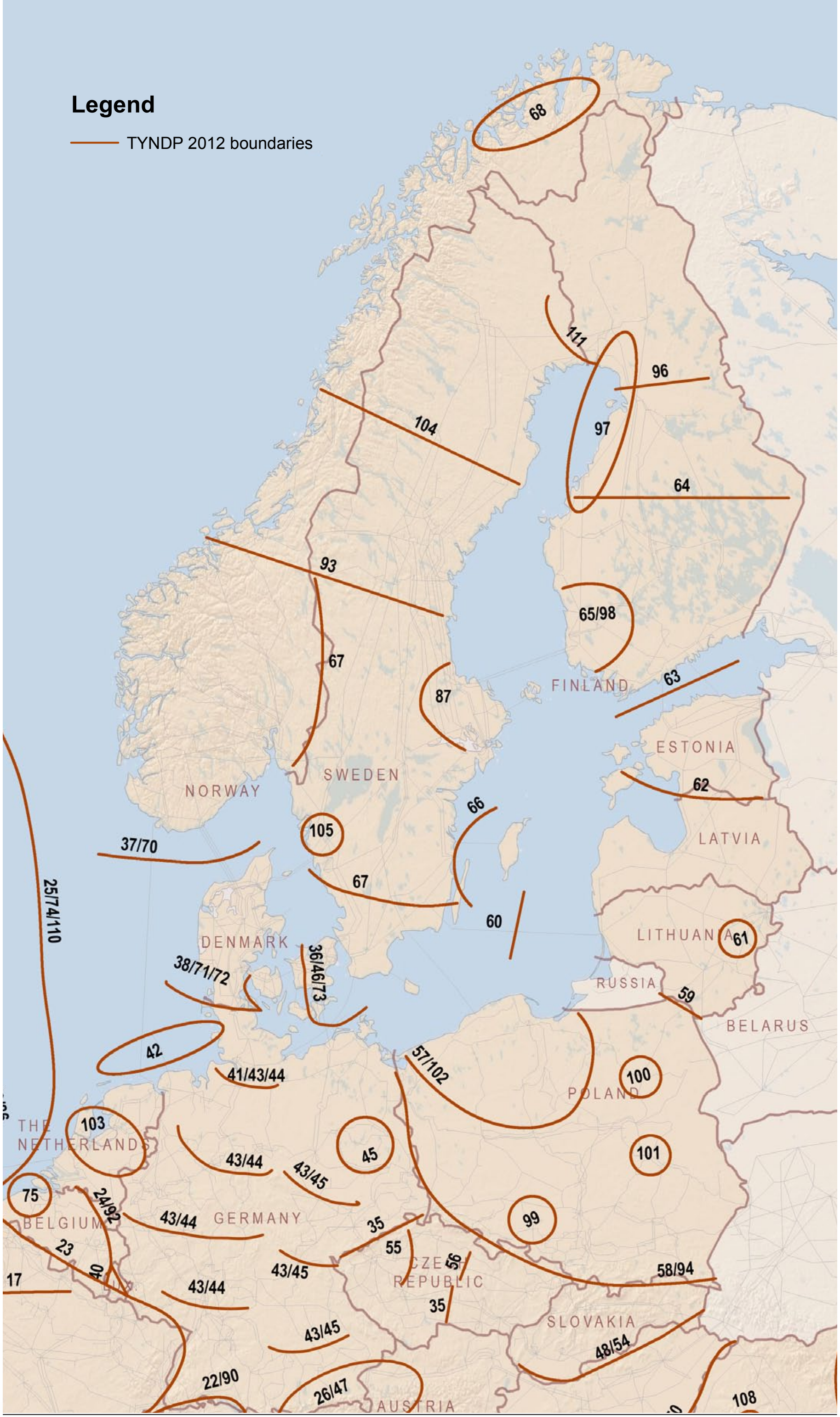


Figure 42:
Projects-Boundaries correspondence

For each project, the following information is displayed:

Column 1	**Project number**	
Column 2	**Investment number**	shows the label under which the investment item is referred to in the TYNDP 2012 package, especially the projects maps shown in Chapter 7.
Column 3+4	**Substation 1 & Substation 2**	show both ends of the investment item. The code of the country concerned is given between brackets.
Column 5	**Brief technical description**	gives a summary of the technical features (e.g. new line/upgrading of existing circuit, underground cable/OHL, double circuit/single circuit, voltage, route length …).
Column 6	**Grid transfer capability increase**	shows in MW the order of magnitude or a range for the additional grid transfer capability brought by the project.
Column 7	**Social and economic welfare**	can show 5 different displays distinguishing 1. the SEW gained via better accommodation of inter-area transits and 2. the SEW gained if the project supplies access to the grid for new generation: < 30 M€/yr < 30 M€/yr and additionally gives direct grid access for new generation ≥ 30 M€/yr and ≤ 100 M€/yr ≥ 30 M€/yr and ≤ 100 M€/yr and additionally gives direct grid access for new generation > 100 M€/yr
Column 8	**RES integration**	can show 4 different displays distinguishing the direct connection of RES (< or > 500 MW) and the accommodation of inter-area flows triggered by large amount of RES (> 500 MW): Neutral Direct access to the grid for less than 500 MW of new RES (medium, connection) Direct access to the grid for more than 500 MW of new RES (high, connection) Increasing the capacity between an area with excess of RES generation to share this with other areas[1] (in order to facilitate at least 500 MW of RES penetration)
Column 9	**Improved security of supply**	shows 3 levels of concern, and specifies the area at risk as the case may be: Minor (no specific need) Medium (supply risk solved for less than 10 years after commissioning) High (supply risk solved for more than 10 years after commissioning)
Column 10	**Losses variation**	Higher losses No clear trend Lower losses

[1] Direct access can be also achieved incidentally.

Column 11	**CO_2 emissions mitigation**	Neutral Medium (savings < 500 kt CO_2/yr) High (savings > 500 kt CO_2/yr)
Column 12	**Technical resilience**	Minor Medium High
Column 13	**Flexibility**	Minor Medium High
Column 14	**Social and environmental impact**	Low risk Medium risk High risk
Column 15	**Project costs**	> 1,000 M€ ≥ 300 and ≤ 1,000 M€ < 300 M€
Column 16	**Present status**	describes the progress of the project, with respect to the main typical phases of grid projects: – Under consideration, – planned, – design & permitting, – under construction and – commissioned.
Column 17	**Expected commissioning date**	gives the year by which the investment should be commissioned.[1)]
Column 18	**Evolution compared to the TYNDP 2010 situation**	explains the reasons for any adaptation of the technical consistency, evolution of the commissioning date and status of the investment.
Column 19	**Investment comment**	displays any additional information that could be of interest for every investment.
Column 20	**Project comment**	displays any additional information that could be of interest for every project.

More information on the methodology on how to calculate the indicators corresponding to the columns 6 – 15 can be found in appendix 3 of the TYNDP report.

1) This date highly depends of the duration of the permitting process, which TSOs do not master. The date given here is the most likely one, according to present status and to TSO's experience in conducting projects. The date proposed for reinforcements at a very early stage, the consistency of which is still uncertain, is likely to be further refined by the next TYNDP.

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
35	35.137	Vitkov (CZ)	Mechlenreuth (DE)	New 400 kV single circuit tie-line between new (CZ) substation and existing (DE) substation. Length: 70 km											under consideration	long term	Progresses as planned.		This project is required to enable power flows between west and east, enhance the transfer capability between CZ and DE and supports the future generation evacuation.
	35.138	tbd (CZ)	tbd (DE) – southeastern part of 50Hertz Transmission control area (Röhrsdorf)	Possible increase of interconnection capacity between CEPS and 50Hertz Transmission is under consideration: – Either a new 400 kV tie-line (OHL on new route) or – a reinforcement of the existing 400 kV tie-line Hradec (CEPS) – Röhrsdorf (50Hertz Transmission).											under consideration	long term	Progresses as planned.		
	35.306	Vitkov (CZ)		New 400/110 kV substation equipped with transformers 2 × 350 MVA.											planned	2017/2018	It is closely dependent on construction of line investment n°308.		
	35.307	Vernerov (CZ)		New 400/110 kV substation equipped with transformers 2 × 350 MVA.	500 MW										planned	2013/2016	Commissioning date has been divided into two phases: – 1st phase – temporary connection of wind plant 180 MW – 2nd phase – finalization of substation construction including connection to the distribution grid (consumption)		
	35.308	Vernerov (CZ)	Vitkov (CZ)	New 400 kV double circuit OHL, 1,385 MVA.											planned	long term	Permitting procedure complications are foreseen (line crosses protected area).		
	35.309	Vitkov (CZ)	Prestice (CZ)	New 400 kV double circuit OHL, 1,385 MVA.											under consideration	long term	Permitting procedure complications are foreseen (line crosses protected area).		
	35.311	Kocin (CZ)		Upgrade of the existing substation 400/110 kV; upgrade transformers 2 × 350 MVA.											design & permitting	long term	Schedule harmonization with market participants.		
	35.312	Mirovka (CZ)		Upgrade of the existing substation 400/110 kV with two transformers 2 × 350 MVA.											planned	long term	Schedule harmonization decided with market participants.		
	35.313	Kocin (CZ)	Mirovka (CZ)	Connection of 2 existing 400 kV substations with double circuit OHL having 120.5 km length and a capacity of 2 × 1,385 MVA.											planned	long term	Schedule harmonization decided with market participants.		
	35.314	Mirovka (CZ)	V413 (CZ)	New double circuit OHL with a capacity of 2 × 1,385 MVA and 26.5 km length.											planned	long term	Schedule harmonization decided with market participants.		
	35.315	Kocin (CZ)	Prestice (CZ)	Adding second circuit to existing single circuit line OHL upgrade in length of 115.8 km. Target capacity: 2 × 1,385 MVA											planned	long term	Schedule harmonization decided with market participants.		
	35.316	Mirovka (CZ)	Cebin (CZ)	Adding second circuit to existing single circuit line (88.5 km, 2 × 1,385 MVA).	500 MW										under consideration	long term	Schedule harmonization decided with market participants.		
	35.317	Hradec (CZ)	Reporyje (CZ)	Upgrade of existing 400 kV single circuit OHL with length of 116.9 km. Target capacity: 1,385 MVA											commissioned	commissioned	Commissioned.		
36	36.141	Ishøj / Bjæverskov (DK)	Bentwisch / Güstrow (DE)	The Kriegers Flak Combined Grid Solution is the new offshore multiterminal connection between Denmark and Germany used for both grid connection of offshore wind farms Kriegers Flak and interconnection. Technical features still have to be determined.	600 MW										planned	long term	Permission for Danish wind farm KF 3 is in pending. Connection to Sweden is withdrawn at present, but can come on a later stage.		The Kriegers Flak Combined Grid Solution is the new offshore multiterminal connection between Denmark and Germany used for both grid connection of offshore wind farms Kriegers Flak and interconnection.

Table of projects – Regional Group Baltic Sea

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
37	37.142	Tonstad (NO)	Wilster (DE)	Nord.Link / NorGer: a new HVDC connection between southern Norway and northern Germany. Estimated subsea cable length: 520 – 600 km Capacity: 1,000 MW	1,000 – 1,400 MW										design & permitting	2018/2021	Revised capacity and progress postponed, due to more demanding system operations and time needed to obtain necessary government permits for reinforcing the national grid.		The purpose is: Market integration with the continent and facilitating RES integration in southern and western Norway. Will also improve security of supply in southern Norway.
	37.408	Kristiansand, Feda (NO)		Reactive compensation due to HVDC links NorNed and Skagerak 4. Reactive power devices in 400 kV substations.											design & permitting	2012/2014	Feda is in the planning and permitting stage. Kristiansand is under construction(commissioned expected as planned 2012)		
	37.406	(southern part of Norway) (NO)		Voltage uprating of existing 300 kV line Sauda / Saurdal – Lyse – Tonstad – Feda – 1 & 2, Feda – Kristiansand; Sauda-Samnanger in long term. Voltage upgrading of existing single circuit 400 kV OHL Tonstad – Solhom – Arendal. Reactive power devices in 400 kV substations.											design & permitting	2016 (2013 – 2018)	Revised progress. Due to more demanding system operations and time needed to obtain necessary government permits for reinforcing the national grid. The investment now embed former TYNDP 2010's investments 407 and 409 and the technical description has been updated accordingly.		
38	38.425	Feda (NO)	tbd (NL)	NorNed 2: a second HVDC connection between Norway and The Netherlands via 570 km 450 kV DC subsea cable with 700 – 1,400 MW capacity.	700 MW										under consideration	long term	NorNed 2 is now not likely be realized during this planning period but is included in the TYNDP calculations and therefore on the project list. NorNed 2 is not included in the current Norwegian national grid development plan.		Additional interconnection between NO and NL under consideration.
39	39.428	Kassø (DK)	Tjele (DK)	Rebuilding of a 400 kV OHL of 173 km from a single circuit to a double circuit . This increases the transfer capacity with approx. 1,000 MW.	1,000 – 1,550 MW										design & permitting	2012/2014	Progresses as planned.		Step 3 in the Danish-German agreement to upgrade the Jutland – DE transfer capacity.
	39.144	Audorf (DE)	Kassö (DK)	Step 3 in the Danish-German agreement to upgrade the Jutland – DE transfer capacity. It consists of partially an upgrade of existing 400 kV line and partially a new 400 kV route in Denmark. In Germany new 400 kV line mainly in the trace of a existing 220 kV line. The total length of this OHL is 114 km.											under consideration	2017	Progresses as planned.		
40	40.446	Bascharage (LU)	Aubange (BE)	As a first step(2016) a PST could be placed in the existing 225 kV line between LU and BE. In a second stage, two solutions are currently investigated (4 TSOs – Elia, Amprion, CREOS, RTE are involved). Solutions 1 would be a new interconnection between CREOS grid in LU and ELIA grid in BE via a 16 km double circuit 225 kV underground cable with a capacity of 1,000 MVA. Solution 2 would be the interconnection between CREOS grid in LU and ELIA grid in BE via a new 380 kV double circuit. The current study will investigate the impact of this new interconnection on other boundaries (impact of loop flow) and on internal grids . The potential reinforcements of the other boundaries and the internal grids will also be taken into account in the evaluation.	380 – 900 MW			Luxemburg area							under consideration	2016 / 2020	The comissioning date and status changed as the study to determine the best investment is still ongoing.		Increase the transfer capability between LU,DE, BE and FR.
	40.A29	Bascharage (LU)	tbd (BE, DE and / or FR)	New interconnection with neighbor(s) either 220 kV or 400 kV											under consideration	2020	New investment in TYNDP.	An ongoing network study (4 TSOs involved) investigates the robustness of the planned 220 kV connection between LU and BE and the potentially need for an upgrading to a 400 kV interconnector in the south.	
	40.447	Heisdorf (LU)	Berchem (LU)	New 20 km double circuit mixed (underground cable + OHL) 225 kV project with 1,000 MVA capacity including substations for infeed in lower voltage levels.				Luxemburg area							design & permitting	2012 / 2017	Progresses as planned.		
	40.A30	Bascharage (LU)	Niederstedem (DE) or tbd (DE)	Upgrading and new construction of an interconnector to DE, in conjunction with the interconnector in the south of LU. Partial upgrading of existing 220 kV lines and partial new construction of lines. With power transformer station in LU.											under consideration	2020	New investment in TYNDP.		

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41	41.149	Dollern (DE)	Stade (DE)	New 400 kV double circuit OHL Dollern – Stade including new 400 kV switchgear in Stade. Length: 14 km	>3,000 MW										design & permitting	mid term	This investment depends on the commissioning of a conventional power plant in the area. The additional reason for delay is the long permitting procedure associated with this investment.		Evacuation of the new conventional generation in the 50Hertz and TenneT area.
	41.150	Conneforde (DE)	Maade (DE)	New 400 kV double circuit (underground cable + OHL) Conneforde – Maade including new 400 kV switchgear Maade. Length: 37 km											design & permitting	long term	Progresses as planned.		
	41.A74	north of Control Area 50Hertz Transmission (DE)		Construction of new substations / lines for integration of newly build power plants in northern part of 50Hertz Transmission control area.											planned	long term	New investment in TYNDP, because of additionnal need for generation evacuation. Some of the investments are to be commissioned by the mid term and the some by long term.	Support of conventional generation integration in northeastern Germany, maintaining of security of supply and support of market development.	
42	42.152	Dörpen / West (DE)		New substation for connection of offshore wind farms.	>8,000 MW										under construction	mid term	Progresses as planned.	Commercially sensitive information about this new wind farm connection cannot be displayed in the TYNDP report.	Integration of the offshore wind parks and the onshore grid reinforcements in the northern DE.
	42.159	Cluster BorWin1 (DE)	Diele (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205 km. Line capacity: 400 MW											under construction	mid term	The commission date of this wind farms connection should be in 2012. Energy transportation is however already enable.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.160	offshore wind park Nordergründe (DE)	Inhausen (DE)	New AC-cable connection with a total length of 35 km.											design & permitting	mid term	Progresses depend on development of the offshore wind farm.		
	42.161	offshore wind park GEOFreE (DE)	Göhl (DE)	New AC-cable connection with a total length of 32 km.											design & permitting	mid term	Progresses depend on development of the offshore wind farm.		
	42.163	Cluster HelWin1 (DE)	Büttel (DE)	New HVDC transmission systm consisting of offshore platform, cable and converters with a total length of 145 km. Line capacity: approx. 690 MW This Project includes also a new substation Büttel and connection of this new substation with the existing OHL Brünsbüttel – Wilster.											under construction	mid term	Progresses with delay.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.164	Cluster SylWin1 (DE)	Büttel (DE)	New line consisting of underground + subsea cable with a total length of 210 km. Line capacity: approx. 864 MW											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.165	Cluster DolWin1 (DE)	Dörpen / West (DE)	New line consisting of underground + subsea cable with a total length of 155 km. Line capacity: 800 MW											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.166	offshore wind park Riffgat (DE)	Emden / Borßum(DE)	New AC-cable connection with a total length of 80 km.											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.167	Cluster BorWin2 (DE)	Diele (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205 km. Line capacity: 800 MW											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.A82	Cluster DolWin2 (DE)	Dörpen / West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 160 km. Line capacity: 900 MW											under construction	mid term	New investment in TYNDP, for connection of new offshore wind farms.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.A83	Cluster DolWin3 (DE)	Dörpen / West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 160 km. Line capacity: 900 MW											design & permitting	mid term	New investment in TYNDP, for connection of new offshore wind farms.		

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	42.A84	Cluster BorWin3	Dörpen / West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 180 km. Line capacity: 900 MW	>8,000 MW										design & permitting	mid term	New investment in TYNDP for connection of new offshore wind farms.		Integration of the offshore wind parks and the onshore grid reinforcements in the northern DE.
	42.A85	Cluster HelWin2	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 145 km. Line capacity: 690 MW											under construction	mid term	New investment in TYNDP for connection of new offshore wind farms.	Due to nondisclosure aggreements it is not possible to give further information about this wind farm connection in TYNDP	
	42.A86	Cluster BorWin4 (DE)	Emden / Ost (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 185 km. Line capacity: 900 MW											under consideration	long term	New investment in TYNDP for connection of new offshore wind farms.		
	42.A87	Cluster SylWin2 (DE)	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 210 km. Line capacity: 800 MW											under consideration	long term	New investment in TYNDP for connection of new offshore wind farms.		
	42.211	further connections of more offshore wind farms (DE)		Further connections in the clusters BorWin, DolWin, SylWin and HelWin.											under consideration	long term	Progresses depend on development of the offshore wind farm.		
43	43.A81	Osterath (DE)	Philippsburg (DE)	New HVDC lines from Osterath to Philippsburg to integrate new wind generation especially from North / Baltic Sea towards Central-South Germany for consumption and storage.	10,000 MW			Bavaria and Baden-Württemberg area							under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		Combined DC and AC new infrastructure to accommodate the new RES generation, the associated flows from north to south and also to secure the security of supply in South Germany.
	43.A152	Emden (DE)	Osterath (DE)	New HVDC lines from Endem to Osterath to integrate new wind generation especially from North / Baltic Sea towards Central Germany for consumption and storage.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		
	43.A153	Wehrendorf (DE)	Urberach (DE)	New lines in HVDC technology from the region of Lower Saxony to North Baden-Württemberg to integrate new wind generation especially from North Sea towards Central-South Europe for consumption and storage. The investment is part of the transmission corridor Cloppenburg – North Baden-Württemberg.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		
	43.A154	Cloppenburg (DE)	Westerkappeln (DE)	New 400 kV double circuit OHL Cloppenburg – Westerkappel (75 km). The investment is part of the transmission corridor Cloppenburg – North Baden-Württemberg.											under consideration	long term	New investment in TYNDP due to increase of RES and changes in conventional power plants in Germany and increase transits.		
	43.A88	Brunsbüttel (DE), Wilster (DE), Kaltenkirchen (DE)	Großgartach (DE), Goldshöfe (DE), Grafenrheinfeld (DE)	New DC lines to integrate new wind generation from northern Germany towards southern Germany and southern Europe for consumption and storage.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		
	43.A75	Lauchstadt (DE)	Meitingen (DE)	New DC lines to integrate new wind generation from Baltic Sea towards Central / South Europe for consumption and storage.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.	New Investment due to increase of RES and changes in conventionel power plants in Germany and increase transits.	
	43.A89	area of northern Lower Saxony (DE)		New lines for integration of on- and offshore wind generation incl. 380 kV lines Halbemond – Emden, Emden – Conneforde and Conneforde – Cloppenburg. Total length: 160 km											under consideration	long term	New investment in TYNDP due to new wind generation projects.		
	43.A90	area of Schleswig-Holstein (DE)		About 300 km new 380 kV lines and around 24 new transformers for integration of onshore wind in Schleswig-Holstein, incl. lines – Brunsbüttel – Barlt – Heide – Husum – Niebüll – border of Denmark, – Audorf – Kiel – Göhl – Siems – Lübeck – Kaltenkirchen and – Kaltenkirchen – Itzehoe – Brunsbüttel.											under consideration	long term	New investment in TYNDP due to new wind generation projects.	The German West-coast line (Brunsbuettel – Niebuel) is planned to be connected to the Danish grid in the 400 kV substation Endrup. The distance from the German / Danish border is approx. 80 km. Bilateral technical / economical investigations are ongoing. Reinforcements in the Danish 400 kV grid are foreseen in order to facilitate the increased power exchange capacity on the Danish-German border.	

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44	44.147	Dollern (DE)	Hamburg / Nord (DE)	New 400 kV double circuit OHL Dollern – Hamburg / Nord including one new 400/230 kV transformer in substation Hamburg / Nord and new 400 kV switchgear Kummerfeld. Length: 43 km	5,000 MW			Bavaria and Baden-Württemberg area							design & permitting	mid term	Delays due to authorization process.		This project helps accommodating the increasing flows, coming mainly form RES, from northwestern Germany to southwestern Germany and Switzerland.
	44.148	Audorf (DE)	Hamburg / Nord (DE)	New 400 kV double circuit OHL Audorf – Hamburg / Nord including two new 400/230 kV transformers in substation Audorf. Length: 65 km											design & permitting	mid term	This investment was scheduled for 2015. Presently it is foreseen a delay of around 1 year due to permitting process.		
	44.151	Wehrendorf (DE)	Ganderkesee (DE)	New line (length: approx. 95 km), extension of existing and erection of substations, erection of 380/110 kV transformers.											design & permitting	mid term	Delays due to authorization process.		
	44.156	Niederrhein (DE)	Dörpen / West (DE)	New 400 kV double circuit OHL Dörpen – Niederrhein including extension of existing substations. Length: 167 km											design & permitting	mid term	Delays due to authorization process.		
	44.157	Wahle (DE)	Mecklar (DE)	New 400 kV double circuit OHL Wahle – Mecklar including two new substations. Length: 210 km											design & permitting	mid term	Delays due to authorization process.		
	44.90.170	Großgartach (DE)	Hüffenhardt (DE)	New 380 kV OHL. Length: 23 km Included with the project: – 1 new 380 kV substation – 2 transformers											under construction	2012	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.171	Hüffenhardt (DE)	Neurott (DE)	Upgrade of the line from 220 kV to 380 kV. Length: 11 km Included with the project: 1 new 380 kV substation.											planned	2020	Progresses as planned.		
	44.90.172	Mühlhausen (DE)	Großgartach (DE)	Upgrading line from 220 kV to 380 kV. Length: 45 km											design & permitting	2014	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.90.173	Hoheneck (DE)	Endersbach (DE)	Upgrading line from 220 kV to 380 kV. Length: 20 km											design & permitting	2014	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.174	Bruchsal Kändelweg (DE)	Ubstadt (DE)	A new 380 kV OHL. Length: 6 km											design & permitting	2014	Postponed from one year due to permitting procedures.		
	44.90.176	Daxlanden (DE)	Eichstetten (DE)	Upgrade of transmission capacity of existing 380 kV line. Length: 120 km											under consideration	2020	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.178	Baden-Württemberg, Süden & Nordosten (DE)"		Installation of 2 × 250 MVAr 380 kV capacitance banks.											under construction	2014	One more bank in addition. Two have already been installed. Projects realized earlier because the need for reactive power compensation became urgent.		
	44.179	Rommerskirchen (DE)	Weißenthurm (DE)	New line, extension of existing and erection of substations, erection of 380/110 kV transformers. Total line length: 100 km.											under construction, design & permitting	mid term	Some parts are commissioned but the main elements of the investment are still in design and permitting due to delays in permitting process.		
	44.181	Dauersberg (DE)	Limburg (DE)	New 380 kV double circuit OHL, extension of existing of substations. Total line length: 20 km											under construction, design & permitting	mid term	Some parts are commissioned but the main elements of the investment are still in design and permitting due to delays in permitting process.		
	44.182	Kriftel (DE)	Obererlenbach (DE)	New 400 kV double circuit OHL Kriftel – Obererlebenbach in existing OHL corridor. Length: 11 km											planned	mid term	Some parts are commissioned but the main elements of the investment are still in design and permitting due to delays in permitting process.		
	44.A80	Area of West Germany (DE)		Installation of several 300 MVAr 380 kV capacitance banks, extension of existing substations.											under consideration	long term	New investment in TYNDP, because of additional needs for RES integration (combined with SoS).		
	44.183	Wehrendorf (DE)		Installation of 300 MVAr 380 kV capacitance banks, extension of existing substations.											design & permitting	mid term	Delays due to authorization process.		
	44.184	Bürstadt (DE)		Installation of 2 × 300 MVAr 380 kV capacitance banks, extension of existing substations.											design & permitting	mid term	Delays due to authorization process.		
	44.185	area of Muensterland and Westfalia (DE)		New lines and installation of additional circuits, extension of existing and erection of several 380/110 kV substations. Total length: approx. 110 km											design & permitting	long term	Delays due to authorization process.		
	44.186	Gütersloh (DE)	Bechterdissen (DE)	New lines and installation of additional circuits, extension of existing and erection of 380/110 kV substation. Total line length: 27 km											under construction	mid term	Delays due to authorization process.		
	44.187	area of West-Rhineland (DE)		New lines and installation of additional circuits, extension of existing and erection of several 380/110 kV substations.											under construction	2013	Progresses as planned.		

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	44.188	Kruckel (DE)	Dauersberg (DE)	New lines, extension of existing and erection of several 380/110 kV substations. Total line length: 130 km	5,000 MW			Bavaria and Baden-Württemberg area							planned	long term	Progresses as planned.		This project helps accomodating the increasing flows coming mainly form RES in NW DE to SW DE and CH.
	44.A78	Pkt. Metternich (DE)	Niederstedem (DE)	Construction of new 380 kV double circuit OHLs, decommissioning of existing old 220 kV double circuit OHLs, extension of existing and erection of several 380/110 kV substations. Length: 108 km											planned	long term	New investment in TYNDP.	RES integration / Market integration especially east-west-direction.	
	44.A77	area of South Wuerttemberg (DE)		Construction of new 380 kV double circuit OHLs, decommissioning of existing double circuit OHLs, extension of existing 380 kV-substations. Length: approx. 60 km											planned	long term	New investment in TYNDP.	RES integration combined with pump storage in the alp region (market) / increasing of the NTC DE – CH / AT.	
	44.190	Saar-Pfalz-Region (DE)		New lines, extension of existing and erection of several 380/110 kV substations. Upgrade of an existing line from 220 to 380 kV											planned	long term	Delays due to authorization process.	Security of Supply (Neub. Frltg Fraulaut – Saarwellingen) combined with RES integration.	
	44.A155	Conneforde (DE)	Unterweser (DE)	Upgrade of 230 kV circuit Unterweser – Conneforde to 400 kV. Line length: 32 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.A156	Dollern (DE)	Elsfleht / West (DE)	New 400 kV line in existing OHL corridor Dollern – Elsfleht / West. Length: 100 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.A157	Dollern (DE)	Landesbergen (DE)	New 400 kV line in existing OHL corridor Dollern – Sottrum – Wechold – Landesbergen (130 km).											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.A158	Hamm / Uentrop (DE)	Kruckel (DE)	Extension of existing line to a 400 kV single circuit OHL Hamm / Uentrop – Kruckel. Length: 60 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.A159	Pkt. Blatzheim (DE)	Oberzier (DE)	New 400 kV double circuit OHL Pkt. Blatzheim – Oberzier including extension of existing substations. Length: 16 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.A160	Urberach (DE)	Daxlanden (DE)	New line and extension of existing line to 400 kV double circuit OHL Urberach – Pfungstadt – Weinheim – Daxlanden including extension of existing substations. Length: 219 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.A161	Bürstadt (DE)	Daxlanden (DE)	New line and extension of existing line to 400 kV double circuit OHL Bürstadt – Lambshein – Daxlanden including extension of existing substations. Length: 134 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.A162	Großgartach (DE)	Endersbach (DE)	Extension of existing 400 kV line Großgartach – Endersbach. Lenght: 32 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	44.175	Birkenfeld (DE)	Ötisheim (DE)	A new 380 kV OHL. Length: 11 km											planned	2020	New investment in TYNDP.		
	44.189	Niederrhein (DE)	Utfort (DE)	New 380 kV double circuit OHL Niederrhein – Utfort (24 km).											under consideration	long term	New investment in TYNDP.		
45	45.90.177				5,000 MW			Bavaria and Baden-Württemberg area										The investment contributes both to project 45 and project 90. For the technical description see project 90.	This project helps accomodating the increasing flows coming mainly form RES in NE DE to South DE and to the Alps.
	45.191	Neuenhagen (DE)	Vierraden (DE)	Project of new 380 kV double circuit OHL Neuenhagen – Vierraden – Bertikow with 125 km length as prerequisite for the planned upgrading of the existing 220 kV double circuit interconnection Krajnik (PL) – Vierraden (DE / 50Hertz Transmission).											design & permitting	2013 / 2015	Project in permitting phase, strong local resistance.		

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	45.193	Halle / Saale (DE)	Schweinfurt (DE)	New 380 kV double circuit OHL between the substations Vieselbach – Altenfeld – Redwitz with 215 km length combined with upgrade between Redwitz and Grafenrheinfeld (see project 153). The Section Lauchstedt – Vieselbach has already been commissioned. Support of RES integration in Germany, annual redispatching cost reduction, maintaining of security of supply and support of the market development. The line crosses the former border between East and West Germany and is right downstream in the main load flow direction. The project will help to avoid loop flows through neighboring grids.	5,000 MW			Bavaria and Baden-Württemberg area							design & permitting	mid term	Project partly completed, strong local public resistance. Delay due to permitting process.		This project helps accomodating the increasing flows coming mainly form RES in NE DE to South DE and to the Alps.
	45.197	Neuenhagen (DE)	Wustermark (DE)	Construction of new 380 kV double circuit OHL between the substations Wustermark – Neuenhagen with 75 km length. Support of RES and conventional generation integration, maintaining of security of supply and support of market development.											under construction	mid term	Project partly under construction and partly in permitting phase. Expected date of commissioning was adjusted due to long permitting process and strong local public resistance.		
	45.199	Western Pomerania (DE)	Uckermark North (DE)	Construction of new 380 kV double circuit OHLs in northeastern part of 50Hertz Transmission control area and decommissioning of existing old 220 kV double circuit OHLs, incl. 380 kV line Bertikow – Pasewalk (30 km). Length: 135 km Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.											planned	2015	Progresses as planned.		
	45.200	Lubmin (DE)	Erfurt area (DE)	380 kV grid enhancement and structural change area Lubmin / Stralsund and area Magdeburg / Wolmirstedt, incl. 380 kV line Güstrow – Wolmirsted (195 km).											planned	long term	Progresses as planned.		
	45.202	area upper Lausitz (DE)	area Gera(DE)	Upgrading existing double circuit 380 kV OHL Bärwalde – Schmölln in the southeastern part of the control area of 50Hertz Transmission. Length: approx. 50 km Support of RES and conventional generation integration in northeastern Germany, maintaining of security of supply and support of market development.											design & permitting	2017	Progresses as planned.		
	45.204	Calbe (DE)		Construction of new 380 kV double circuit OHL between substation Calbe for double connection / loop into an existing line.											planned	mid term / long term	The evolution of this investment depends on the development of the power plant in the area. The date mentioned in the TYNDP 2010 was a typing mistake.		
	45.205	Fördertsedt	area Magdeburg (DE)	Construction of new 380 kV double circuit OHL from the substation Förderstedt with 20 km length for double connection / loop in for Förderstedt. Reinforcement of existing switchgear. Support of RES and conventional generation integration, maintaining of security of supply and support of market development.											planned	2015 / 2020	Progresses as planned.		
	45.206	area Leipzig(DE)	area Chemnitz (DE)	Construction of new double circuit 380 kV OHL in existing corridor Röhrsdorf – Remptendorf (103 km).											under consideration	2020	Progresses as planned.		
	45.207	substations in southwestern part of 50Hertz Transmission control area (DE)		Construction of new 380 kV substation in southern Magdeburg area and restructuring of existing 220 kV equipment. Total length: approx. 50 km											planned	long term	Some of the investments are to be commissioned by the mid term and the some by long term.		
	45.208	lines and substations in southwestern part of 50Hertz Transmission control area (DE)		Construction of new 380 kV double circuit OHL in existing corridor Pulgar – Vieselbach (103 km). Support of RES and conventional generation integration, maintaining of security of supply and support of market development.											planned	2015 / 2020	Progresses as planned.		

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	45.209	substations in 50Hertz Transmission control area (DE)		Extension of existing and erection of new 380 kV substations and several 380 / 110 kV substations, incl. reactive power compensation devices.	5,000 MW			Bavaria and Baden-Württemberg area							design & permitting	mid term	This investment includes several substations in the 50Hertz Transmission control area. Present status varies form design & permitting, planning to under consideration and the date of commissioning varies from short / mid to long term.		This project helps accomodating the increasing flows coming mainly form RES in NE DE to South DE and to the Alps.
	45.A163	Wolmirstedt (DE)	Wahle (DE)	New double circuit OHL 380 kV. Line length: 111 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	45.A164	Vieselbach (DE)	Mecklar (DE)	New double circuit OHL 400 kV in existing OHL corridor (129 km).											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	45.A165	Mecklar (DE)	Grafenrheinfeld (DE)	New double circuit OHL 400 kV (130 km).											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	45.A166	Altenfeld (DE)	Grafenrheinfeld (DE)	New double circuit OHL 400 kV (130 km).											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	45.A169	Grafenrheinfeld (DE)	Grossgartach (DE)	Additional 380 kV circuit on an existing line. Length: 160 km											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	45.A167	Redwitz (DE)	Schwandorf (DE)	New double circuit OHL 400 kV in existing OHL corridor Redwitz – Mechlenreuth – Etzenricht – Schwandorf (185 km).											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	45.A168	Raitersaich (DE)	Isar (DE)	New 400 kV line in existing OHL corridor Raitersaich – Ludersheim – Sittling – Isar (160 km).											under consideration	long term	New investment due to increase of RES, changes in conventional power plants in Germany and increase transits.		
	45.153	Redwitz (DE)	Grafenrheinfeld (DE)	Upgrade of 230 kV connection Redwitz – Grafenrheinfeld to 400 kV, including new 400 kV switchgear Eltmann. Line length: 97 km											design & permitting	mid term	Investment delay due to delay in the imple-mentation or the line Halle – Schweinfurt (investment 45.193).		
	45.154	Redwitz (DE)		New 500 MVAr SVC in substation Redwitz.											planned	mid term	Progresses as planned.		
	45.155	Raitersaich (DE)		New 500 MVAr SVC in substation Raitersaich.											planned	mid term	Progresses as planned.		
	45.47.158																	The investment contributes both to project 45 and project 47. For the technical description see project 47.	
46	46.194	wind farm cluster Baltic Sea East (DE)	Lüdershagen / Lubmin (DE)*	Offshore wind farm connection project (by AC-cables on transmission voltage level or by clustering with DC connections) has to be constructed and afterwards also to be operated by the TSO (in this project: 50Hertz Transmission) according to German law.	>2,000 MW										design & permitting	2012-2020	This investment includes several connections of offshore wind farms in the eastern part of the Baltic Sea. The present expected date of commissioning varies from 2012 to 2020.		The integration of offshore wind generation in the Baltic Sea.
	46.195	wind farm cluster Baltic Sea West (DE)	Bentwisch (DE)	Offshore wind farm connection project (by AC-cables on transmission voltage level or by clustering with DC connections) has to be constructed and afterwards also to be operated by the TSO (in this project: 50Hertz Transmission) according to German law.											design & permitting	2013-2020	This investment includes several connections of offshore wind farms in the western part of the Baltic Sea. The present expected date of commissioning varies from 2013 to 2020.		

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Project identification					**Project assessment**														
47	47.A76	Vöhringen / Leupolz (DE)	Westtirol (AT)	Upgrade of an existing OHL to 380 kV, extension of existing and erection of new 380 kV substations including 380 / 110 kV transformers. Transmissions routs Vöhringen – Westtirol and Pkt. Woringen – Memmingen. Length: 114 km. This project will increase the current power exchange capacity between the DE, AT and CH.	>2,000 MW										planned	long term	New investment in TYNDP.		The reinforcement of the interconnection between Austria and Germany. Also the support the interaction between the RES in northern Europe(mainly DE) with the pump storage in the Austrian Alps. The project scheduling is not related only to the network needs, but even to the feasibility and to the authorization process (the possibility to anticipate specific projects could be evaluated in the future considering the three above mentioned elements).
	47.158	Irsching (DE)	Ottenhofen (DE)	Upgrade of 230 kV connection Irsching – Ottenhofen to 400 kV, including new 400 kV switchgear Zolling. Length: 76 km											planned	mid term	Progresses as planned.	The investment contributes also to project 45.	
	47.212	Isar / Ottenhofen (DE)	St. Peter (AT)	New 400 kV double circuit OHL Isar – St. Peter including new 400 kV switchgears Altheim, Simbach and St. Peter, and one new 400/230 kV transformer in substation Altheim and fourth circuit on line Isar – Ottenhofen. Line length: 90 km											design & permitting	2017	Progresses as planned.		
	47.26.216	St. Peter (AT)	Tauern (AT)	Completion of the 380 kV line St. Peter – Tauern. This contains an upgrade of the existing 380 kV line St. Peter – Salzburg from 220 kV operation to 380 kV operation and the erection of a new internal double circuit 380 kV line connecting the substations Salzburg and Tauern (replacement of existing 220 kV lines on optimized routes). Moreover the erection of the new substations Wagenham and Pongau and the integration of the substations Salzburg and Kaprun is planned. Line length: 130 km											design & permitting	2017 / 2019	Preparation for the permitting procedure is ongoing. APG is making efforts to set the 380 kV Salzburg-line 2017 into service. Depending on possible delays during the permitting procedure the commissioning is expected between 2017 and 2019	The investment contributes also to project 26.	
	47.26.218																	The investment contributes both to project 26 and project 47. For the technical description see project 47.	
	47.219	Westtirol (AT)	Zell-Ziller (AT)	Upgrade of the existing 220 kV line Westtirol – Zell-Ziller and erection of additional 220/380 kV transformers. Line length: 105 km											partly under construction	2013 – 2020	Project consists of several measures and is on schedule.		
	47.26.220																	The investment contributes both to project 26 and project 47. For the technical description see project 47.	
	47.221	St. Peter (AT)	Ernsthofen (AT)	Upgrade from 220 kV operation to 380 kV and erection of a 380 kV substation in Ernsthofen and St. Peter.											under construction	2013	The project is on schedule. Permissions are obtained. Commissioning is expected for 2013		

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57	57.320	Dargoleza (PL)	—	A new AC 400/110 kV (450 MVA) substation between existing substations Słupsk and Żarnowiec in northern Poland. New substation Dargoleza is connected by splitting and extending of existing 400 kV line Słupsk – Dargoleza.	3,000 MW										planned	2020	The time horizon for commissioning of this investment has been changed due to change in wind farms connection schedule in the region.	The new substation Dargoleza is required for the connection new wind generation in northern Poland.	Wind The infrastructure in this project assures reliable connection of 3,000 MW of wind generation in northern Poland. It also allows the evacuation of power in the southern direction.
	57.328	Piła Krzewina (PL)	Bydgoszcz Zachód (PL)	New 84 km 400 kV double circuit 2 × 1,870 MVA OHL interconnection line Piła Krzewina – Bydgoszcz Zachód temporarily on 220 kV.											design & permitting	2016	The time schedule of the project was shifted to meet the schedule of the RES (wind) generation connection. This one year delay in the plans appeared after updating of the NDP. The change in the NDP introduced a double circuit.		
	57.329	Żydowo (PL)	Słupsk (PL)	A new AC 400/110 kV substation next to existing 220/110 kV substation in northern Poland with transformation 400/110 kV 450 MVA. New substation Żydowo is connected by new 70 km 400 kV 2 × 1,870 MVA OHL double circuit lines Żydowo – Słupsk and Żydowo – Gdańsk Przyjaźń. Dismantling of existing 220/110 kV transformers + upgrade of substation SŁupsk.											planned	2020	The date of commissioning evolved due to regulatory, social and environmental issues. The investment also foresee upgrade works in substation Słupsk.		
	57.330	Żydowo (PL)	Gdańsk Przyjaźń (PL)	A new AC substation in Gdańsk Agglomeration Area. New substation Gdańsk Przyjaźń is connected by splitting and extending of one circuit of existing line Żarnowiec – Gdańsk Błonia and new 150 km 400 kV 2 × 1,870 MVA double circuit OHL line Żydowo – Gdańsk Przyjaźń with one circuit from Żydowo to Gdańsk temporarily on 220 kV after dismantling of 220 kV line Żydowo – Gdańsk.											planned	2020	The date of commissioning evolved due to regulatory, social and environmental issues.		
	57.352	Dunowo (PL)	Plewiska (PL)	Construction of a new double circuit 400 kV OHL Dunowo – Żydowo (2 × 1,870 MVA) partly using existing 220 kV line. Construction of a new 400 kV OHL Plewiska – Piła Krzewina – Żydowo (2x1870 MVA), single circuit temporarily working as a 220 kV. A new AC 400 kV switchgear in existing substation Pila Krzewina. Upgrade of substation Dunowo.											design & permitting	2020	Progressed as planned. The investment also foresee upgrade works in substation Dunowo.		
58	58.353	Krajnik (PL)	Baczyna (PL)	Construction of a new double circuit 400 kV OHL Krajnik – Baczyna (2 × 1,870 MVA, 91 km), single circuit temporarily working at 220 kV on Krajnik – Gorzów part. New substation 400 kV Baczyna will be connected by splitting and extending existing line Krajnik – Plewiska. Upgrading of limitations line Krajnik – Plewiska.	>1,000 MW										planned	2020	Progresses as planned.		Bridge Third interconnection between Poland and Germany.
	58.355	Mikułowa (PL)	Świebodzice (PL)	Double circuit line 220 kV Mikułowa – Świebodzice will be upgraded to 400 kV – single circuit temporarily working at 220 kV.											planned	2020	Progresses as planned.		
	58.A67	Gubin (PL)		New 400 kV substation planned near the PL – DE border. The substation will be connected to planned line Eisenhüttenstadt (DE) – Plewiska (PL) creating new lines Eisenhüttenstadt (DE) – Gubin (PL) and Gubin (PL) – Plewiska (PL).											planned	2020	New investment in TYNDP.	This new substation on the third DE – PL connection is necessary for future generation connection while ensuring interconnection capability.	
	58.140	Eisenhüttenstadt (DE)	Plewiska (PL)	New 400 kV double circuit OHL Eisenhüttenstadt (DE) – Plewiska (PL) including the construction of new substation Plewiska Bis (PL).											planned	2020	Progresses as planned.		

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59	59.368	Ełk (PL)	PL-LT border (LT)	Construction of a new 400 kV OHL Ełk to PL – LT border. (2 × 1,870 MVA, 108 km).	1,000 MW			South LT and NE/central PL							design & permitting	2015	Progresses as planned.		"LitPol Link" project. Interconnection of Lithuanian power system with Polish power system via Back to Back station. This project allows integration of Baltics to the internal European power market.
	59.369	Siedlce Ujrzanów (PL)	Miłosna (PL)	Construction of a new 400 kV OHL Siedlce Ujrzanów – Miłosna (1,870 MVA, 84 km). A new AC 400 kV switchgear in existing substation Siedlce Ujrzanow with transformation 400/110 kV 400 MVA.											design & permitting	2015	Progresses as planned.		
	59.370	Ełk (PL)	Łomża (PL)	Construction of a new 400 kV double circuit OHL Ełk – Łomża (2 × 1,870 MVA, 95 km). A new AC 400 kV switchgear in existing substation Ełk. A new 400 kV AC substation Łomża											design & permitting	2015	Łomża has been elected as end substation for the project and the technical description is adapted accordingly. Progresses as planned otherwise.		
	59.371	Ostrołęka (PL)	Narew (PL)	Construction of a new 400 kV OHL Ostrołęka – Łomża – Narew (1,870 MVA, 120 km). A new AC 400 kV switchgear in existing substation Ostroleka (in two stages) with transformation 400/220 kV 500 MVA and with transformation 400/110 kV 400 MVA. Extension of 400 switchgear in substation Narew.											design & permitting	2015	Progressed as planned. The investment also foresee extension works in substation Narew.		
	59.372	Oltarzew (PL)		A new AC substation with two transformers 400/220 kV 2 × 500 MVA and one 400/110 kV 330 MVA will be connected by splitting 400 kV line Rogowiec – Miłosna and Miłosna – Płock and 220 kV line Mory – Sochaczew and Mory – Janów.											under construction	2015	Progresses as planned.		
	59.373	Ostrołęka (PL)	Stanisławów (PL)	Single circuit line 220 kV Ostrołęka – Miłosna will be partly upgraded to double circuit line 400 kV (2 × 1,870 MVA, 106 km) with development of Ostrołęka 400 kV substation. New substation 400 kV Stanisławów will be connected by splitting and extending existing line Miłosna – Narew and Miłosna – Siedlce.											design & permitting	2020	Progresses as planned.		
	59.374	Kozienice (PL)	Siedlce Ujrzanów (PL)	Existing single circuit line will be upgraded to 400 kV line in the same direction (1,870 MVA, 90 km). Upgrade of Kozienice substation to connect the new line.											design & permitting	2020	Progressed as planned. The investment also foresee extension works in substation Kozienice.		
	59.375	Płock (PL)	Olsztyn Mątki (PL)	New single circuit line 400 kV (1,870 MVA, 180 km) with development of Olsztyn Mątki 400 kV substation.											design & permitting	2020	Progresses as planned.		
	59.376	Alytus (LT)	PL-LT border (PL)	Construction of Back-to-Back convertor station near Alytus 330 kV substation. Construction of double circuit 400 kV OHL between Alytus and PL – LT border (2 × 1,870 MVA, 51 km).											design & permitting	2015	Progresses as planned.		
	59.379	Kruonis (LT)	Alytus (LT)	New double circuit 330 kV OHL (2 × 1,870 MVA, 53 km).											planned	2015	Progresses faster than initially planned to support the LitPol project.		
60	60.377	Klaipeda (LT)	Telsiai (LT)	New single circuit 330 kV OHL (943 MVA, 85 km).	700 MW			West LV region							under construction	2014	Project delayed because of land renting issues.		"NordBalt" project. Planned DC connection between Lithuania and Sweden. The project will connect the Baltic grid to the Nordic and integrate the Baltic countries with the Nordic electricity market, increases security of supply. Possibility to connect offshore wind farms as well.
	60.378	Panevezys (LT)	Musa (LT)	New single circuit 330 kV OHL (1,080 MVA, 80 km).											planned	2018	Project postponed after investment portfolio optimization.		
	60.383	Klaipeda (LT)	Nybro (SE)	"NordBalt" project: A new 300 kV HVDC VSC partly subsea and partly underground cable between Lithuania and Sweden. Length: 440 km											design & permitting	2015	Progresses as planned.		

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	60.62.384	RigaCHP1 (LV)	Imanta (LV)	A new 12.5 km AC 330 kV cable will be built from RigaCHP1 substation to Imanta substation. Both substations will be reconstructed, according new line connecting. New cable will be underground and one part will be underwater (under Daugava river). Expected capacity: 880 MW	700 MW			West LV region							under construction	2012	Progresses as planned.	The investment contributes also to project 62.	"NordBalt" project. Planned DC connection between Lithuania and Sweden. The project will connect the Baltic grid to the Nordic and integrate the Baltic countries with the Nordic electricity market, increases security of supply. Possibility to connect offshore wind farms as well.
	60.A52	Ekhyddan (SE)	Nybro / Hemsjö (SE)	New single circuit 400 kV OHL.											under consideration	2019	New investment in TYNDP.		
	60.62.385	Grobina (LV)	Imanta (LV)	Kurzeme project a Latvian grid reinforcement project with new 330 kV OHL construction and connection to the Riga node. New 330 kV OHL construction mainly instead of the existing 110 kV double circuit line route, 110 kV line will be renovated at the same time and both will be assembled on the same towers. Length: 380 km Capacity: 800 MW											design & permitting	2018	Investment delays due to authorization process and the extensive works.	The investment contributes also to project 62.	
61	61.380	Visaginas (LT)	Kruonis (LT)	New single circuit 330 kV OHL (1,080 MVA, 200 km).	1,400 MW										planned	2020	Progresses as planned.		New NPP project. Grid development for connection of new Lithuanian nuclear power plant planned in Visaginas to the power system. This project allows safe and reliable integration of new NPP to the power system.
	61.382	Vilnius (LT)	Neris (LT)	New single circuit 330 kV OHL (943 MVA, 50 km).											planned	2020	Progresses as planned.		
62	62.60.384				450 – 600 MW			Riga region										The investment contributes both to project 62 and project 64. For the technical description see project 62	This project will increase the transfer capability between Estonia and Latvia and will accommo-date RES generation in the Baltic Sea. This will be the 3rd corridor between these c ountries.
	62.60.385																	The investment contributes both to project 62 and project 64. For the technical description see project 62	
	62.386	Kilingi – Nomme(EE)	RigaCHP2 (LV)	Estonia – Latvia third interconnection will consist of 330 kV AC OHL Harku – Lihula – Sindi in Estonian part and OHL between Kilingi – Nõmme substation in Estonia and TEC2 substation in Latvia. The third interconnection allows to increase the NTC between Estonia and Latvia additionally in the range of 450 to 600 MW .											planned	2020	Progresses as planned.		
	62.387	Tartu (EE)	Sindi (EE)	A new 162 km internal connection will be established on existing route resulting in double circuit line with 2 different voltages (330/110 kV).											under construction	2014	Progresses as planned.		
	62.388	Harku (EE)	Sindi (EE)	New double circuit OHL with 2 different voltages 330/110 kV and with capacity 1,200/240 MVA and a length of 140 km. Major part of new internal connection will be established on existing right of way on the western part of Estonian mainland.											design & permitting	2018	Progresses as planned.		
63	63.389	Eesti (EE)	Püssi (EE)	Reinforcement of existing 57 km single circuit 330 kV OHL. Expected capacity:1,200 MVA	650 MW			NW Estonia							commissioned	commissioned	Commissioned		Estlink2 The main driver for this cluster is integration need of Electricity Market. This project will increase the transfer capability between Estonia and Finland and will accommo-date RES generation in the North of Estonia and will increase the security of supply in the Baltics.
	63.390	Balti (EE)	Püssi (EE)	Reconstruction of 68 km single circuit 330 kV OHL.											commissioned	commissioned	Commissioned		
	63.391	Püssi (EE)	Anttila (FI)	A new HVDC (450 kV) connection will be built between Estonia and Finland. On the Finnish side, a 14 km DC overhead line will be built to a new substation Anttila where the converter station will be placed. On the Estonian side, a 11 km DC cable line will be built to a existing substation Püssi where the converter station will be placed. Length of marine cable: 140 km Expected capacity: 650 MW											under construction	2014	The expected date of commissioning is beginning of 2014, postponed a few months compared to the preliminary estimate end of 2013.		

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64	64.392	Yllikkälä (FI)	Huutokoski (FI)	New 155 km single circuit 400 kV OHL and renovation of 400 kV substations in Yllikkälä and Huutokoski. Expected capacity: 1,850 MVA.	700–1,400 MW			West coast Finland							under construction	2013	Progresses as planned. Expected date of commission is beginning of 2013.		Several 400 kV AC lines are planned in Finland to be built to increase the north-south transmission capacity thus enabling the integration of new renewable and conventional generation in northern Finland and to compensate the dismantling of the obsolescent existing 220 kV lines. The commissioning of the lines is scheduled to take place in segments both in mid and long term.
	64.393	Seinäjoki Ulvila Ventusneva (FI)	Tuovila (FI) Kristinestad (FI) Pyhänselkä (FI)	Four new single circuit 400 kV OHL are part of project in upgrading Ostrobothnian 220 kV system into 400 kV and strengthening the 400 kV grid in northern Finland. Commissioning of first section in year 2011, second in 2014 third in approx. 2018 and fourth approx. 2020. Total length of lines: 520 km Expected capacity: 1,850 MVA											under construction	2011 / 2020	Project has progressed as planned. Since TYNDP 2010 Seinäjoki – Tuovila has been constructed and Ulvila – Kristinestad has progressed to design and permitting phase. Keminmaa – Pyhänselkä is now presented as a separate investment item.		
	64.A62	Pyhänselkä (FI)	Petäjävesi or Vihtavuori (FI)	New single circuit 400 kV OHLs will be built from middle Finland to Oulujoki Area to increase the capacity between North and South Finland.											design & permitting	2020	New investment in TYNDP.		
65	65.394	Hikiä (FI)	Forssa (FI)	New 80 km single circuit 400 kV OHL and building of 400 kV substation in Forssa.	800 MW			SW Finland							design & permitting	2015	Progresses as planned.		Reinforcements due to changed exchange patterns and reliable grid operation of Southwest Finland.
	65.A63	Forssa (FI)	Lieto (FI)	New 67 km single circuit 400 kV OHL.											under consideration	2017	New investment in TYNDP.		
66	66.400	Ekhyddan (SE)	Barkeryd (SE)	New single circuit 400 kV OHL.	1,250 MW										design & permitting	2017	Progresses as planned.		The new subsea connection to the island of Gotland will be two connections with a capacity of 500 MW for each cable.
	66.401	Västervik (SE)	Gotland (SE)	New DC subsea cable interconnection +/- 300 kV (2 × 500 MW).											design & permitting	2017 -2021	The first cable is progressing as planned but the second cable is planned to be in commission after 2017 due to adjustments to RES.	The new subsea connection to the island of Gotland will be two connections with a capacity of 500 MW for each cable. The first cable is planned to be in commission 2017 and the second is planned to be in commission between 2020 and 2021.	
67	67.402	Barkeryd (SE) Hallsberg (SE)	Tveiten (NO) Hurva (SE)	"South West link" consisting of three main parts: 1) New 400 kV line between Hallsberg and Barkeryd (SE), length 170 km; 2) new double HVDC VSC underground cable and OHL between Barkeryd and Hurva (SE), length 250 km and 3) new double HVDC VSC line between Barkeryd (SE) and Tveiten (NO), length 103 km. The project also include new substations and converter stations in the connection points line.	East – West 1,400 MW North – South 1,200 MW										design & permitting	2014-2019	Commissioning date updated after bilateral negotiations between the two countries. Hallsberg – Barkeryd – Hurva expected in 2014, Barkeryd – Tveiten in 2019.		5 investments of HVDC and AC lines in Sweden and Norway as well as between the countries, resulting in increased GTC and market integration
	67.411	Rød (NO)	Sylling (NO)	Voltage upgrading of existing single circuit 300 kV OHL Rød – Tveiten – Flesaker – Sylling in connection with the new HVDC line to Sweden, the Syd Vest link.											design & permitting	2018 / 2020	Investment postponed, especially because of long permitting processes.		
	67.412	Rød (NO) – Sylling (NO) – Flesaker (NO)	Hasle (NO) Tegneby (NO) Tegneby (NO)	Reinvestment and capacity increase Oslofjord 400 kV subsea cables. Three cables: – Filtvedt – Brenntangen, – Solberg – Brenntangen and – Teigen – Evje.											design & permitting	2015	Investment delayed, especially because of long permitting processes. One cable is under construction.		
68	68.421	Ofoten (NO)	Balsfjord (NO)	New 160 km single circuit 400 kV OHL.	350–1,500 MW			Northern Norway							design & permitting	2016	Investment delayed, especially because of long permitting processes.		The main purpose of this project is to secure the norther part of Norway.
	68.422	Balsfjord (NO)	Hammerfest (NO)	New 360 km single circuit 400 kV OHL.											design & permitting	2018	Investment delayed, especially because of long permitting processes.		
	68.423	Skaidi (NO)	Varangerbotn (NO)	New 230 km single circuit 400 kV OHL.											planned	2022	Investment postponed, especially because of long permitting processes.		

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				Project identification	Project assessment														
70	70.405	Kristiansand (NO)	Rød (NO)	Voltage upgrading of an existing single circuit 300 kV OHL and a new section of OHL between Rød and Bamle. Total length: 175 km	700 MW										design & permitting	2014	Progresses as planned.		Market integration and RES integration.
	70.426	Kristiansand (NO)	Tjele (DK)	Skagerak 4: 4th HVDC connection between southern Norway and western Denmark, built in parallel with the existing 3 HVDC cables, new 700 MW including 230 km 500 kV DC subsea cable.											under construction	2014	Progresses as planned.		
71	71.427	Endrup (DK)	Eemshaven (NL)	COBRA: New single circuit HVDC connection between Jutland and the Netherlands via 350 km subsea cable. The DC voltage will be up to 320 kV and the capacity 600–700 MW.	700 MW										design & permitting	2016	Progresses as planned.		Cobra
72	72.430	Revsing (DK)	Landerupgård (DK)	New 18 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.	950 MW			DK West and North DE							planned	2017	Progresses as planned.		The main purpose of the project is to integrate and transmit large scale wind power in DK West.
	72.435	Endrup (DK)	Revsing(DK)	Upgrade of 50 km double circuit 400 kV OHL to reach a capacity of approx. 2,000 MW.											design & permitting	2015	Earlier date of commissioning than initially expected caused by reprioritization of project. Also one of the substations has been changed: Endrup was replaced by Tjele.		
	72.436	Idomlund (DK)	Endrup (DK)	New 74 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.											under consideration	2018/2020	Envisaged route changed from Idomlund–Tjele to Idomlund–Endrup.		
73	73.432	Asvæsværket (DK)	Kyndbyværket (DK)	New 60 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.	>1,000 MW										design & permitting	2014	Progresses as planned.		The project will increase the stability of the DK eastern power system and allow for larger transmission and transit.
	73.433	Glentegård (DK)	Amagerværket & H.C. Ørstedværket (DK)	New 22 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.											planned	2016	Progresses as planned.		
87	87.A53	Forsmark (SE)	Råsten (SE)	New 50 km single circuit 400 kV OHL.	1,215 MW										design & permitting	2019	New investment in TYNDP.		Several 400 kV AC lines and stations due to increase of nuclear power and RES, result in increased GTC.
	87.A54	Råsten (SE)	Hamra (SE)	New 85 km single circuit 400 kV OHL.											design & permitting	2019	New investment in TYNDP.		
	87.A55	Forsmark (SE)	Stackbo (SE)	New 70 km single circuit 400 kV OHL.											design & permitting	2018	New investment in TYNDP.		
	87.A56	Ängsberg (SE)	Horndal (SE)	New 55 km single circuit 400 kV OHL.											under consideration	2020	New investment in TYNDP.		
	87.A57	Horndal (SE)	Lindbacka (SE)	New 145 km single circuit 400 kV OHL.											under consideration	2020	New investment in TYNDP.		
	87.A58	Hamra (SE)	Västerås (SE)	New 50 km single circuit 400 kV OHL.											planned	2021	New investment in TYNDP.		
	87.399	Vasteras (SE)	Lindbaka (SE)	Upgrade/replacement of existing single circuit 220 kV lines to 400 kV.											under consideration	2021	All investments in project 87 has been prioritized and result in new commissioning dates		
90	90.131	Bickigen (CH)		Addition of a second 400/220 kV transformer in an existing substation.	4,000 MW										design & permitting	2012	Progresses as planned.		This project increase the transfer capability between FR, DE, AT towards pump storage in CH.
	90.132	Mühleberg (CH)		Construction of a new 400/220 kV substation.											design & permitting	2015	Delays due to authorization process.		
	90.134	Bassecourt (CH)	Romanel (CH)	Construction of different new 400 kV line sections and voltage upgrade of existing 225 kV lines into 400 kV lines. Total length: 140 km											design & permitting	2015	Delays due to authorization process.		
	90.136	area of Bodensee (DE, AT, CH)		Construction of new lines, extension of existing ones and erection of 400/220/110 kV substation. This project will increase the current power exchange capacity between the DE, AT and CH. The project is expected to increase NTC and improve the security of supply.											planned	long term	Progress as planned.		
	90.129	Beznau (CH)	Mettlen (CH)	Upgrade of the existing 65 km double circuit 220 kV OHL to 400 kV.											design & permitting	2015	Progresses as planned.		
	90.130	La Punt (CH)	Pradella/Ova Spin (CH)	Installation of the second circuit on existing towers of a double circuit 400 kV OHL (50 km).											planned	2017	Delays due to authorization process.		
	90.133	Bonaduz (CH)	Mettlen (CH)	Upgrade of the existing 180 km double circuit 220 kV OHL into 400 kV.											under consideration	2020	Progresses as planned.		

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	90.44.170				4,000 MW													The investment contributes both to project 44 and project 90. For the technical description see project 44.	This project increase the transfer capability between FR, DE, AT towards pump storage in CH.
	90.44.172																	The investment contributes both to project 44 and project 90. For the technical description see project 44.	
	90.44.173																	The investment contributes both to project 44 and project 90. For the technical description see project 44.	
	90.44.176																	The investment contributes both to project 44 and project 90. For the technical description see project 44.	
	90.45.177	Goldshöfe (DE)	Bünzwangen (DE)	A new 380 kV OHL. Length: 45 km											under consideration	2020	Progresses as planned.	The investment contributes also to project 45.	
92	92.146	Aachen / Düren region (DE)	Lixhe (BE)	Connection between Germany and Belgium including new 100 km HVDC underground cable and extension of existing 380 kV substations. On Belgian side, new 380 kV circuit between Lixhe and Herderen and second 380 kV OHL in / out from Herderen to Lixhe. In Belgium, addition of 2 transformers 380/150 kV in Lixhe and in Limburg part.	1,000 MW			Northern Belgium							design & permitting	2017	Project entered design and permitting phase in 2011, technical description has been completed and expected date of commissioning is 2017.	Alegro Project	First Belgium – Germany interconnection. This project enhances security of supply of both BE and DE. This HVDC link in an AC grid brings flexibility and bidirectional power control allowing integration of RES in both countries. This project aims to be a demonstration for HVDC link integration in the AC meshed grid.
93	93.413	Ørskog (NO)	Fardal (NO)	New 285 km single circuit 400 kV OHL.	2,250 MW			Southwest of Trondheim (county Møre and Romsdal)							under construction	2015	Investment delayed due to due to long permitting procedure.	The project is key to improve security of supply in Mid-Norway: Presently, for several N-1 contingencies, load might be disconnected. The project is also the pre-requisite to lift the ban on RES development in the whole area covered by the new line Ørskog – Fardal.	Security of supply for Mid-Norway (Møre and Romsdal mainly) and RES integration in western Norway.
	93.398A	under consideration (SE)		New shunt compensation of OHL.											under consideration	2015	New part of investment 398 in TYNDP 2010.	Investment 398 in TYNDP 2010 has been divided into 398A and 398B. 398B is described in project 104.	
	93.403	Scandinavia North (SE)	Scandinavia South (SE)	A joint Stattnett & Svenska Kraftnat study north-south reinforcement (AC or VSC), expected length: 400 – 500 km, under study.											under consideration	2025	Postponed after reprioritization of the project portfolio.		
	93.414	Fardal (NO)	Aurland (NO)	Voltage upgrading of existing single circuit 300 kV OHL Fardal – Aurland Extension of 413 – Ørskog – Fardal.											planned	2020	Investment postponed, especially because of long permitting processes.		
	93.417	Aura / Viklandet (NO)	Fåberg (NO)	Voltage upgrading of existing single circuit 300 kV OHL Aura / Viklandet – Fåberg.											under consideration	long term	Investment postponed, especially because of long permitting processes.		
	93.416	Klæbu (NO)	Aura / Viklandet (NO)	Voltage upgrading of existing single circuit 300 kV OHL Klæbu – Aura.											design & permitting	2018 (2016-2020)	Investment postponed, especially because of long permitting processes.		
94	94.139	Vierraden (DE)	Krajnik (PL)	Upgrade of existing 220 kV line Vierraden – Krajnik to double circuit 400 kV OHL.	>1,000 MW										design & permitting	long term	Expected date of commissioning was adjusted due to long permitting process and strong local public resistance.		PSTs: Control of the transits of power on the polish synchronous profile (increase of import capacity, increase of grid operation safety).
	94.A68	Krajnik (PL)		Upgrade 400 kV.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		
	94.A69	Mikułowa (PL)		Upgrade 400 kV.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		
	94.A70	Krajnik (PL)		New PST.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		
	94.A71	Mikułowa (PL)		New PST.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		

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96	96.A64	Keminmaa (FI)	Pyhänselkä (FI)	Integration of new generation + increased transmission capacity demand.	1,000 MW										under consideration	2019	New investment in TYNDP, split out from investment 393, and now been moved as a stand-alone project cluster because of his specific benefits.		Integration of new generation and increased transmission capacity demand.
97	97.A65	Uusnivala (FI)	Pyhäjoki (FI)	New double circuit 400 kV OHLs.	1,600 MW										under consideration	2020	New investment in TYNDP, required to connect Fennovoimas new 1,250 – 1,700 MW nuclear power plant that will be built in Pyhäjoki.		New investment in TYNDP, required to connect Fennovoimas new 1,250 – 1,700 MW nuclear power plant that will be built in Pyhäjoki.
98	98.A66	Rauma (FI)	Forssa (FI) Lieto (FI) Ulvila (FI)	New single circuit 400 kV OHLs.	1,600 MW										under consideration	2020	New investment in TYNDP, required to connect TVO's new 1,000 – 1,800 MW nuclear power plant that will be built in Olkiluoto.		New investment in TYNDP, required to connect TVO's new 1,000 – 1,800 MW nuclear power plant that will be built in Olkiluoto.
99	99.324	Dobrzeń (PL)	Wrocław / Pasikurowice (PL)	New 76 km 400 kV 2 × 1,870 MVA OHL double circuit line from Dobrzeń to splitted Pasikurowice – Wrocław line. Upgrade and extension of 400 kV switchgear in substation Dobrzeń.	1,800 MW			Warsaw and lower Silesia area							design & permitting	2017	Progresses globally as planned. Technical description and commissioning date have been updated so as to deliver full benefit as from 2017.		Dobrzeń: The project introduces new infrastructure (2 × 400 kV line) to allow power evacuation from two (2 × 9,000 MW) conventional units to be installed in existing power plant Opole. The new line provides power supply for agglomeration Wroclaw, it increases the security of supply for this area.
100	100.335	Ostrołęka (PL)	Olsztyn Mątki (PL)	New 138 km 400 kV 2 × 1,870 MVA double circuit OHL line Ostrołęka – Olsztyn Mątki after dismantling of 220 kV line Ostrołęka – Olsztyn with one circuit from Ostrołęka to Olsztyn temporarily on 220 kV.	1,000 MW										design & permitting	2017	The time schedule of the project was shifted to meet the schedule of the generation connection.		Ostrołęka: The new 400 kV line allows power evacuation from new 1,000 MW conventional unit to be installed in existing power plant Ostroleka.
101	101.327	Kozienice (PL)	Ołtarzew (PL)	New 130 km 400 kV 2 × 1,870 MVA OHL double circuit line Kozienice – Ołtarzew. Upgrade and extension of 400 kV switchgear in substation Kozienice for the connevtion of new line.	1,000 MW			Warsaw area							design & permitting	2017	The time schedule of the project was shifted to meet the schedule of the generation connection.		Kozienice: The new 2 × 400 kV line allows power evacuation from new 1,000 MW conventional unit to be installed in existing power plant Kozienice. The new unit is foreseen to supply Warsaw agglomeration area.
	101.338	Kozienice (PL)	Mory / Piaseczno (PL)	Replacement of conductors (high temperature conductors).											under construction	2014	Progresses as planned, with commissioning now expected in 2014.		The project also allows to close the 400 kV ring around Warsaw agglomeration are increasing the security of supply significantly.
102	102.A72	Gdańsk Błonia (PL)		Extension and upgrade of an existing 400/110 kV substation Gdańsk Błonia for connection of planned 900 MW power plant.	2,900 MW										planned	2020	New investment in TYNDP.	Power Evacuation North. The upgraded substation will connect a planned 900 MW CCPP.	North: The north-south corridor provides necessary capacity to evacuate the power from new 2,900 MW of conventional generation planned to be installed in northern Poland.
	102.334	Pątnów (PL)	Grudziądz (PL)	New 174 km 400 kV 2 × 1,870 MVA double circuit OHL line Pątnów – Grudziądz after dismantling of 220 kV line Pątnów – Jasiniec (two parallel lines) and Jasiniec – Grudziądz. One circuit from Pątnów to Grudziądz via Jasiniec temporarily on 220 kV.											design & permitting	2020	The time schedule of the project was shifted to meet the schedule of the generation connection.	Power Evacuation North.	
	102.326	Grudziądz (PL)	Gdańsk Przyjaźń (PL)	A new AC 400/110 kV substation between existing substation Grudziądz and planned substation Gdańsk Przyjaźń. New substation Pelplin is connected by new 110 km 400 kV 2 × 1,870 MVA OHL double circuit lines Grudziądz – Pelplin and Pelplin – Gdańsk Przyjaźń after dismantling of 220 kV line Jasiniec – Gdańsk.											planned	2020	The time schedule of the project was shifted to meet the schedule of the generation connection.	Power Evacuation North.	

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103	103.145	Niederrhein (DE)	Doetinchem (NL)	New 400 kV line double circuit DE-NL interconnection line. Length: 60 km	13,900 MW			NW part of Netherlands							design & permitting	>2013	Delays due to authorization process.		The project reinforces the Dutch grid to accommodate new conventional and renewable generation, to handle new flow patterns and to increase the interconnection capacity between DE and NL.
	103.438	Eemshaven (NL)	Diemen (NL)	New 175 – 200 km AC overhead line with capacity of 2 × 2,650 MVA of 380 kV.											design & permitting	2018	Delays due to authorization process.		
	103.439	Borssele (NL)	Geertruidenberg (NL)	New 100 – 130 km double circuit 380 kV OHL with 2 × 2,650 MVA capacity.											design & permitting	2016	Delays due to authorization process.		
	103.440	Maasvlakte (NL)	Beverwijk (NL)	New 380 kV double circuit mixed project (OHL + underground cable) including approximately 20 km of underground cable for 2,650 MVA. The cable sections are a pilot project. The total length of cable at 380 kV is frozen until more experience is gained.											under construction	2016	Delays due to authorization process.		
	103.441	Zwolle (NL)	Hengelo (NL)	Upgrade of the capacity of the existing 60 km double circuit 380 kV OHL to reach a capacity of 2 × 2,650 MVA.											under consideration	long term	Progresses as planned.		
	103.442	Krimpen aan de Ijssel (NL)	Maasbracht (NL)	Upgrade of the capacity of the existing 150 km double circuit 380 kV OHL to reach a capacity of 2 × 2,650 MVA.											under consideration	long term	Progresses as planned.		
104	104.398B	under consideration (SE)		New series compensation of OHL.	1,200 MW										under consideration	2015	Reprioritization of projects.	Investment 398 in TYNDP 2010 have been divided into 398A and 398B. 398A is described in project 93.	RES integration in Mid-Norway (Trøndelag and Nordland) and reinforcement of Swedish internal interconnections in order to facilitate wind power integration in northern Sweden.
	104.415	Namsos (NO)	Klæbu and Storeheia (NO)	New line and voltage upgrade of 286 km single circuit 400 kV OHL											design & permitting	2015	Delays due to authorization process.	New line and voltage upgrade to facilitate new wind power generation.	
	104.418	Nedre Røssåga (NO)	Namsos (NO)	Upgrade of 70 km single circuit 400 kV OHL.											design & permitting	2019	Investment postponed, especially because of long permitting processes.	Increased capacity between North and Mid-Norway. Facilitates RES integration.	
	104.420	Storheia (NO)	Orkdal / Trollheim (NO)	New 130 km single circuit 400 kV OHL.											design & permitting	2017 – 2020	Investment postponed due to long permitting procedure.	New line to facilitate wind power generation.	
	104.A59	Råbäcken (SE)	Letsi – Betåsen (SE)	New 55 km single circuit 400 kV OHL.											under consideration	2017	New investment in TYNDP. Will probably be postponed after 2020 due to later development of wind power in the area.		
	104.A51	Svartisen (NO)	Nedre Røssåga (NO)	New 116 km 400 kV OHL.											planned	2020	New investment in TYNDP.	New line to facilitate wind power generation.	
105	105.A60	Skogssäter (SE)	Stenungsund / Stenkullen (SE)	New 80 km single circuit 400 kV OHL.	600 MW										under consideration	2019	New investment in TYNDP.		This project facilitates the connection of wind power along the Swedish west coast.
110	110.424	Kvilldal (NO)	tbd (GB)	A new 1,000 MW HVDC bipolar installation connecting western Norway and Great Britain via 800 km subsea cable. DC voltage is to be determined.	1,000 – 1,400 MW										design & permitting	2018 / 2021	Capacity revised. Investment postponed, especially because of long permitting processes.		Market integration. Facilitate RES integration in southern and western Norway and improve security of supply.
111	111.396	Finland North (FI)	Sweden North (SE)	Third single circuit 400 kV AC OHL between Sweden and Finland. Expected capacity: 1,850 MVA	700 MW										under consideration	2021	The projects reinforcing the north-south transmission in the Scandinavia have been prioritized ahead of this project. Based on common estimation project can be delayed to 2021. SvK will evaluate the project and the timetable in ongoing studies		Third AC 400 kV cross border line between North-Sweden and North-Finland is under consideration. Strengthening the AC connection between Finland and Sweden is necessary due to new wind power generation, larger conventional units and decommissioning of the existing 220 kV interconnector.

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	58	Ensdorf (DE)	St. Avold (FR)	Change of conductors on the German part of this single circuit 220 kV line (9 km) and installation of a phase-shifter in Ensdorf (DE) 220 kV substation.											commissioned	commissioned	Commissioned.		
	168	Goldshöfe (DE)	Dellmensigen (DE)	Upgrade the line Goldshöfe – Dellmensigen from 220 kV to 380 kV. Line length: 114 km Included with the project : 3 × 380 kV substations, 2 transformers											under construction	2014	Investment 168 has been postponed to 2014 due to local resistance against the project in a specific area. The rest of the investment is ready.		
	168a	region South-West Bavaria (DE)		Upgrading the existing 220 kV OHL to 380 kV, length 100 km, and the extension of existing substations, erection of 380/110 kV-transformers.											cancelled	cancelled	The project was abandoned / was not seen necessary with the new set of projects in place. Note: in the previous TYNDP the status of the project was under consideration and not planned (printing mistake).		
	192	Hamburg / Krümmel (DE)	Schwerin (DE)	This 380 kV double circuit OHL project will close the missing gap in the northeastern German grid infrastructure. Only 65 km of new line must be constructed, 22 km already exist.											under construction	2012 / 2013	Commissioning delayed by complex permitting procedure. Line is partly constructed. Is expected to be commissioned in 2012 / 2013 short term.		
	198	Wuhlheide (DE)	Thyrow (DE)	Berlin South Ring: replacement of an existing old 220 kV double circuit OHL by a 380 kV double circuit OHL. Length: 50 km											cancelled	cancelled	Project was depending on the replacement of a CHP power plant based in Berlin. Due to a new general CHP concept the plant size could be adopted and the upgrade of the existing 220 kV connection to 380 kV was not necessary any longer. Project was given up with regard to the CHP plant investor.		
	322	Kromolice (PL)		A new AC substation between existing substations Plewiska and Ostrów and Pątnów in Poznań Agglomeration Area with transformation 400/110 kV 400 MVA. New substation Kromolice is connected by splitting and extending existing line Ostrów – Plewiska and Pątnów – Plewiska.											under construction	2012	The investment process ongoing according to plan. Faster commissioning date reported after update of NDP. The project will be commissioned by the end on 2012.		
	331	Gorzów (PL)	Leśniow (PL)	Upgrading of sag limitations (new capacity 461 MVA).											planned	2015	The investment process ongoing according to plan.		
	336	Warszawa Praga (PL)		A new AC substation with 2 × 275 MVA 220/110 kV transformation between existing substations Miłosna and Mory in Warszawa Agglomeration Area. New substation Warszawa Praga is connected by splitting and extending existing line Miłosna – Mory.											planned	>2015	The project appeared in the plans for generation connection purpose. Planned commissioning is dependant upon generation investment (the investor has with-drawn a new gen. unit from the plans). There is an existing combined heat power plant in this area; possible new generation in the future.		
	344	Lublin Systemowa (PL)	Abramowice (PL)	New 220 kV cable / OHL interconnection line Lublin Systemowa – Abramowice in Lublin agglomeration area (522 MVA, 18 km).											design & permitting	>2020	Investment postponed due to change in generation sector plans.		
	346	Halemba (PL)		Halemba substation is connected by splitting and extending of existing 220 kV lines Kopanina – Katowice.											cancelled	cancelled	Project withdrawn from TSO plans because of cancellation of construction of new generation unit.		
	348	several substations in PSE O control area		Installation additional and exchange existing transformers (400/110 kV and 220/110 kV), capacitors and SVC in substations. Upgrading of substations.											design & permitting	2015	The investment process ongoing according to plan.		

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	349	Puławy (PL)		A new AC 400 kV switchgear in existing substation Pulawy (with transformation 400/220 kV 500 MVA) will be connected by splitting and extending existing 400 kV lines: Kozienice – Lublin Systemowa and Kozienice – Ostrowiec.											planned	2020	The investment process ongoing according to plan. This investment is connected to the construction of a new power plant.		
	350	Chełm (PL)	Lublin Systemowa (PL)	Construction of a new 400 kV OHL Lublin Systemowa-Chełm with single circuit (1,870 MVA). A new AC 400 kV switchgear in existing substation Chelm with transformation 400/220 kV 500 MVA.											planned	2020	Upon withdrawal of new conventional power plant from the plans the content of the project in the area has changed. Initially the project was foreseen to accommodate a conventional generator.		
	351	Blachownia (PL)		A new AC 400 kV switchgear in existing substation Blachownia (with transformation 400/220 kV 500 MVA and 400/110 kV 400 MVA) will be connected by splitting and extending existing 400 kV line Joachimów – Wielopole and 220 kV line Kedzierzyn – Groszowice.											planned	2020	The project appeared in the plans for generation connection purpose. Planned commissioning is dependant upon generation investment (the investor has with-drawn a new gen. unit from the plans). There is an existing heat power plant in this area; possible new generation in the future.		
	354	Byczyna (PL)	Podborze (PL)	Double line 400 kV Byczyna – Czeczott – Podborze (2 × 1,870 MVA, 155 km) will be built in parallel with 220 kV line Byczyna – Bieruń – Poręba – Podborze in the same road. New substation 400 and 220 kV Podborze (with transforma-tion 400/220 kV 500 MVA) will be connected by splitting and extending existing lines Wielopole – Nosovice, Kopanina – Liskovec, Bujaków – Liskovec, Komorowice – Bieruń, Moszczenica – Poręba and new double circuit line 400 kV Podborze – Czeczott.											design & permitting	after 2020	The delay in the plans appeared after updating of the NDP. The time schedule of the project was shifted to meet the schedule of the generation connection.		
	356	Janów (PL)		New substation 400 kV Janów (with transformation 400/110 kV 400 MVA) will be connected by splitting and extending existing line Rogowiec – Płock.											planned	2020	The investment process is according to the plan.		
	357	Joachimów (PL)		Replacement of a transformer 400/220 kV (500 MVA).											planned	2020	The investment process ongoing according to plan.		
	359	Morzyczyn (PL)	Pomorzany / Glinki (PL)	New line 220 kV (522 MVA).											planned	>2020	Future realization of the investment dependant upon needs of increase of security of supply in the Szczecin agglomeration area.		
	360	Miłosna (PL)	Siekierki (PL)	New cable connection 220 kV Miłosna – Warszawa Siekierki (333 MVA, 10 km).											planned	>2020	Future realization of the investment dependant upon needs of increase of security of supply in the Warcowa agglomeration area.		
	361	Ołtarzew (PL)	Mory (PL)	Replacement of conductors (high temperature conductors). New capacity: 461 MVA											planned	2020	The investment process ongoing according to plan. The upgrade method not decided yet.		
	362	Wielopole (PL)	Moszczenica (PL)	Replacement of conductors (high temperature conductors). New capacity: 461 MVA											planned	2020	The investment process ongoing according to plan. The upgrade method not decided yet.		
	363	Byczyna (PL)	Siersza (PL)	Replacement of conductors (high temperature conductors). New capacity: 461 MVA											planned	2020	The investment process ongoing according to plan. The upgrade method not decided yet.		
	367	several substations in PSE O control area		Installation of an additional transformer and replacement of an existing one (400/110 kV and 220/110 kV). Shunt reactors in substations. Upgrading and decommissioning of substations.											planned	2020	The investment process ongoing according to plan.		
	397	Varangerbotn (NO)	Pirttikoski or Petäjäskoski (FI)	New single circuit 380 – 400 kV OHL (500 km).											under consideration	2020 / 2025	Based on a common Statnett / Fingrid study conclusion from the more detailed study on the project that is can be postponed beyond 2021. The need is related to the oil / refinery and wind development on the northern Norway		
	407	Tonstad (NO)	Arendal (NO)	Voltage upgrading of existing single circuit 400 kV OHL Tonstad – Solhom – Arendal.													This investment proposed as stand-alone in the TYNDP 2010 is now merged into investment 37.406. Its evolution is monitored there.	This investment proposed as stand-alone in the TYNDP 2010 is now merged into investment 37.406. Its evolution is monitored there.	

Table of projects – Regional Group Baltic Sea

Project identification					Project assessment														
Project number	**Investment number**	**Substation 1**	**Substation 2**	**Brief technical description**	**Grid transfer capacity increase**	**Socio-economic welfare**	**RES integration**	**Improved security of supply**	**Losses variation**	**CO_2 mitigation**	**Technical resilience**	**Flexibility**	**Social and environmental impact**	**Project costs**	**Present status**	**Expected date of commissioning**	**Evolution compared to the TYNDP 2010 situation**	**Investment comment**	**Project comment**
	409	Feda, Tonstad (NO)		Reactive power devices in 400 kV substations.													This investment proposed as stand-alone in the TYNDP 2010 is now merged into investment 37.406. Its evolution is monitored there.	This investment proposed as stand-alone in the TYNDP 2010 is now merged into investment 37.406. Its evolution is monitored there.	
	413a	Sima (NO)	Samnanger (NO)	New 420 kV line Sima – Samnanger to ensure security of supply in the region of Hordaland/ Bergen, and to integrate new hydro power.											under construction	2013/2014	Project going according to the plan.		
	419	Namsos (NO)	Storheia (NO)	New 119 km 800 MVA single circuit Namsos – Roan – Storheia OHL to connect new wind power generation at Fosen.											under construction	2015	This projects is now embedded in the investment 104.415.		
	65	Curon (IT) / Glorenza (IT)	new substation close to the border in AT	New 380/220 kV substation in AT directly located near the border. Erection of a 24 km single circuit 220 kV connection via OHL and underground cable till Graun (IT) and upgrade of the existing line Graun (IT) – Glorenza (IT).											cancelled	cancelled	It has been replaced by investment n°ITA-5 "New interconnection between AT and IT". This project which was depicted in the TYNDP 2010 suffered important changes in the design.		
	319	Skawina (PL)		A new AC 400/110 kV substation next to existing 220/110 kV substation in Cracow Agglomeration Area with transformation 400/110 kV 2 × 400 MVA. New substation Skawina is connected by splitting and extending of existing 400 kV lines Tarnów – Tucznawa and Rzeszów – Tucznawa. Dismantling of existing 220/110 kV transformers.											design & permitting	2015	The investment process ongoing according to plan.		
	321	Kromolice (PL)	Pątnów (PL)	New 79 km 400 kV 1,870 MVA OHL interconnection line Kromolice – Pątnów with one circuit from Plewiska to Koninn temporarily on 220 kV after dismantling of 220 kV line Plewiska – Konin.											under construction	end 2012	The investment process ongoing according to plan. Faster commissioning date reported after update of NDP. This project is due to be put in operation by the end of 2012.		
	323	Warszawa Siekierki (PL)	Piaseczno (PL)	A new AC 220/110 kV substation (with transformation 220/110 kV 2 × 275 MVA) in Warsaw Agglomeration Area connected by a new 20 km 220 kV 333 MVA cable/OHL line Warszawa Siekierki – Piaseczno.											design & permitting	2020	Investment postponed due to change in new generation unit connection schedule which was scheduled for 2015 but it was withdrawn from the medium term.		
	325	Krajnik (PL)	Pomorzany (PL)	A new AC substation in Szczecin Agglomeration Area. New substation Pomorzany is connected by new 24 km 220 kV 522 MVA line Krajnik – Pomorzany and 220/110 kV (275 MVA) transformer to existing 110 kV switchgear.											planned	2016	The delay in the plans appear after updating of the NDP. The time schedule of the project was shifted to meet the schedule of the generation connection (combined cycle power plant in Pomorzany).		
	332	Recław (PL)	Glinki (PL)	A new AC substation in Szczecin Agglomeration Area. New substation Recław is connected by new 52 km 220 kV 522 MVA line Recław – Glinki, existing 110 kV single circuit line Morzyczyn – Recław upgraded to 220 kV and two 220/110 kV (275 MVA) transformer to existing 110 kV switchgear. Splitting of existing 220 kV line Morzyczyn – Olice and expanding to Glinki substation.											design & permitting	2016	The delay in the plans appear after updating of the NDP. The time schedule of the project was shifted due to proper coordination with other investments in the area (325).		
	333	Pasikurowice (PL)	Świebodzice (PL)	A new AC substation in Wrocław Agglomeration Area. New substation Wrocław is connected to new 135 km (sum) 400 kV 1,870 MVA lines: Pasikurowice – Wrocław and Świebodzice – Wrocław. New 400 kV Wrocław substation with 2 × 400 MVA, 400/110 kV transformation. New 400 kV Świebodzice substation with 1 × 500 MVA, 400/220 kV transformation and 1 × 400 MVA, 400/110 kV transformation. New 400 kV OHL interconnection line Wrocław – Świebodzice after dismantling of 220 kV line Świebodzice – Biskupice and new 400 kV OHL interconnection line Pasikurowice – Wrocław, including new Wrocław substation.											under construction	2015	The investment process ongoing according to plan. The line Pasikurowice – Wrocławd and the substation Wrocław are already commissioned.		

Table of projects – Regional Group Baltic Sea

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environ-mental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
	337	Radkowice (PL)	Kielce Piaski (PL)	New 26 km 220 kV 522 MVA OHL line Radkowice – Kielce Piaski, in Kielce agglomeration area.											design & permitting	2015	The investment process ongoing according to plan.		
	340	Lubocza (PL)		An existing substation in Kraków Agglomeration Area. Existing substation will be upgraded by splitting and ex-tending existing 220 kV line Siersza – Klikowa and installing second ATR 220/110 kV (160 MVA).											commissioned	commissioned	In the previous NDPs of PL the projects were structure in steps of 5 years. Therefore the date of commissioning mentioned in TYND 2010 is 2015. The project will be commissioned by the need of 2012.		
	341	Pątnów (PL)	Włocławek (PL)	Upgrading of sag limitations OHL 220 kV (389 MVA).											cancelled	cancelled	Investment suspended. After connection of planned generation unit in substation Włocławek Azoty the possibility of overload in the existing lines is eliminated.		
	342	Czarna (PL)	Polkowice (PL)	New 400 kV OHL interconnection line Czarna – Polkowice (1,870 MVA, 22 km), including new Polkowice 400 kV substation with 500 MVA, 400/220 kV transformation.											design & permitting	2016	The investment process ongoing according to plan. The delay in the commissioning of the project appeared after updating of the NDP.		
	343	Byczyna (PL)		Upgrading of existing AC 220 kV substation Byczyna. A new 400 kV AC substation in Silesia Agglomeration Area with transformation 400/220 kV 2 × 500 MVA. New substation Byczyna is connected by splitting and extending existing line Tarnów – Tucznawa.											planned	2015	The investment process ongoing according to plan		
	358	Ostrów (PL)	Kromolice (PL)	Installation of a 2nd 400 kV circuit along an already existing line on the same voltage. (1,870 MVA, 212 km).											design & permitting	2020	The investment process ongoing according to plan		
	364	Czarna (PL)	Polkowice (PL)	New line will be second 400 kV circuit to existing line in the same direction. (1,870 MVA, 22 km).											planned	2020	The investment process ongoing according to plan. The first out of 2 circuits will be operational starting with 2015.		
	365	Wyszków (PL)		New substation 400 kV Wyszków (with transformation 400/110 kV 400 MVA) will be connected by splitting and extending line Ostrołęka – Stanisławów.											design & permitting	2025	The investment delayed because of spacial planing problems.		
	431	Tjele (DK)	Trige (DK)	New 46 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.											Planned	long term	Investment moved to longer time horizon.		
	203	area Wolmirstedt (DE)	under consideration	Support of RES and conventional generation integration, maintaining of security of supply and support of market development.											under consideration	2020	Included in new investment H3 due to new wind BS generation.		
	429	Ferslev (DK)	Vester Hassing (DK)	New 20 km single circuit 400 kV line via a cable with a capacity of approx. 800 MW.											planned	2018	No change.		
	180	Mengede (DE)	Kruckel (DE)	Installation of a second circuit 380 kV OHL and extension of existing substations. Line length: 16 km.											design & permitting	mid term	Project develops according ot the plan.		
	398	under consideration (SE)		New series and shunt compensation of OHL.											cancelled	cancelled		This investment is splitted in 2 parts (investment 104.398B and 93.398A).	
	381	Visaginas (LT)	Liksna (LV)	Upgrade single circuit OHL (943 MVA, 50 km).											under consideration	2020	Progresses as planned.		
	143	Kassö (DK) Ensted (DK)		Installation of two PSTs. This step includes also planed strengthening of existing 380 kV lines in the grid of TenneT.eu and Energinet.dk.											commissioned	commissioned	Commissioned.		
	169	Großgartach (DE)		Upgrade the substation for a higher short circuit capacity. New installation includes 10 gas insulated bays, 63 kA, 3 busbars and 2 transformers.											commissioned	commissioned	Commissioned.		
	201	Bärwalde (DE)	Schmölln (DE)	New internal double circuit 380 kV line connecting the substations St. Peter and Salzach neu (replacement of the existing 220 kV line). Length: 46 km											design & permitting	2014	Delays due to authorization process.		

Table of projects – Regional Group Baltic Sea

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environ-mental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
	196	wind farm Baltic 1 (DE)	Bentwisch (DE)	Connection of the offshore wind farm Baltic 1 (AC-cables on transmission voltage level).											commissioned	commissioned	Commissioned.		
	210	substations in 50Hertz Transmission control area		Construction of new 380/110 kV substations.											commissioned	commissioned	Freiberg and Stendal / West are commissioned. The remaining substations were transferred to the 44.209 investment.		
	382a	Bitenai (LT)		New 330 kV switching station.											commissioned	commissioned			
	37.408	Kristiansand, Feda (NO)		Reactive compensation due to HVDC links NorNed and Skagerak 4. Reactive power devices in 400 kV substations.											design & permitting	2012 / 2014	Feda is in the planning and permitting stage. Kristiansand is under construction (commissioned expected as planned 2012).		
	410	Kristiansand (NO)		Spare transformer for the HVDC Skagerak interconnection transformer.											under construction	2012	Will be commissioned 2012.		
	434	Fraugde (DK)	Herslev(DK)	New single circuit HVDC-LCC installation including a 56 km 450 kV DC subsea cable with 600 MW capacity.											commissioned	commissioned	Commissioned September 2010.		
	395	Rauma (FI)	Finnböle (SE)	A new 500 kV HVDC connection will be built in parallel with the existing one between Finland and Sweden. On the Swedish side, a 70 km direct current overhead line will be built to a new substation Finnböle where the converter station will be placed. Total length of line: 300 km Capacity: 800 MW											commissioned	commissioned	In TYNDP 2010 project was in construction phase. Project progressed as planned and is now completed.		
	281	Albertirsa (HU)	Martonvasar (HU)	Adding second circuit to existing 400 kV single circuit OHL. Line length: 45 km											commissioned	commissioned	Commissioned earlier due to scheduling of the field work.		
	339	Morzyczyn (PL)		A new AC substation in Szczecin Agglomeration Area with transformation 400/220 kV 330 MVA and 400/110 kV 330 MVA. New substation Morzyczyn is connected by splitting and extending existing 400 kV line Krajnik – Dunowo.											commissioned	commissioned	Commissioned. In the previous NDPs of PL the projects were structure in steps of 5 years. Therefore the date of commissioning mentioned in TYND 2010 is 2015. The project was commissioned in 2011.		
	345	Łagisza (PL)		A new AC 400 kV switchgear in existing substation Łagisza (with transformation 400/220 kV 500 MVA and 400/110 kV 330 MVA) is connected by splitting and extending of exist-ing 400 kV lines Rokitnica – Tucznawa.											commissioned	commissioned	Commissioned. In the previous NDPs of PL the projects were structure in steps of 5 years. Therefore the date of commissioning mentioned in TYND 2010 is 2015. The project was commissioned in 2011.		
	347	Gdańsk I (PL)		A new AC 400 kV switchgear in existing substation Gdańsk I is connected by splitting and extending of existing 400 kV lines Żarnowiec – Gdańsk Błonia.											commissioned	commissioned	Commissioned. In the previous NDPs of PL the projects were structure in steps of 5 years. Therefore the date of commissioning mentioned in TYND 2010 is 2015. The project was commissioned in 2011.		
	A61	Samnanger	Sauda	Voltage upgrade of existing 300 kV line.											under consideration	2021	New project.		
	A73	Żarnowiec (PL)		Extension and upgrade of an existing 110 kV switchgear and installation of 400/110 kV transformer dedicated to wind farms planned to be connected to Żarnowiec substation. Upgrade of existing 400 kV switchgear for transformer installation.											planned	2020	The Żarnowiec substation is one of several substations in northern Poland incorporated in the project Wind Integration. The upgraded substation will serve as connection point for RES generation.		

Table of projects – Regional Group Baltic Sea

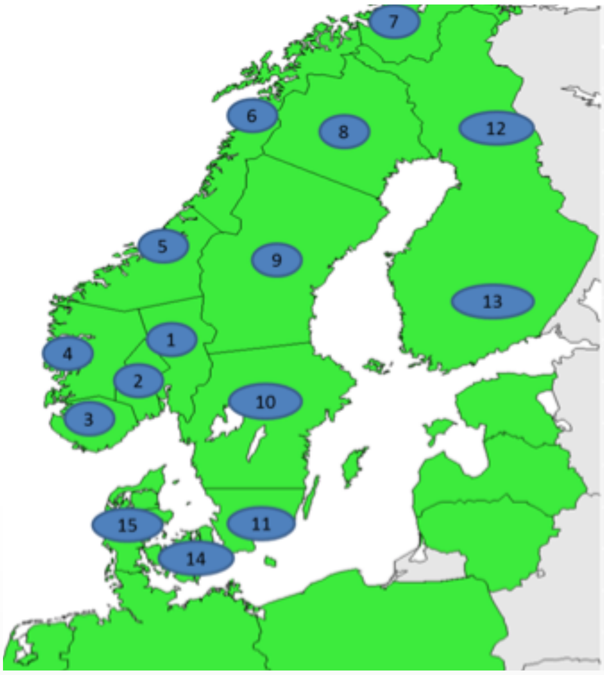
A4.3_1 NTCs Used in Market Studies

Market model area interconnection		NTC 2015 Direction →	NTC 2015 Direction ←	NTC 2020 Direction →	NTC 2020 Direction ←
NORGEOST	NORGESENT	2000	5300	2000	5500
NORGEOST	NORGEMIDT	250	250	500	500
NORGESENT	NORGESYD	1300	1500	1300	1600
NORGESENT	NORGEVEST	1500	3500	2000	4000
NORGESYD	NORGEVEST	1700	1600	2100	2100
NORGESYD	NETHERLANDS	700	700	1400	1400
NORGESYD	GERMANY	0	0	1400	1400
NORGEVEST	NORGEMIDT	400	400	600	600
NORGEVEST	ENGLAND	0	0	1600	1600
NORGEMIDT	NORGENORD	200	1000	200	1300
NORGENORD	NORGEFINN	150	200	500	800
NORGESENT	SVER-SNO3	0	0	1200	1200
NORGEOST	SVER-SNO3	2145	2095	2145	2095
NORGEMIDT	SVER-SNO2	600	1000	600	1000
NORGENORD	SVER-SNO2	200	200	200	200
NORGENORD	SVER-SNO1	600	500	600	500
NORGESYD	DANM-WEST	1600	1600	1600	1600
NORGEFINN	FIN-NORD	50	50	50	50
SVER-SNO1	SVER-SNO2	4200	3300	4200	3300
SVER-SNO2	SVER-SNO3	8000	7300	8700	7300
SVER-SNO3	SVER-SNO4	6500	3200	6500	3200
SVER-SNO4	POLAND	600	600	600	600
SVER-SNO3	DANM-WEST	740	740	740	740
SVER-SNO4	DANM-OST	1300	1700	1300	1700
SVER-SNO1	FIN-NORD	1300	1300	1000	1300
SVER-SNO3	FIN-SYD	1350	1350	1350	1350
SVER-SNO4	LITHUANIA	0	0	700	700

Market model area interconnection		NTC 2015 Direction →	NTC 2015 Direction ←	NTC 2020 Direction →	NTC 2020 Direction ←
SVER-SNO4	GERMANY	600	600	600	600
DANM-OST	DANM-WEST	600	600	600	600
DANM-WEST	NETHERLANDS	600	600	600	600
DANM-WEST	GERMANY	1500	2000	2500	2500
DANM-OST	GERMANY	550	550	550	550
FIN-NORD	FIN-SYD	1800	1800	3500	2500
FIN-SYD	ESTONIA	1000	1000	1000	1000
ESTONIA	LATVIA	750	750	1450	1350
LITHUANIA	POLAND	500	0	1000	1000
GERMANY	NETHERLANDS	3800	3800	3800	3800
CZECH	POLAND	111	1033	800	1800
SLOVAKIA	POLAND	83	326	600	500
GERMANY	CZECH	800	2100	1300	2600
GERMANY	FRANCE	3000	3000	3000	3000
TYSKLAND	BELGIUM	0	0	1000	1000
GERMANY	POLAND	306	1141	2000	3000
LATVIA	LITHUANIA	1300	1500	1300	1500
FIN-SYD	Russia	350	1400	700	1400
FIN-NORD	Russia	0	70	0	70
Russia	Russia_Baltics_dummy	600	0	600	0
LITHUANIA	Russia_Baltics_dummy	0	600	0	600
ESTONIA	Russia_Baltics_dummy	0	600	0	600
LATVIA	Russia_Baltics_dummy	0	400	0	400
DANM-OST	KF_DK	0	0	600	600
KF_DK	KF_DE	0	0	400	400
KF_DE	GERMANY	0	0	400	400
KF_DK	GERMANY	0	0	600	600

2015: max import to Poland from DE/CZ/SK 500 MW, max export from Poland to DE/CZ/SK 2500 MW
2020: max import to Poland from DE/CZ/SK 2000 MW, max export from Poland to DE/CZ/SK 3000 MW

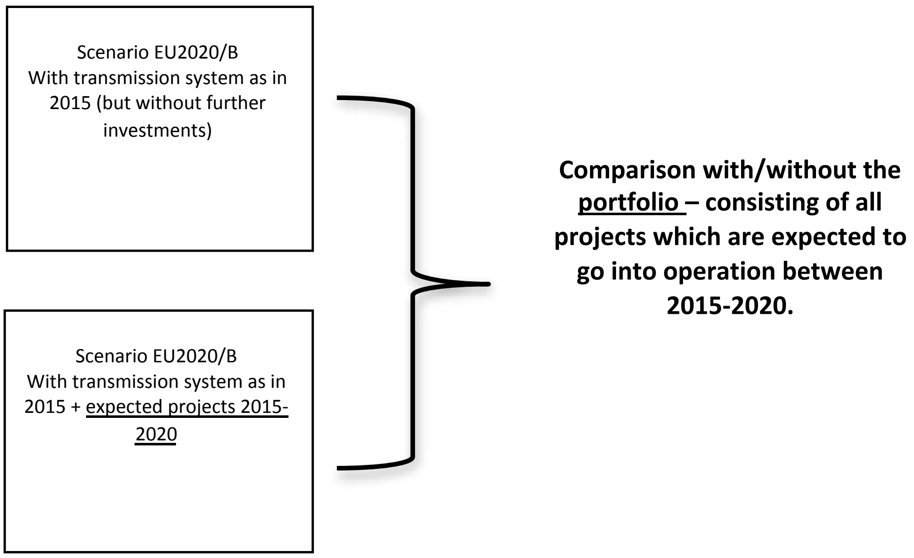
Areas in Norway, Sweden, Finland and Denmark:



#	Area
1	Norgeost
2	Norgesent
3	Norgesyd
4	Norgevest
5	Norgemidt
6	Norgenord
7	Norgefinn
8	Sver-sno1
9	Sver-sno2
10	Sver-sno3
11	Sver-sno4
12	Fin-nord
13	Fin-syd
14	Danm-ost
15	Danm-west

A4.3_1 “Portfolio Concept”

The following figure explains the portfolio concept used for estimating the effect of the investment portfolio.

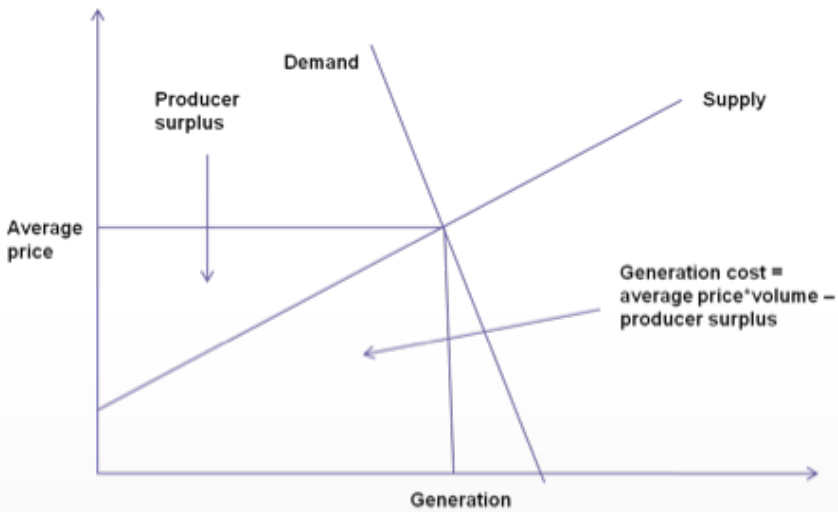


A4.3_2 Benefit Analysis

The calculation of savings in generation costs and electricity market benefit is described below.

Savings in generation costs

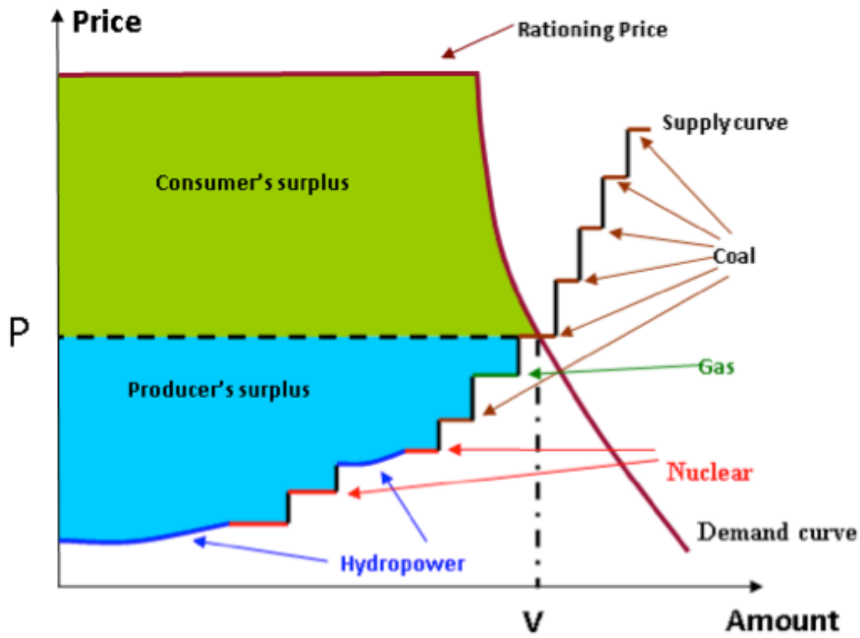
The method to calculate generation costs:



Generation costs were calculated for each area in 2015 and 2020 grid situations using the method described above. Savings in generation costs were calculated for each area by calculating the change in generation costs due to the investment portfolio. The total savings in generation were calculated by summing up the savings in generation costs in each individual area.

Electricity market benefit

Picture describing the electricity market benefit



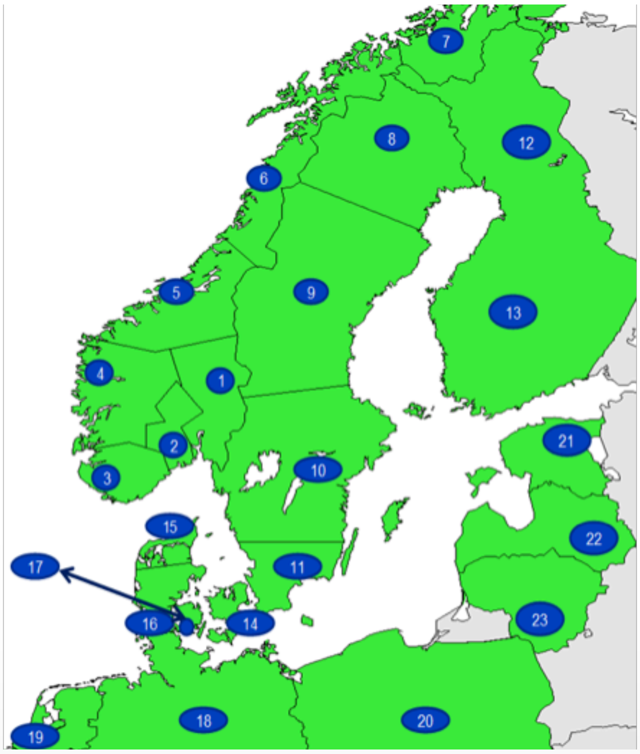
The electricity market benefit takes into account the effect of the investment for the whole society. It consists of producer surplus, consumer surplus, and congestion rent for TSOs.

Electricity market benefits were calculated for EU2020 and B2020 in both 2015 grid and 2020 grid situations. The benefit of the investment portfolio was calculated by calculating the difference of total electricity market benefits between the two grid situations. Electricity market benefit refers to the annual benefit in the region over simulated hydrological years. Transmission losses are not taken into account in benefit analysis, the model only considers losses for cables between bidding areas. Losses are however calculated for two cases, before and after the investment portfolio.

A4.3_3 Generation Mix, Demand and Power Flow

Snapshot 1 – Sweden and Norway 1

Snapshot 1 – Sweden and Norway 1							
	Total generation and demand in MW						
	Sweden	Norway	Denmark	Finland	Lithuania	Poland	Germany
Hydro	12,472	12,105	0	2,900	47	302	1,986
Wind	1,064	652	922	512	39	947	2,335
Nuclear	4,610	0	0	5,073	0	81	14,602
CCGT	0	900	0	0	163	389	357
CHP	0	0	1,930	0	0	0	0
Coal	0	0	0	0	0	6,049	1,224
Gas	0	0	0	0	170	0	0
Oil shale	0	0	0	0	0	0	0
Lignite	0	0	0	0	0	3,640	2,270
Other	1,334	0	0	1,906	63	0	17,955
Total generation	19,480	13,657	2,851	10,392	482	11,408	40,728
Demand	14,336	12,680	3,417	8,678	1,331	14,241	45,572
Balance	5,144	977	-566	1,713	-849	-2,833	-4,844

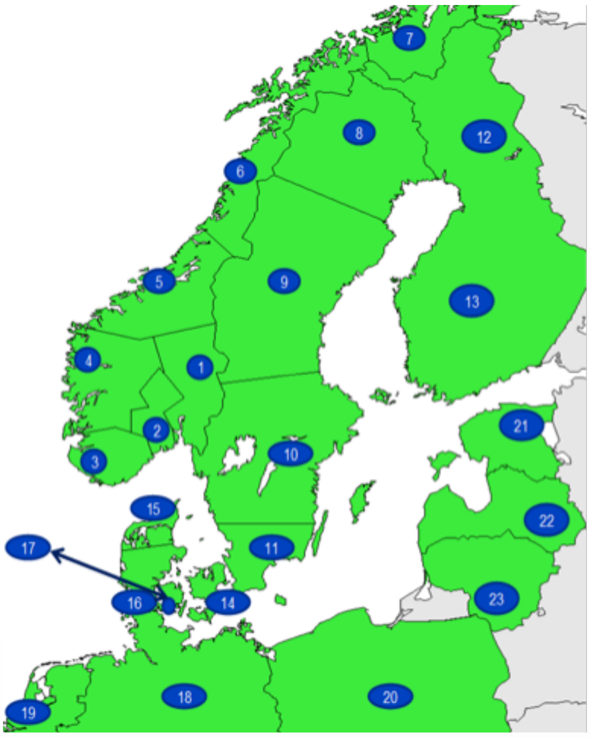


Transmissions		
From	To	MW*
(1) Norgeost	(10) Sver-Sno3	-1713
(5) Norgemidt	(9) Sver-Sno2	-568
(6) Norgenord	(8) Sver-Sno1	600
(6) Norgenord	(9) Sver-Sno2	200
(7) Norgefinn	(12) Fin-Nord	50
(3) Norgesyd	(15) Jyll-Nord	800
(3) Norgesyd	(19) The Netherlands	700
(3) Norgesyd	(18) Germany	360
(4) Norgevest	(24) Great Britain	834
(2) Norgesent	(10) Sver-Sno3	-287
(6) Norgenord	(5) Norgemidt	1300
(11) Sver-Sno4	(14) Danm-Ost	852
(10) Sver-Sno3	(15) Jyll-Nord	740
(8) Sver-Sno1	(12) Fin-Nord	118
(10) Sver-Sno3	(13) Fin-Syd	-182
(11) Sver-Sno4	(18) Germany	600
(11) Sver-Sno4	(20) Polen	600
(23) Lithuania	(11) Sver-Sno4	-647
(9) Sver-Sno2	(10) Sver-Sno3	8700

* Negative value = opposite direction

Snapshot 2 – Sweden and Norway 2

Snapshot 2 – Sweden and Norway 2							
	Total generation and demand in MW						
	Sweden	Norway	Denmark	Finland	Lithuania	Poland	Germany
Hydro	12,239	18,537	0	2,779	40	348	1,702
Wind	542	892	454	569	160	412	4,245
Nuclear	5,194	0	0	5,595	0	81	14,602
CCGT	0	900	0	0	443	1,012	12,257
CHP	0	0	0	0	0	0	0
Coal	0	0	0	0	0	8,482	2,515
Gas	0	0	0	0	170	0	0
Oil shale	0	0	0	0	0	0	0
Lignite	0	0	0	0	0	3,927	2,270
Other	1,086	0	0	1,596	63	0	16,703
Total generation	19,061	20,330	454	10,539	876	14,262	54,294
Demand	15,224	13,662	4710	10,052	1,441	17,822	62,605
Balance	3,837	6,667	-4256	487	-564	-3,560	-8,311

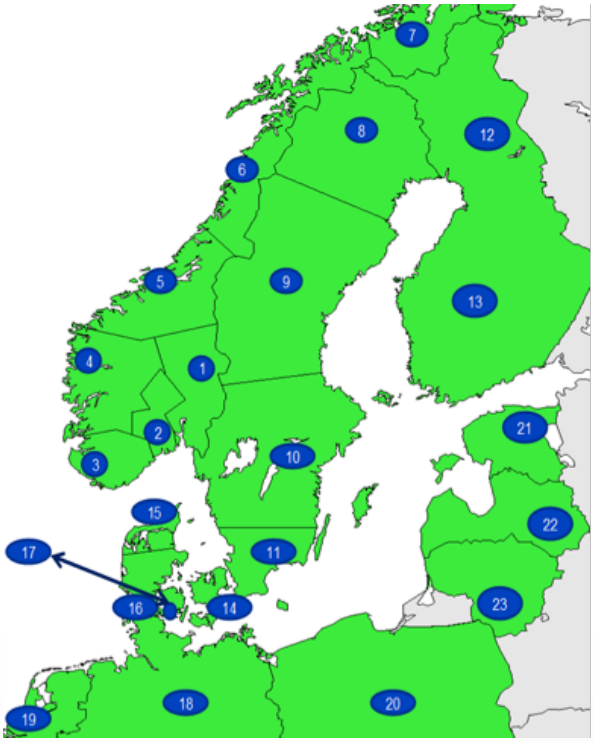


Transmissions		
From	To	MW*
(1) Norgeost	(10) Sver-Sno3	0
(5) Norgemidt	(9) Sver-Sno2	455
(6) Norgenord	(8) Sver-Sno1	600
(6) Norgenord	(9) Sver-Sno2	200
(7) Norgefinn	(12) Fin-Nord	50
(3) Norgesyd	(15) Jyll-Nord	1600
(3) Norgesyd	(19) The Netherlands	1400
(3) Norgesyd	(18) Germany	1400
(4) Norgevest	(24) Great Britain	952
(2) Norgesent	(10) Sver-Sno3	11
(11) Sver-Sno4	(14) Danm-Ost	1300
(10) Sver-Sno3	(15) Jyll-Nord	740
(8) Sver-Sno1	(12) Fin-Nord	605
(10) Sver-Sno3	(13) Fin-Syd	558
(11) Sver-Sno4	(18) Germany	600
(11) Sver-Sno4	(20) Polen	600
(23) Lithuania	(11) Sver-Sno4	-700

* Negative value = opposite direction

Snapshot 3 – Denmark and Norway

Snapshot 3 – Denmark and Norway					
	Total generation and demand in MW				
	Sweden	Norway	Denmark	Finland	Germany
Hydro	8,316	16,505	0	2,142	2,269
Wind	1,629	816	3,365	924	37,864
Nuclear	9,466	0	0	5,915	14,670
CCGT	0	900	0	0	357
CHP	0	0	3,039	0	0
Coal	0	0	0	0	1,224
Gas	0	0	0	0	0
Oil shale	0	0	0	0	0
Lignite	0	0	0	0	2,270
Other	4,116	0	0	3,216	10,389
Total generation	23,528	18,222	6,404	12,196	69,042
Demand	21,739	20,459	6,088	13,063	62,232
Balance	1,788	-2,237	316	-867	6,810

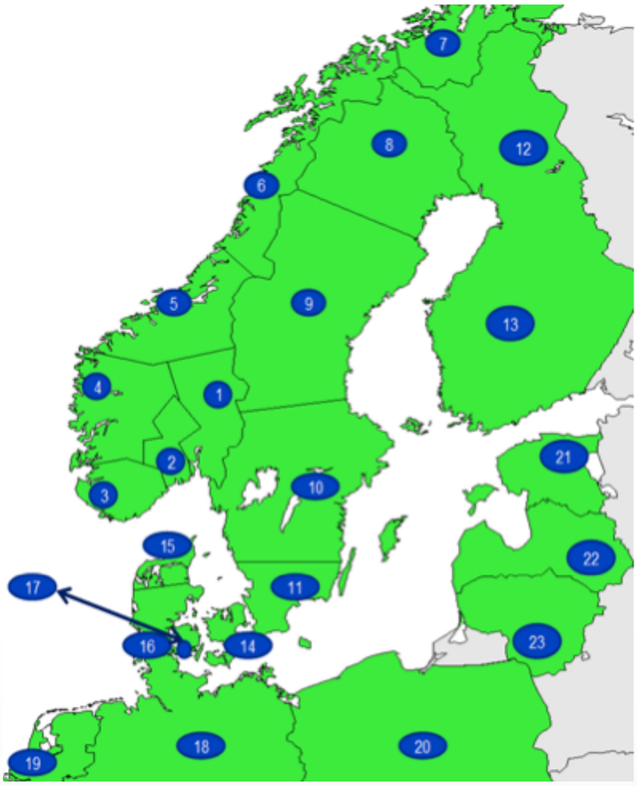


Transmissions		
From	To	MW*
(3) Norgesyd	(2) Norgesent	1600
(3) Norgesyd	(4) Norgevest	2100
(1) Norgeost	(10) Sver-Sno3	300
(5) Norgemidt	(9) Sver-Sno2	-1000
(6) Norgenord	(8) Sver-Sno1	-500
(6) Norgenord	(9) Sver-Sno2	-200
(2) Norgesent	(10) Sver-Sno3	1200
(7) Norgefinn	(12) Fin-Nord	32
(4) Norgevest	Great Britain	997
(3) Norgesyd	(19) The Netherlands	-1379
(3) Norgesyd	(18) Germany	-58
(3) Norgesyd	(15) Jyll-Nord	-1528
(11) Sver-Sno4	(14) Danm-Ost	-755
(16) Jyll-syd	(18) Germany	-2157
(10) Sver-Sno3	(15) Jyll-Nord	-740
(14) Danm-Ost	(18) Germany	-550
(16) Jyll-syd	(19) The Netherlands	29

* Negative value = opposite direction

Snapshot 4 – Finland

Snapshot 4 – Finland				
	Total generation and demand in MW			
	Norway	Finland	Sweden	Estonia
Hydro	19,948	2,845	10,859	0
Wind	945	346	634	79
Nuclear	0	5,073	5,584	0
CCGT	900	0	0	17
CHP	0	0	0	156
Coal	0	0	0	0
Gas	0	0	0	0
Oil shale	0	0	0	245
Lignite	0	0	0	0
Other	0	2,392	1,835	0
Total generation	21,793	10,656	18,912	496
Demand	14,739	10,827	16,638	1,089
Balance	7,055	-171	2,274	-593

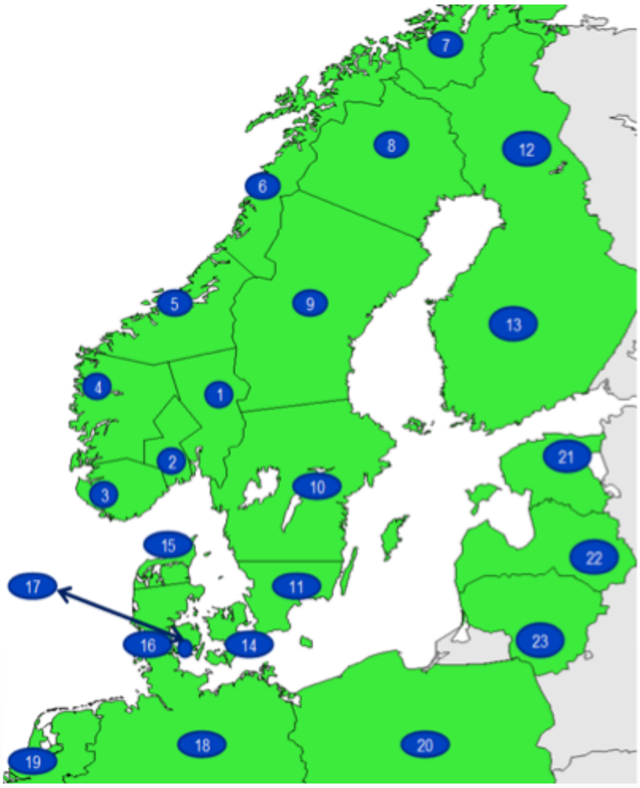


Transmissions		
From	To	MW*
(8) Sver-Sno1	(12) Fin-Nord	576
(10) Sver-Sno3	(13) Fin-Syd	647
Russia	(13) Fin-Syd	-117
Russia	(12) Fin-Nord	14
(13) Fin-Syd	(21) Estonia	1000
(7) Norgefinn	(12) Fin-Nord	50

* Negative value = opposite direction

Snapshot 5 – Finland and Sweden 1

Snapshot 5 – Finland and Sweden 1								
	Total generation and demand in MW							
	Sweden	Norway	Denmark	Finland	Lithuania	Estonia	Poland	Germany
Hydro	9,580	19,133	0	2,142	53	0	756	2,269
Wind	1,791	715	3,237	980	121	490	4,524	37,519
Nuclear	9,493	0	0	5,915	0	0	81	17,339
CCGT	0	0	0	0	664	80	1,012	357
CHP	0	0	3,051	0	0	230	0	0
Coal	0	0	0	0	0	0	7,582	1,224
Gas	0	0	0	0	170	0	0	0
Oil shale	0	0	0	0	0	245	0	0
Lignite	0	0	0	0	0	0	3,894	2,270
Other	4,116	0	0	3,216	258	0	0	10,389
Total generation	24,980	19,847	6,287	12,252	1,266	1,046	17,849	71,367
Demand	21,893	14,737	6,273	13,292	1,807	1,520	21,305	72,965
Balance	3,087	5,110	15	-1,040	-541	-474	-3,456	-1,598

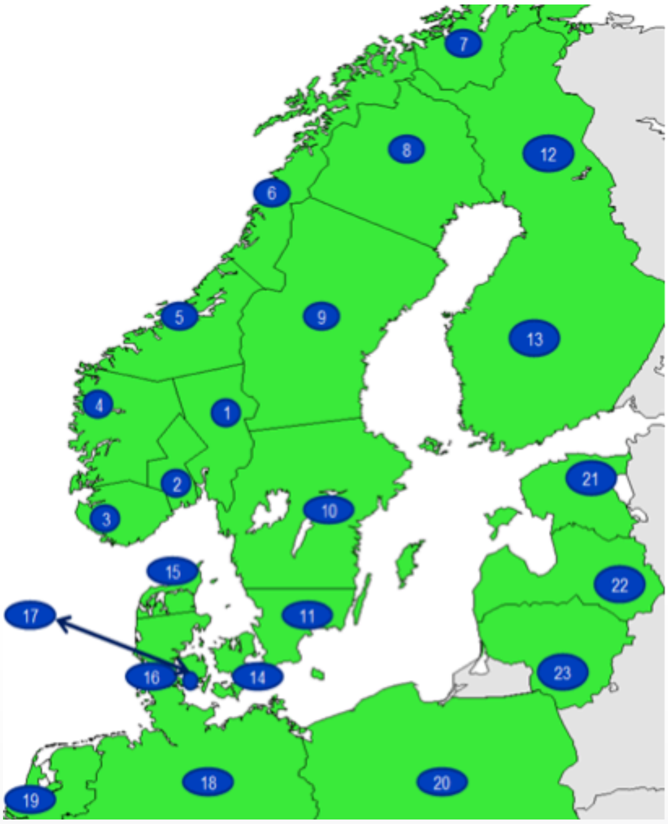


Transmissions		
From	To	MW*
(8) Sver-Sno1	(12) Fin-Nord	1000
(10) Sver-Sno3	(13) Fin-Syd	1350
Russia	(13) Fin-Syd	-348
Russia	(12) Fin-Nord	0
(13) Fin-Syd	(21) Estonia	1000
(7) Norgefinn	(12) Fin-Nord	38
(1) Norgeost	(10) Sver-Sno3	347
(5) Norgemidt	(9) Sver-Sno2	-1000
(6) Norgenord	(8) Sver-Sno1	-500
(6) Norgenord	(9) Sver-Sno2	-200
(11) Sver-Sno4	(14) Danm-Ost	-253
(10) Sver-Sno3	(15) Jyll-Nord	-223
(2) Norgesent	(10) Sver-Sno3	1200
(11) Sver-Sno4	(18) Germany	-240
(11) Sver-Sno4	(20) Poland	600
(23) Lithuania	(11) Sver-Sno4	-700

* Negative value = opposite direction

Snapshot 6 – Finland and Sweden 2

Snapshot 6 – Finland and Sweden 2								
	Total generation and demand in MW							
	Finland	Sweden	Norway	Denmark	Estonia	Lithuania	Poland	Germany
Hydro	808	3,177	7,195	0	0	53	491	1,635
Wind	911	1,246	269	2,289	330	53	3,444	33,743
Nuclear	5,915	9,273	0	0	0	0	81	2,086
CCGT	0	0	1,507		50	392	640	357
CHP	0	0	0	3,581	230	0	0	0
Coal	0	0	0	0	0	0	6,049	1,224
Gas	0	0	0	0	0	170	0	0
Oil shale	0	0	0	0	245	0	0	0
Lignite	0	0	0	0	0	0	3,784	2,270
Other	4,031	5,479	0	0	0	258	0	9,991
Total generation	11,664	19,174	8,971	5,869	855	927	14,488	51,305
Demand	9,728	20,311	16,429	4,211	1,272	1,581	16,400	46,445
Balance	1,936	-1,137	-7,457	1,659	-417	-654	-1,912	4,860

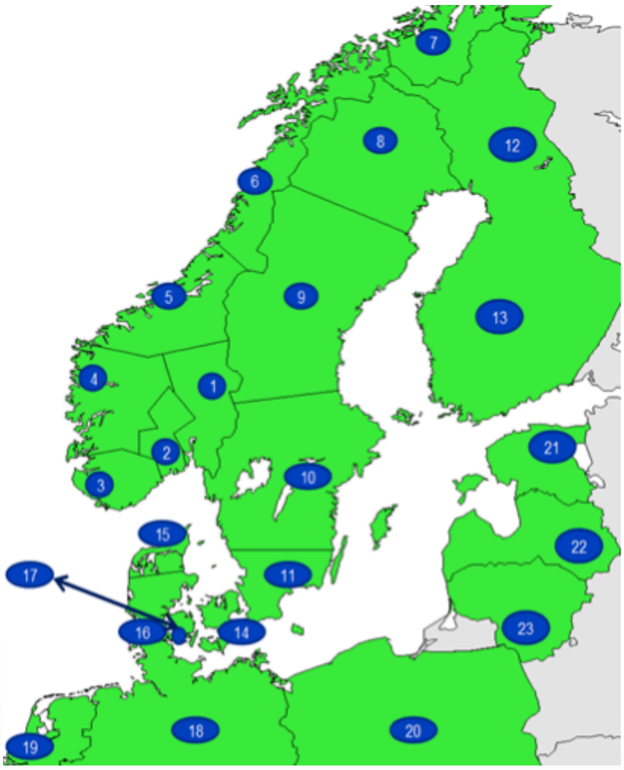


Transmissions		
From	To	MW*
(8) Sver-Sno1	(12) Fin-Nord	-1300
(10) Sver-Sno3	(13) Fin-Syd	-1350
Russia	(13) Fin-Syd	1400
Russia	(12) Fin-Nord	70
(13) Fin-Syd	(21) Estonia	706
(7) Norgefinn	(12) Fin-Nord	-50
(1) Norgeost	(10) Sver-Sno3	-2095
(5) Norgemidt	(9) Sver-Sno2	-1000
(6) Norgenord	(8) Sver-Sno1	-500
(6) Norgenord	(9) Sver-Sno2	0
(11) Sver-Sno4	(14) Danm-Ost	-1700
(10) Sver-Sno3	(15) Jyll-Nord	-740
(2) Norgesent	(10) Sver-Sno3	-600
(11) Sver-Sno4	(18) Germany	-600
(11) Sver-Sno4	(20) Poland	9
(23) Lithuania	(11) Sver-Sno4	-350

* Negative value = opposite direction

Snapshot 7 – Baltic Countries 1

Snapshot 7 – Baltic countries 1						
	Total generation and demand in MW					
	Estonia	Latvia	Lithuania	Sweden	Finland	Poland
Hydro	0	152	73	12,382	874	476
Wind	454	241	238	1,573	1,161	2,843
Nuclear	0	0	0	9,466	5,915	81
CCGT	40	319	521	0	0	976
CHP	234	59	0	0	0	0
Coal	0	0	0	0	0	8,738
Gas	0	0	170	0	0	0
Oil shale	245	0	0	0	0	0
Lignite	0	0	0	0	0	3,870
Other	0	0	290	4,018	4,628	0
Total generation	973	771	1,291	27,439	12,578	16,984
Demand	1,395	1,298	1,643	21,951	13,686	20,544
Balance	-422	-527	-352	5,489	-1,109	-3,560

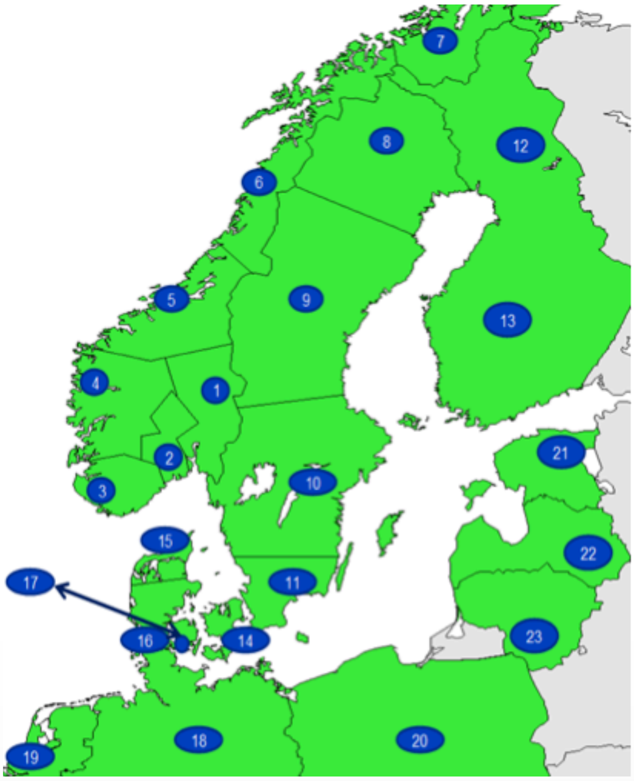


Transmissions		
From	To	MW*
(22) Latvia	(23) Lithuania	52
(13) Fin-syd	(21) Estonia	1000
(23) Lithuania	(11) Sver-Sno4	-700
Russia	(21) Estonia	0
Russia	(22) Latvia	0
Russia	(23) Lithuania	600
(23) Lithuania	(20) Poland	1000

* Negative value = opposite direction

Snapshot 8 – Baltic Countries 2

Snapshot 8 – Baltic countries 2						
	Total generation and demand in MW					
	Estonia	Latvia	Lithuania	Sweden	Finland	Poland
Hydro	0	1,264	73	9,037	2,694	348
Wind	213	101	100	809	485	1,002
Nuclear	0	0	0	8,885	5,915	81
CCGT	0	0	163	0	0	1,012
CHP	199	42	0	0	0	0
Coal	0	0	0	0	0	7,776
Gas	0	0	170	0	0	0
Oil shale	245	0	0	0	0	0
Lignite	0	0	0	0	0	3,927
Other	0	0	143	2,871	2,623	0
Total generation	657	1,407	649	21,602	11,718	14,145
Demand	1,045	966	1,339	12,536	11,164	17,390
Balance	-389	441	-690	9,065	553	-3,245

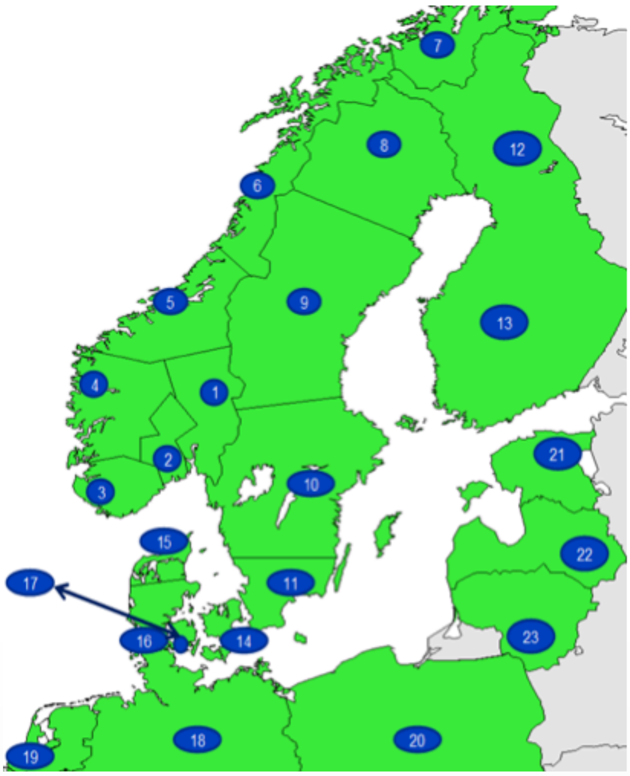


Transmissions		
From	To	MW*
(22) Latvia	(23) Lithuania	1016
(13) Fin-syd	(21) Estonia	965
(23) Lithuania	(11) Sver-Sno4	-658
Russia	(21) Estonia	0
Russia	(22) Latvia	0
Russia	(23) Lithuania	16
(23) Lithuania	(20) Poland	1000

* Negative value = opposite direction

Snapshot 9 – Baltic Countries 3

Snapshot 9 – Baltic countries 3						
	Total generation and demand in MW					
	Estonia	Latvia	Lithuania	Sweden	Finland	Poland
Hydro	0	359	73	2,312	1,215	665
Wind	243	49	48	581	623	562
Nuclear	0	0	0	9,263	5,915	81
CCGT	100	995	824	0	0	1,012
CHP	229	55	0	0	0	0
Coal	0	0	0	0	590	9,018
Gas	0	0	170	0	0	0
Oil shale	743	0	0	0	0	0
Lignite	0	0	0	0	0	3,927
Other	0	0	234	4,939	4,235	0
Total generation	1,315	1,458	1,350	17,095	12,577	15,265
Demand	1,129	1,159	1,387	19,877	12,275	18,825
Balance	187	299	-38	-2,783	302	-3,560

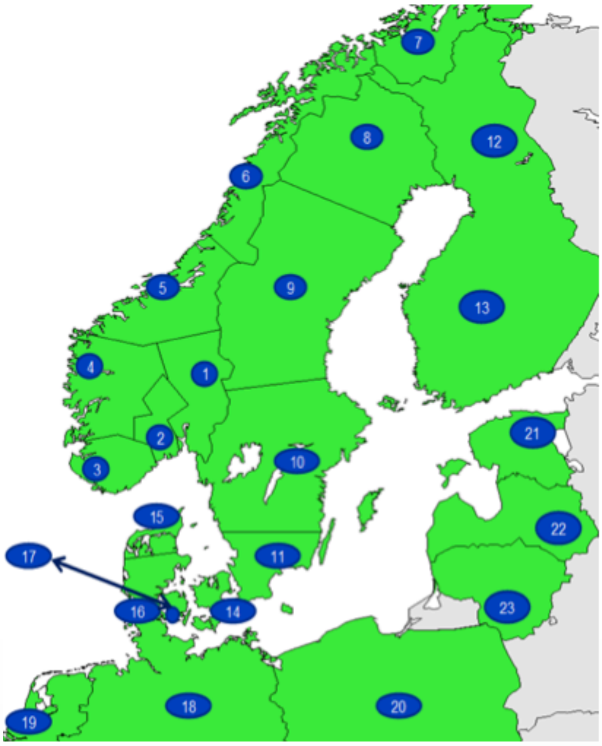


Transmissions		
From	To	MW*
(22) Latvia	(23) Lithuania	484
(13) Fin-syd	(21) Estonia	-1
(23) Lithuania	(11) Sver-Sno4	46
Russia	(21) Estonia	0
Russia	(22) Latvia	0
Russia	(23) Lithuania	600
(23) Lithuania	(20) Poland	1000

* Negative value = opposite direction

Snapshot 10 – Baltic Countries 4

Snapshot 10 – Baltic countries 4						
	Total generation and demand in MW					
	Estonia	Latvia	Lithuania	Sweden	Finland	Poland
Hydro	0	218	53	6,237	1,368	620
Wind	446	67	66	1,856	512	5,720
Nuclear	0	0	0	9,273	5,915	81
CCGT	0	56	163	0	0	267
CHP	230	66	0	0	0	0
Coal	0	0	0	0	0	6,049
Gas	0	0	170	0	0	0
Oil shale	245	0	0	0	0	0
Lignite	0	0	0	0	0	3,640
Other	0	0	258	4,108	4,542	0
Total generation	922	407	710	21,474	12,337	16,377
Demand	1,460	1,189	1,718	20,812	11,519	18,562
Balance	-538	-782	-1,008	662	818	-2,185



Transmissions		
From	To	MW*
(22) Latvia	(23) Lithuania	-32
(13) Fin-syd	(21) Estonia	1000
(23) Lithuania	(11) Sver-Sno4	-621
Russia	(21) Estonia	0
Russia	(22) Latvia	288
Russia	(23) Lithuania	312
(23) Lithuania	(20) Poland	-107

* Negative value = opposite direction

A 4.3_4 Grid Losses

Grid losses in the Nordic system

As described in Chapter 4.3.1 the change in losses in Nordic and Baltic transmission systems were analyzed. Indeed, it is of interest to have an estimate of transmission grid losses as the grid is developed and the production system changes due to the fact that losses are a strong environmental factor; for example, savings in losses are equal to savings in emissions. Due to the different methodology used to study the losses in Baltic and Nordic countries the results are not comparable.

The results illustrate the mechanism. Even though the grid is developed with more interconnectors and lower impedance, the increased transmission of power will increase the main grid losses. A reason for this is the long distance between production and consumption as well as connections to neighboring countries. As Figure 44 shows, the losses in Baltic countries are much lower than in Nordic countries due to the smaller size of the system. In Baltic countries the grid losses are expected to decrease from the year 2015 to 2020 as a direct result of investments.

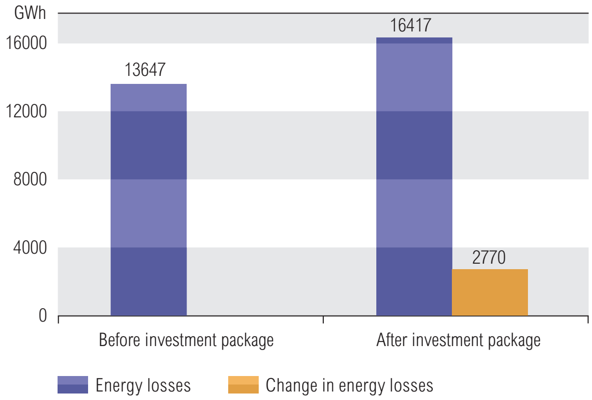


Figure 43:
Estimate annual transmission grid losses in Sweden, Norway, Finland and Denmark before and after the investment portfolio.

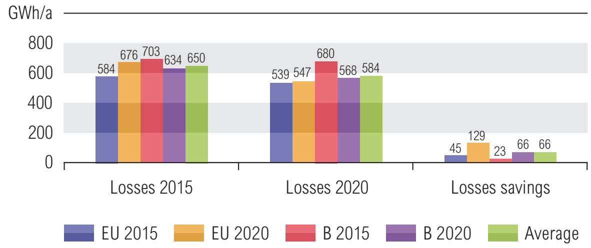


Figure 44:
Estimated Sum Of Annual Transmission Grid Losses In Estonia, Latvia And Lithuania In Years 2015 And 2020.

Losses in the Baltic system

For the Baltic countries system losses were calculated with the PSS/e model (the reason for this is that no Baltic model exists in the Samlast model, which is also the reason for the different approach) for 110 – 330 kV grid for four different scenarios EU2015, EU2020, B2015 and B2020. For the year 2015 only mid-term project lines were turned on. For the year 2020 all perspective lines were turned on. Each scenario was divided into 5 snapshots each representing 20 % equivalent time duration. In addition, losses P were calculated for each snapshot. Following this, annual system losses were calculated according to the following formula:

$$W_{losses} = \sum_{i=1}^{n} (P_{loss\_i} \times 0{,}2 \times 8760h)$$

If all lines would be built, each scenario shows savings in losses compared with the case with no investments. The greatest savings would be in scenario EU2020, and the smallest in B2015.

The last part in figure 44 shows the savings losses when comparing each case with a respective scenario with no investments.

A4.4_1 EMPS and SAMLAST Model Description

EMPS is the most commonly used electricity market model in the Nordic countries. The development of the model started in the 1960s and its primary function was to optimize hydro power plant production. Later during deregulation of the electricity markets, it was developed into a market model and analyzing tool.

EMPS input data consists of consumption data, generation data including marginal costs, and transmission capacities. Input data is provided based on price areas, which are connected with transmission interconnectors; a single country may consist of one or several price areas. Input data is given in a weekly level accuracy and divided into sub weekly levels using proportional factors. This study utilizes a dataset with ten sub weekly categories ("load periods").

Typical results are simulated production and consumption, electricity prices, duration curves, energy and power flows between areas, electricity market benefit, bottleneck hours, and so on.

Samlast is a development of the EMPS model and adds full power flow calculation for each of the 13260 market solutions from the EMPS model. With a detailed description of the Nordic power grid it is possible to establish the power flow in each connection for all of the different production and load distributions.

A4.4_2 MAPS Model Description

The MAPS model belongs to the class of models applying non-sequential Monte Carlo simulation. Demand and generation is modeled in each area with limited transmission capacity between areas, where the maximum number of allowed areas to model is 100. Cables outside the model area are treated as generation nodes.

Demand is modeled as a curve of 1080 hours of peak period load, together with forecast uncertainties due to cold and mild winters with 10 levels of corresponding probabilities. Generation is described at power plant unit level, that is, generation capacity together with its forced outage rate. Between areas limited transmission capacity is modeled together with probability of the transmission capacity to be in operation. Since no reserves are included the results are valid for a market failure.

The following countries were modeled in the study:

- Norway: 7 areas
- Sweden: 4 areas
- Denmark: 2 areas
- Finland: 2 areas
- Estonia, Latvia and Lithuania: 1 area each

ENTSO-e's scenarios B2020 and EU2020 were used as input data. Two simulations were made, one without the investment portfolio and one with the investment portfolio, each for the following three strained situations:

- Severe load with no wind power and no import
- Normal load with failure on nuclear reactors with BWR-technique (boiled water reactor), that is, 7 out of 10 Swedish reactors and 2 out of 6 Finish reactors, and half import.
- Severe load with gas restriction (that is no gas production in Denmark, Finland, Estonia, Latvia and Lithuania) and no import. This situation was only simulated for the EU2020 scenario.

LOLP and EUE are presented as results of the analyzed situations.

MAPS calculated the probability for the market to fail for an hour in an area of the Baltic Sea region. This LOLP (Loss of Load Probability) can be expressed by percentage or hours pr. year (e.g. 0.1 % = 0.001 * 8760 hours/year = 8.76 hours pr. year). The following criterions are used:

- Green: LOLP < 0.05 %
- Yellow: LOLP between 0.05 % and 0.1 %
- Red: LOLP > 0.1 %

MAPS also calculate the EUE (Expected Unserved Energy). This depends on the installed capacity of an area and is therefore not proportional to the LOLP.

References

[1] Bjørn H. Bakken, Arne Haugstad, Knut S. Hornnes, Sivert Vist, Bjørn Gustavsen, Jarand Røynstrand: Simulation and Optimization of Systems with Multiple Energy Carriers. The 1999 Conference of the Scandinavian Simulation Society, SIMS'99, Linkøping, Sweden, Oct. 18 – 19, 1999.

[2] Knut S. Hornnes, Arne Johannesen, Reidar Ognedal, Arvid Pedersen, Dag Lysheim: A Combined Production and Transmission Model for Planning of Power Transmission in a Hydro-Thermal System, 11th PSCC Conference, Avignon, August 30 – September 3, 1993.

[3] Knut S. Hornnes: A model for coordinated utilization of production and transmission possibilities in a power system dominated by hydropower. Dr.ing.-thesis 1995, The Norwegian Institute of Technology, Department of Electrical Power Engineering. ISBN 82-7119-865-3. ISSN 0802-3271.

A5.2_1 Regional Additional Market Study Scenarios Simulated

Different CO_2 prices

Sensitivity case shows that the investment portfolio is also adequate for the situation with different CO_2 prices. Net energy flows are from North to South in this sensitivity case similarly to base scenarios, except for the flow between Denmark and Germany in scenario EU2020 with low CO_2 price. The biggest changes compared to the base scenarios are in balances in Germany, Poland, and Denmark and in flows between those three countries.

The following figures illustrate the net flows and balances after CO_2 prices are switched. The figures show the changes relative to the corresponding base scenarios. In the EU2020 scenario the decrease in CO_2 price affects Germany, Poland and Denmark most of all. The generation in Germany and Poland increases, which in turn increases the flows from South to North. In addition, the export from RGBS to other RGs increases compared to the base EU2020 scenario. The generation in Denmark decreases significantly because of inexpensive lignite generation in Germany and Poland. In Baltic countries total generation also decreases for the same reason. In the EU2020 sensitivity case RGBS is a net exporter.

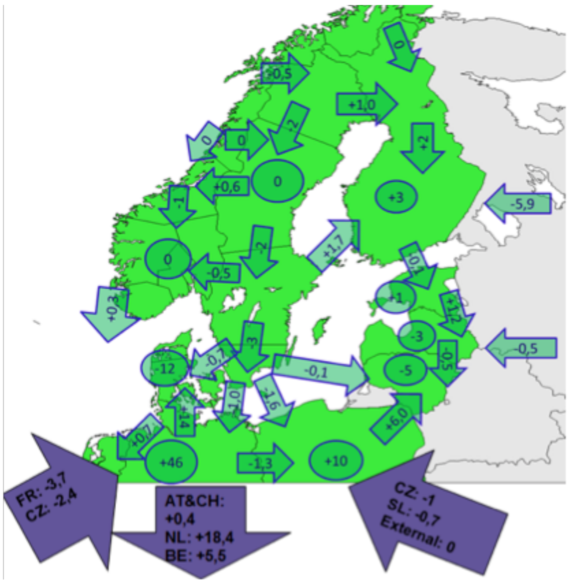


Figure 45:
Netflows and balances in scenario EU2020 with different CO_2 prices (difference from the base EU2020 scenario; TWh/a)

In the B scenario the increase in CO_2 price affects Germany and Poland most significantly. The generation in both countries decreases. Flows from North to South and West to East increase and import to RGBS increases compared to the base B scenario. RGBS is a net importer in this sensitivity case.

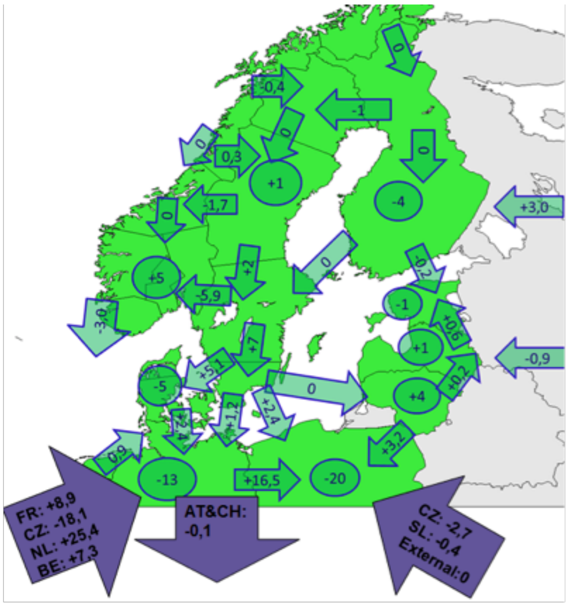


Figure 46:
Netflows and balances in scenario B with different CO_2 prices (difference from the base B scenario; TWh/a)

Average price differences from the regional average price weighted by consumption in this sensitivity case are presented below. Prices in the Baltic Sea region converge after the investment portfolio similarly to base scenarios.

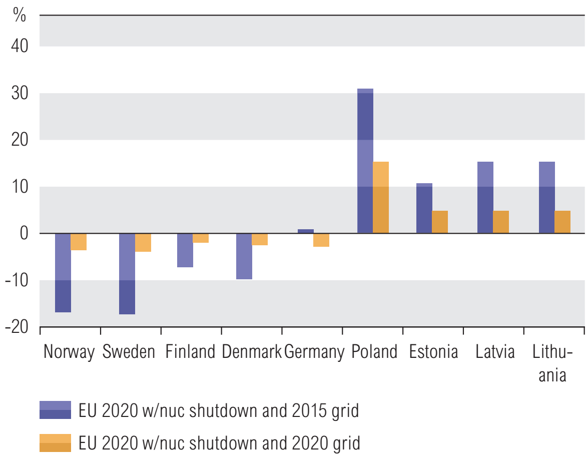


Figure 47:
Average price differences from the consumption weighted average prices in RGBS region in scenario EU2020 with different CO_2 prices (€/MWh)

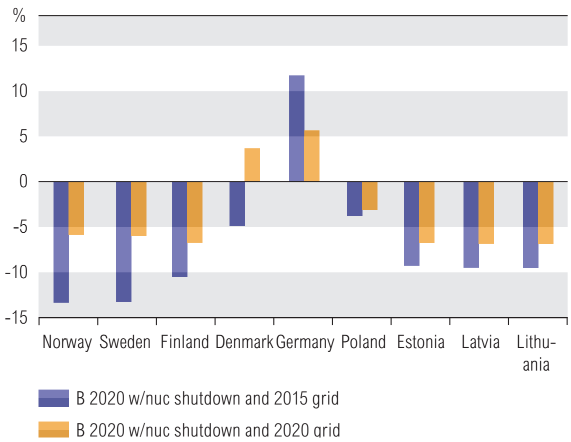


Figure 48:
Average price differences from the consumption weighted average prices in RGBS region in scenario B with different CO_2 prices (€/MWh)

The following table shows the electricity market benefit, savings in generation costs, and change in CO_2 emissions in the Baltic Sea region due to the investment portfolio. In the EU2020 sensitivity case the savings in generation costs are low and CO_2 emissions increase because lignite replaces gas and export from RGBS to other RGs increases after the investment portfolio. Total electricity market benefit is lower than in base case EU2020 because consumer benefit decreases relatively more due to increased export which increases prices. In B sensitivity case import to RGBS decreases which leads to higher generation costs in the RGBS region. Even if generation increases, CO_2 emissions decrease because coal based generation is replaced with natural gas based generation. Total electricity market benefit is lower than in the base case B mainly because congestion rents decrease in this case more than in the base case due to higher CO_2 price which leads to bigger price differences. Consumer and producer benefits are about the same as in the base case B.

	EU 2020 with different CO_2 prices	Scenario B with different CO_2 prices
Electricity market benefit	540	150
Savings in generation costs	7	–120
Change in CO_2 emissions	+7,7	–1,7

Table 5.
Electricity market benefit (M€/a), savings in generation costs (M€/a) and change in CO_2 emissions (Mt/a) in RGBs due to the investment portfolio in scenarios EU2020 and B with different CO_2 prices

A5.3_1 Wet and Dry Year Balances and Net Flows

The following figures show the balances and net flows in the Baltic Sea region in a wet year and in a dry year. In a dry year the direction of the flows turns and net energy flows are from continent to Nordic countries.

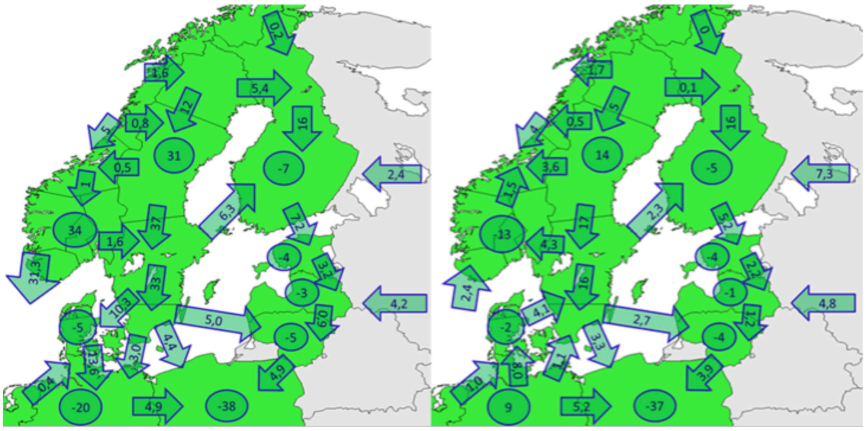


Figure 49:
Balances and net flows in EU2020 with 2020 grid in wet year (left) and dry year (right) (TWh/a)

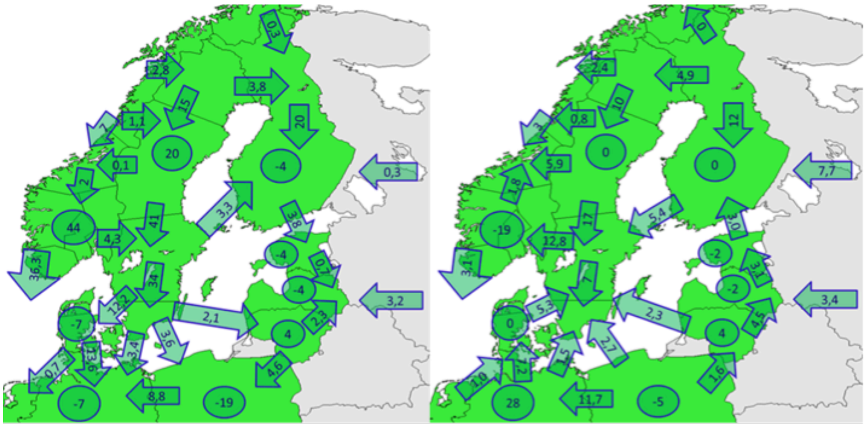


Figure 50:
Balances and net flows in B2020 with 2020 grid in wet year (left) and dry year (right) (TWh/a)

A5.3_2 Price Convergence in EU2020 and Scenario B with Nuclear Phase out in Germany

Average prices in EU2020 and scenario B with Nuclear Phase Out are presented in the following figures. Similar to base scenarios EU2020 and B, prices in the Baltic Sea region converge with the investment portfolio.

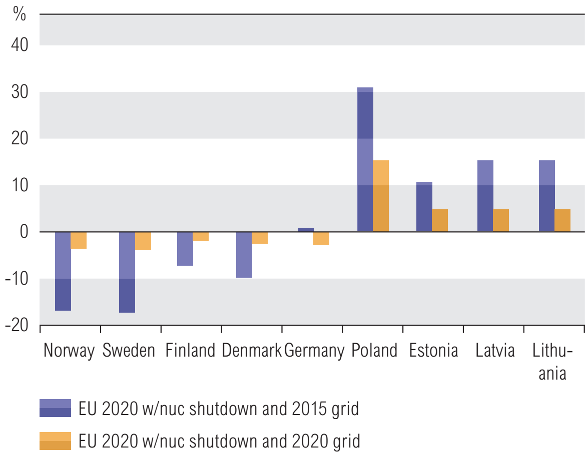


Figure 51:
Average price differences from the consumption weighted average prices in RGBS region in scenario EU 2020 w/ nuclear phase out

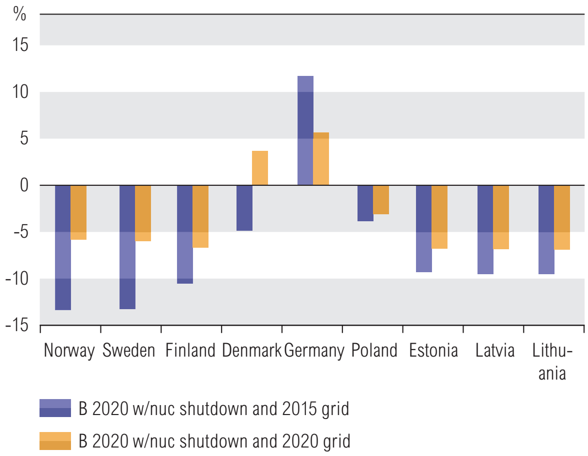


Figure 52:
Average price differences from the consumption weighted average prices in RGBS region in scenario B w/ nuclear phase out

A10.1_1 Snapshots and Grid Studies

To determine the NTCs and to check the network capability in different operational regimes and stressed situations several network studies were performed in all Baltic Sea region member TSOs. One of the objectives of the network studies was to analyze the network performance in strained situations with the basic inputs from market studies. Some of the examples are presented below for different areas of the Baltic Sea region.

Snapshots and Grid studies in the North and West part of the Baltic Sea Region

Four different snapshots were studied to verify NTC and GTC values as well as the technical resilience of the investment portfolio. Static and dynamic analysis was carried out on the snapshots.

Regarding operational conditions in the North part of the observed area the flow capacities are determined by means of the following restrictions:

- Capacity from North Finland to South Finland is dimensioned by thermal limits.
- Capacity from South Finland to North Finland and further to North Sweden is dimensioned by dynamic instability (oscillations).

- The capacity from North Sweden to South Sweden is dimensioned by voltage stability.
- The capacity from North-Sweden to Northern Finland is dimensioned by thermal limits.

The investment portfolio was found technically resilient and suitable to serve the power flows that the market model produced. New bottle necks would arise without the investments or planned production could not be connected. With the investment portfolio the network is also N-1 secure under extreme conditions. The analysis made on the snapshots showed no problems in the Swedish grid.

The 400 kV voltage level has been found optimal for transmission of electricity in Nordic countries and series capacitors are used to compensate the reactance of the long transmission lines to increase the transmission capacity where it is limited by dynamic instability. Series capacitors will also be used on new long 400 kV lines, where it is technically feasible. In addition, other FACTS devices such as SVCs are used when found profitable.

The snapshots were also used for analyzing the previously reported NTC values. This analysis showed that the reported values were still found to be correctly assumed.

The Nordic power balance is estimated to be increasingly positive, both in the short- and the long-term, even in strained winter situations. Plans of new renewable energy such as small hydro plants in Norway and wind power plants in both Norway and Sweden contribute to making new HVDC-interconnector investments profitable. However, the marginal benefit from each cable will decrease. Transit situations will also occur more often, typically on cold winter days with high load and insufficient domestic production availability to maximize the export.

Snapshots and Grid studies in the South-West part of the Baltic Sea Region

- Regional Group Baltic Sea prepared and analyzed a single planning case for the South-West part of the region:
  - High wind in Denmark and highest power flows from South Norway to other areas in Norway with the following selection procedure:
  - First, filtering situations with high wind production in Denmark;
  - Then, summing up and sorting in decreasing order simultaneous transmissions from South Norway to other areas in Norway;
  - Finally, choosing a situation with the highest flows and highest wind at the same time.

The resulting planning case for Denmark is illustrated in following figure. Since the borders Denmark West (DK-W) to Norway, Sweden and the Netherlands as well as Denmark East (DK-E) to Germany and the domestic border DK-W to DK-E are HVDC based, the focus of grid studies has been the evaluation of risks of internal contingencies and NTC violations at the AC based borders DK-W to Germany and DK-E to Sweden.

Figure 53 summarizes the grid study types for the Danish synchronous areas: DK-W and DK-E.

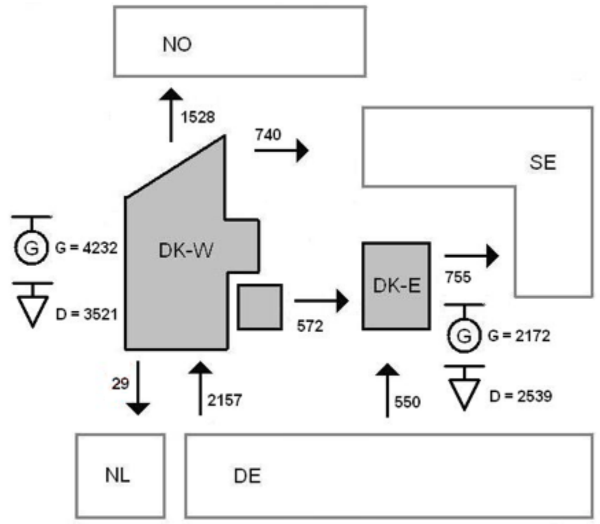


Figure 53:
Initial power balance of South-West planning case. G and D mean generation and demand, respectively. The power exchange directions are by arrows.

Regarding the transmission system in the South-West part of the region, the DC load-flow and N-1 contingency analysis should be sufficient procedures with which to evaluate the risk of internal contingency or NTC violation at the Danish AC borders. In addition, the AC load-flow and N-1 contingency analysis were performed to: (i) secure the results of the DC load-flow based approach and (ii) confirm that the voltage profiles remain within acceptable operational ranges. The dynamic stability simulations were made to ensure that a 3-phase short-circuit fault with tripping of the affected component would not lead to massive post-sequential disconnection of (dispersed) generation with a possibly larger risk of NTC violations than that from the DC and AC load-flow based assessment.

Synchronous area	Load flow		N-1 contingency		Dynamic stability
	DC	AC	DC	AC	
DK-W	√	√	√	√	√
DK-E	√	√	√	√	·/·

Table 6:
Grid study types for South-West

The grid studies have not disclosed any risk of internal contingency or NTC violation at the Danish borders. However, several concerns regarding the selected planning case were raised:

- The grid studies are detailed, but only made for a single planning case
- After an inspection of domestic generation, demand and values / directions of power exchange at the Danish borders, it was found that the selected planning case could not lead to a risk of NTC violation or internal contingency within the Danish transmission system.

For example, outage of the Cobra HVDC link to the Netherlands, with initial 29 MW power flow to the Netherlands, would reduce the power transport through the AC connections to Germany reducing the risk of NTC violation. Outage of a generation unit in Denmark East or an HVDC link either from Denmark West or from Germany to Denmark East would reduce the power transport through the AC connections to Sweden thus reducing the risk of NTC violation. Such obvious observations made through inspection of the selected planning case have been confirmed by grid studies.

Snapshots and Grid studies in the East and East-South part of the Baltic Sea Region

Calculation methodology

A steady state grid analysis was performed according to snapshots nr 7 – 10 in Chapter 4.3 and the calculation results were verified by each Baltic country checking the transmission adequacy inside national power systems and on the interconnections with neighboring countries. Grid analyses were performed by using modeling and simulation software PSS/E.

Observations during normal operation and N-1 contingencies were made in order to verify the following criteria:

- Operation voltage limit check on 110 kV and 330 kV grid
- Thermal flow limits for lines and transformers at 330 kV level
- Thermal limits on 3-winding power transformers

The following n-1 contingencies were analyzed:

- Consequently tripping of all 330 kV lines
- Consequently tripping of all 330 kV power transformers

Snapshot selections

For adequacy analysis of transfer capabilities in Baltic States – Estonia, Latvia and Lithuania, four different snapshot cases were developed from the market simulations, to verify the results with the grid calculations in the corresponding grid models. The overview of the selected snapshots is given in the following figures and tables.

The summary of the generation and consumption balances and transmission flows for snapshots 7 – 10 are displayed in the tables below.

	Snapshot			
	7	8	9	10
ESTONIA				
Generation	973	657	1315	922
Demand	1395	1045	1129	1460
Balance	-422	-389	187	-538
LATVIA				
Generation	771	1407	1458	407
Demand	1298	966	1159	1189
Balance	-527	441	299	-782
LITHUANIA				
Generation	1291	649	1350	710
Demand	1643	1339	1387	1718
Balance	-352	-690	-38	-1008

Table 7:

Balance summary of Baltic States for snapshots nr. 7 – 10. Values in the table are given in MW units.

From	To	Snapshot			
		7	8	9	10
Estonia	Latvia	578	575	184	462
Finland	Estonia	1000	965	-1	1000
Russia	Estonia	0	0	0	0
Russia	Latvia	0	0	0	288
Russia	Lithuania	600	16	600	312
Latvia	Lithuania	52	1016	484	-32
Lithuania	Poland	1000	1000	1000	-107
Lithuania	Sweden	-700	-658	46	-621

Table 8:
Interchanges in Baltics for different snapshots, MW

Snapshot NR 7 – maximum power flow on DC links

Snapshot 7 represents the situation when the sum of simultaneous DC links flows, regardless of direction of the flow, is at the maximum level. Four HVDC links were observed – two HVDC links between Estonia and Finland (Estlink1 and 2) with total capacity of 1,000 MW, HVDC link between Lithuania and Sweden with maximum capacity of 700 MW and between Lithuania and Poland with capacity of 1,000 MW.

Figure 54:
Snapshot nr 7 – System load, generation and HVDC flows for Baltic States

Snapshot NR 8 – Maximum absolute transit in Baltic countries

Snapshot 8 represents the situation when the simultaneous transit flow between Baltic States, regardless of direction of the flow, is at the maximum level. The snapshot summary is represented in Figure 55 below.

Figure 55:
Snapshot nr. 8 – System load, generation and HVDC flows for Baltic States

Snapshot NR 9 – Maximum simultaneous generation surplus in Baltic countries

Snapshot 9 represents the situation when the Baltic States have the highest generation surplus. The overall simultaneous generation In Baltic States covers all the system load and surplus is mainly exported to Poland. The snapshot summary is illustrated in Figure 56 below.

Figure 56:
Snapshot nr. 9 – System load, generation and HVDC flows for Baltic States

Snapshot NR 10 – Maximum simultaneous energy deficit in Baltic countries

Snapshot 10 represents a situation whereby there is a highest simultaneous energy deficit in Baltic countries. The sum of simultaneous generation is not covering the load in Baltic States and the energy deficiency is covered by import mainly from HVDC links. The snapshot summary is illustrated in Figure 57 below.

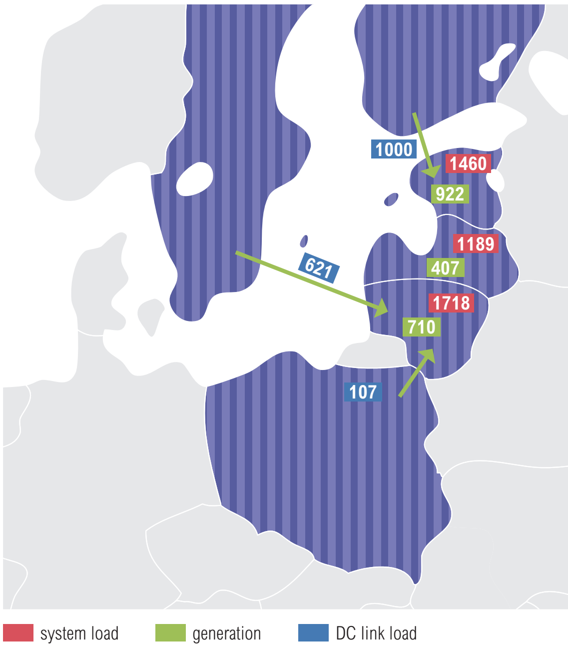


Figure 57:
Snapshot nr. 10 – System load, generation and HVDC flows for Baltic States

Calculation results of East and East-South area

The calculation results in case of snapshots nr 7 to 10 showed full compliance with the stated operational criteria in all Baltic States. It means the operational voltage in 330 grid was in the range of allowed values and the power flown in 330 kV network and power transformers did not exceed the given thermal or other limits, defined by TSOs.

The calculations also showed that without the new projects in Baltics that are listed in the ten year network development plan the grid would be not sufficient to carry such flows resulting from the market studies. Although there were no voltage and loading violations identified it was observed that in some cases the flows were almost close to the maximum allowed. This may well draw one to the conclusion that the grid reinforcements are neither overestimated nor underestimated.

12.1 Abbreviations

AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power Generation
DC	Direct Current
EIP	Energy Infrastructure Package
ELF	Extremely Low Frequency
EMF	Electromagnetic Field
ETS	Emission Trading System
ENTSO-E	European Network of Transmission System Operators for Electricity (see § A2.1)
FACTS	Flexible AC Transmission System
FLM	Flexible Line Management
GTC	Grid Transfer Capability (see § A2.6)
HTLS	High Temperature Low Sag Conductors
HV	High Voltage
HVAC	High Voltage AC
HVDC	High Voltage DC
KPI	Key Performance Indicator
IEM	Internal Energy Market
LCC	Line Commutated Converter
LOLE	Loss of Load Expectation
NGC	Net Generation Capacity
NRA	National Regulatory Authority
NREAP	National Renewable Energy Action Plan
NTC	Net Transfer Capacity
OHL	Overhead Line
PEMD	Pan European Market Database
PCI	Project of Common Interest (see EIP)
PST	Phase Shifting Transformer
RAC	Reliable Available Capacity
RC	Remaining Capacity
RES	Renewable Energy Sources
RG BS	Regional Group Baltic Sea
RG CCE	Regional Group Continental Central East
RG CCS	Regional Group Continental Central South
RG CSE	Regional Group Continental South East
RG CSW	Regional Group Continental South West
RG NS	Regional Group North Sea
SEW	Social and Economic Welfare
SO&AF	Scenario Outlook & Adequacy Forecast
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
VSC	Voltage Source Converter

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