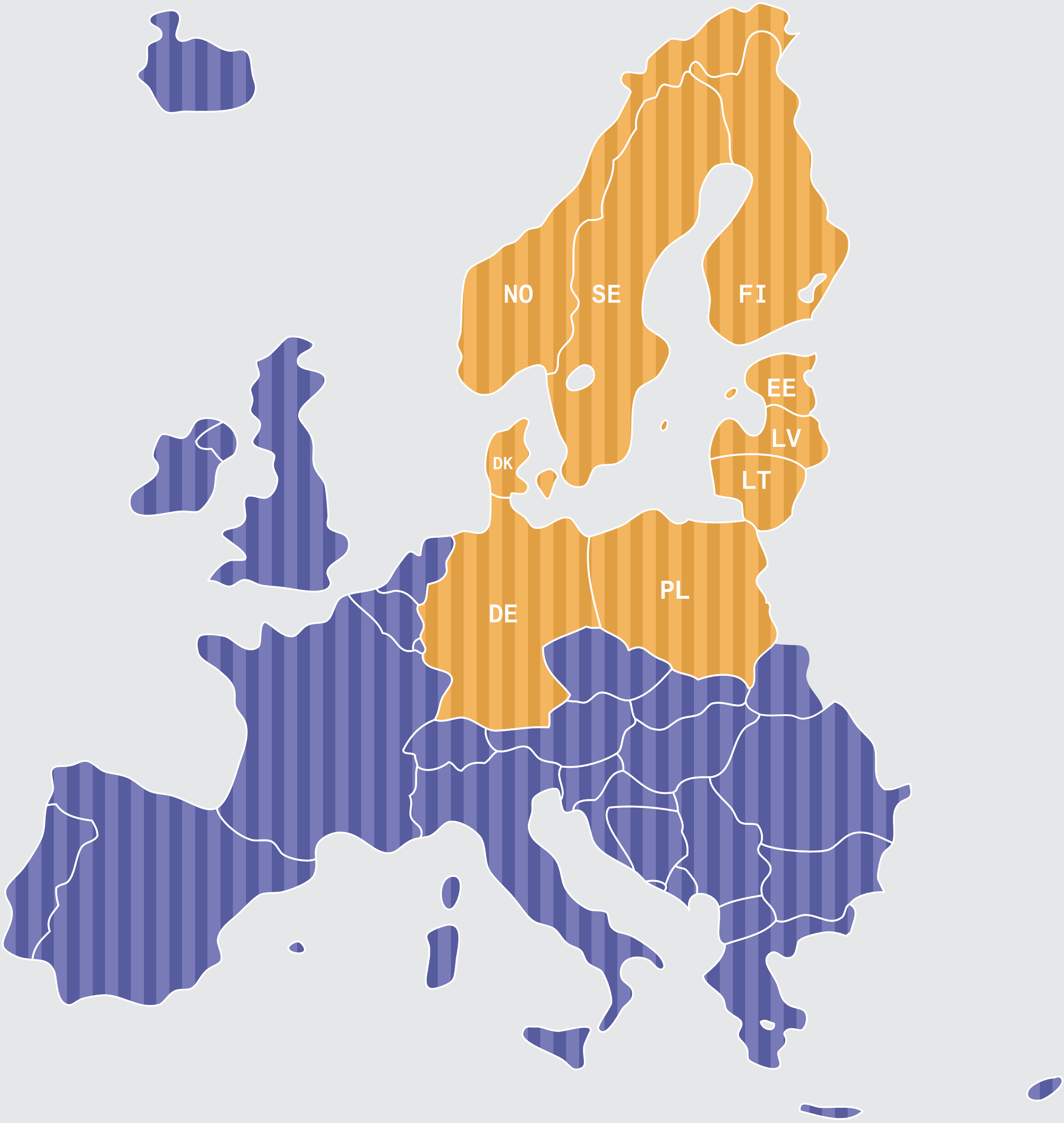
REGIONAL INVESTMENT PLAN 2014
BALTIC SEA Final



European Network of
Transmission System Operators
for Electricity

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0 Executive summary

0.1 ENTSO-E delivers the TYNDP 2014 Package

Every two years, the European Network of Transmission System Operators for Electricity (ENTSO-E) publishes the Ten-Year Network Development Plan (TYNDP). Together, the Regional Investment plans, the Scenario Outlook and Adequacy Forecast, provide a reference for the development of the European electricity grid development. The TYNDP identifies reinforcements of significant importance which are required to facilitate connection of large volumes of RES and for the integration of the energy market whilst maintaining the security of supply. The TSOs of the Regional Group Baltic Sea within the ENTSO-E present this Regional Investment Plan for 2030, additionally including projects of regional importance. The Baltic Sea region within ENTSO-E covers Denmark, Norway, Sweden, Finland, Estonia, Latvia, Lithuania, Poland and Germany.

0.2 What is new in the TYNDP 2014?

- Active Stakeholders engagement contributed to the Baltic Sea Regional Investment plan 2014.

ENTSO-E developed in strong cooperation with stakeholders, the TYNDP and Regional Investment plans. Stakeholders contributed via European and regional workshops, public web-consultations and bilateral meetings.

- Third parties further involved

During the preparatory phase of the TYNDP, ENTSO-E updated its third party process to ensure that third party projects could be considered in a non-discriminatory manner which resulted in the successful incorporation of their transmission investment proposals and their storage investment third party proposals.

- CBA improvement

Previously TYNDP 2012 utilized a multi criteria assessment methodology for assessing the projects. In the TYNDP this process have been further refined and developed in an open and transparent manner in accordance with the requirements defined in the Reg. (EU) 347/2013. This robust and consistent methodology applied to all TYNDP project assessments, including assessment of candidate projects of common interest.

- Four different Visions until 2030 -

With engagement of the stakeholders four different futures (Visions) have been developed, which consider a range of possible future outcomes based around a range of potential energy policies. The objective of developing these Visions is to ensure any future transmission proposals are robust against future uncertainties.

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0.3 The TYNDP 2014 explores four different visions of development until 2030

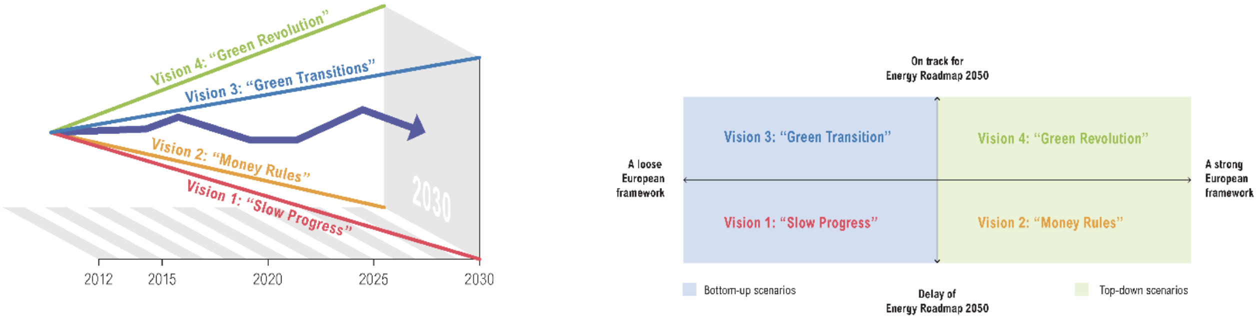

Figure 1Illustration of four Visions

By 2030, the changes in the generation mix as described in the Visions will result in increased power flows between the regions and between the member states within the region.
Given the significant increase in volumes of RES in the Baltic Sea Region, to avoid heavy curtailment of RES output, additional interconnection-capacity would be required.

A more flexible power system is required due to two main reasons:

- A shift from thermal to renewables.
  This generation shift causes new transport patterns, which increases the need for more flexibility in the transmission system. Adding interconnectors to the system is one way of providing flexibility. This flexibility is required in order to integrate renewables whilst maintaining adequate security of supply.

- A shift from coal to gas.
  The analysis shows that new interconnectors between the different synchronous areas of the Region Baltic Sea, leads to large reduction of the regional CO2-emissions. Especially interconnectors going between
    - the hydro-based Nordic system with seasonal patterns and the increasingly wind/solar – based UK and Continental systems with hourly patterns contributes both to a large amount of renewables in the system and to a large reduction of the regional CO2-emissions.

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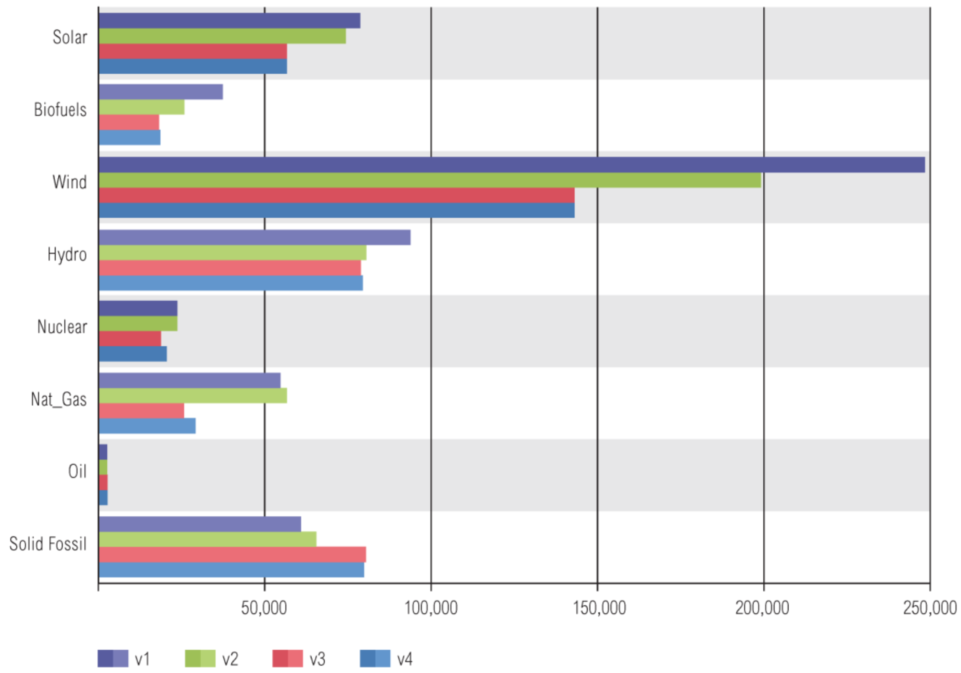

Figure 2 Installed generation capacity in the Baltic Sea Region in Visions 1, 2, 3 and 4. Installed capacities are in total. V1: 435 GW; V2: 430 GW; V3: 541GW; V4: 608GW

Even with four visions there are still some uncertainties in the future system that affect the grid development planning including: location of new RES capacity; interaction with third countries; evolution of nuclear capacity; competitiveness of generation investments; Regional group Baltic Sea prepared some sensitivity cases in order to be more certain on the effects of some of these uncertainties. The analysed sensitivity are named (1) Low Nuclear, (2) Delays in project commissioning and (3) Baltic Sea Green Vision. Sensitivity analyses are described in Appendix "Sensitivity analyses".

0.4 Investment drivers in Baltic Sea Region

The Baltic Sea region covers three different synchronously connected power systems, Continental Europe, Nordic, the Baltic States and IPS/UPS of Russia, which are linked with HVDC connections. Currently the Nordic system is linked via several HVDC cables with Continental Europe, 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 system. Parts of the region are large and scarcely populated, which causes additional challenges in transmission of electricity. Dynamic phenomena restrict the transmission capacity due to long distances between production and consumption areas.

The main drivers for system development in the region are the expected increase in renewable generation initiated by policy targets and higher primary energy prices, as well as the aim of securing a dynamic internal electricity market across Europe.

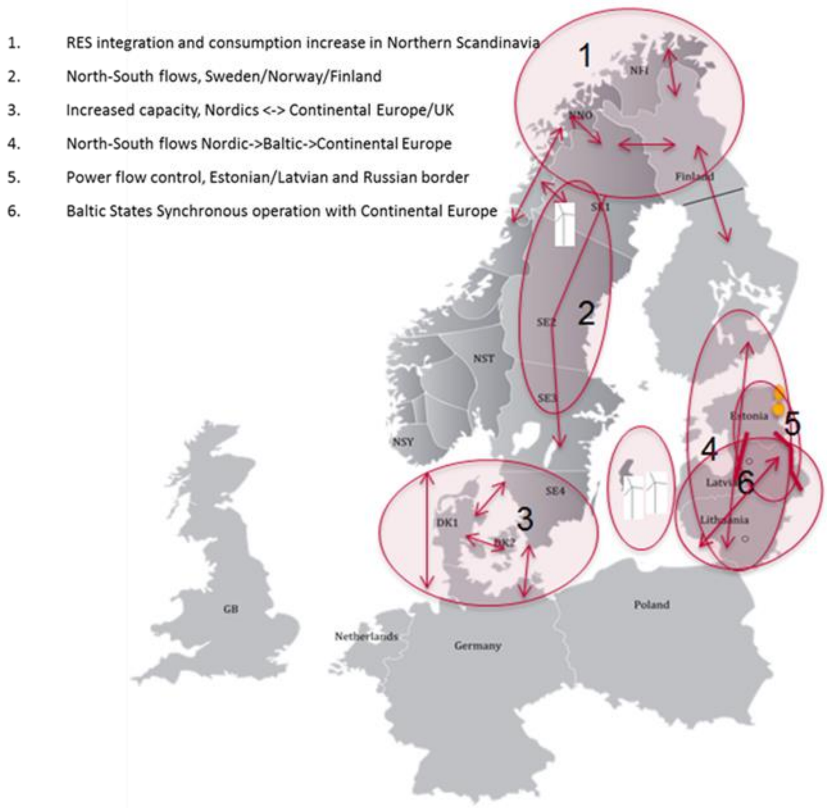

Figure 3 Regional topics of interest, studied during exploratory studies

The EIP (Energy Infrastructure Priorities) call for further integration of the Baltic States into the common European electricity markets and further integration of the Nordic countries with the Continental European systems. This will make the system more robust and give possibilities to accommodate larger amounts of renewable energy sources (RES) within and around the region. New connections between Nordic and Continental European countries are necessary to handle the changes in generation portfolios in the Continental countries and the Baltic Sea region. The nuclear phase out plan in Germany and further integration of RES into continental systems also make connections to the large hydro systems in the Nordic area interesting from a feasibility point of view. In addition to the existing and planned direct connections from the Nordic countries to central Europe, the transmission system of the Baltic States after connection to the central European network will serve as an alternative route between Nordic and Continental Europe.

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Figure 4 Baltic electricity peninsula

The PCI project Estonia/Latvia/Lithuania synchronous interconnection with the Continental European networks is aimed at infrastructure development for deeper market integration and synchronous operation of the power systems of the Baltic States with the Continental European networks. Two different landing points and two differently routed interconnections are required to achieve physical separation of the two redundant interconnections in order to establish a reliable synchronous connection between the transmission systems of Baltic States and Continental Europe networks. The first Lithuania – Poland connection (LitPol Link) is already decided and it will be the first connection. The second connection is still under investigation. The projects consists mainly of the 330-400 kV cross-border lines and internal lines in order to reinforce internal grids to handle the situation. Baltic Power System synchronisation with the Continental Europe network is a unique project as a main driver for not increase of the Grid transfer capacity but to disconnect from the synchronous operation with the IPS/UPS system and connect with the Continental European networks synchronously. During 2012-2013 Lithuanian, Latvian and Estonian TSOs carried out the Feasibility study "Interconnection Variants for the Integration of the Baltic States to the EU Internal Electricity Market" to evaluate the possible technical and economic consequences and benefits of synchronizing power systems of Baltics within synchronous area of Continental Europe. The study was prepared by Gothia Power Company. The list of investments is not final and is very preliminary including just a few of probable necessary investments. Only SEW was analysed via simplified capacity increase approach and no grid studies were performed in this stage as the exact route and investments are not decided yet.

0.4.1 Main flows from North to South

In visions 1 and 2 there are large North-South flows prevailing in the region and additionally some interchange of power from east to west depending on the wind generation. Nordic surplus is exported to Central Europe mainly through Scandinavia-Continental Europe connection links. In the Baltics the flows tend to be both north and south bound, depending mainly on the RES generation in Nordics. As these visions have relatively low CO2 prices compared to other two visions, Poland is a large exporter with its large thermal generation with a main direction to Germany.

In total, the Baltic Sea region is an exporting region in Vision 1. The dominant energy flows are directed from the Nordics towards Central Europe as illustrated below.

In Vision 3 and 4 the flows are still mainly from the north towards central Europe, but the large amounts of intermittent energy ensures more fluctuation in the flows on interconnectors which especially can be seen on the interconnectors to the UK. It should also be noted that the flows through the Baltics become more one-directional as the price of CO2 increases the need for import from Nordic countries.

A major tendency in the anticipated visions is the energy flow from the Nordic countries to other areas of Europe. This is mainly facilitated by the surplus in the Nordic countries, where excess hydro, nuclear and wind power is available. Germany, Poland and the Baltic States are the main recipients of this energy with Germany acting as a net-importer especially in Vision 3 and 4. This is due to the phase-out of the nuclear power plants and high share of coal power plants, of which competitiveness is reduced by the rising CO2 costs in visions 3 and 4. Poland is also an importer of low marginal cost energy in Vision 3 and 4 due to very high share of coal power. The main transmission direction will be north-south in the Baltic and the Nordic countries and east-west; west-east between Finland, the Baltic States and UK, Continental Europe.

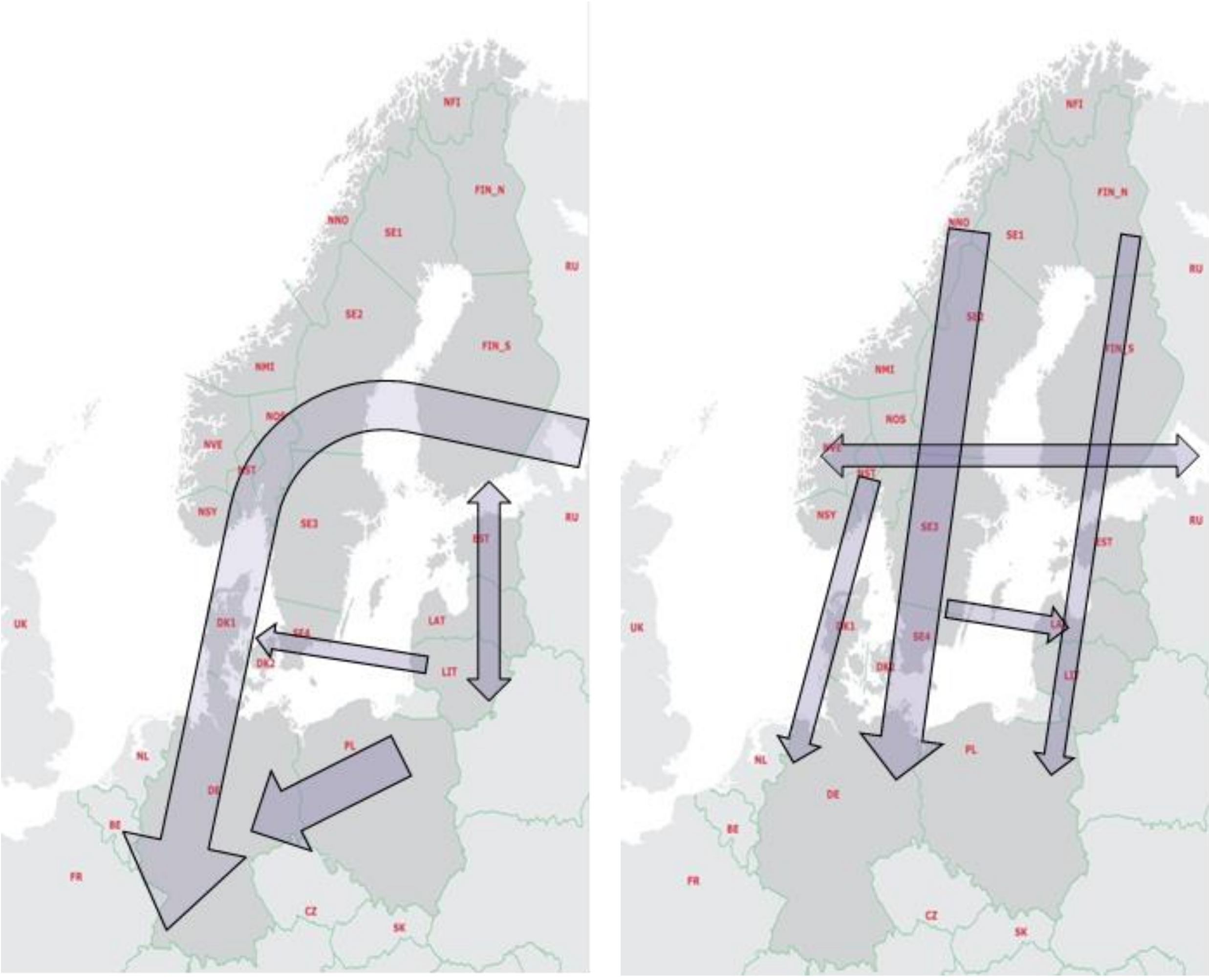

Figure 5 Bulk power flows: Visions 1 and 2 (left); Visions 3 and 4 (right);

The largest bottlenecks appear on boundaries between Scandinavia and Central Europe and North – South flows from North Scandinavia to Southern Scandinavia, where interconnectors are loaded in range of 80-90%. Also interconnections from the Baltics to Scandinavia are heavily utilised, up to about 70% on average throughout the year.

0.4.2 Integration of RES

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 all around the region, but mainly concentrating on the coastal areas and the highlands in the North of the region. New wind and hydro generation in the northern areas which already have a high surplus of energy balance requires a strengthening of internal grid in North-South direction in Sweden, Norway and Finland, additionally to interconnection capacities between the countries.

Lack of grid capacity would most probably lead to lower investments in RES, and hence not achieving RES targets. The high power flows between the Nordic area and Continental Europe will also create additional motivation for reinforcements within the Continental European grid.

0.5 Investments and analysis results

In response to the investment needs, the Regional Investment Plan 2014-2030 for the Baltic Sea Region includes internal projects in the region as well as several interconnectors. However German and Polish internal projects are analysed in the Continental Central East group of ENTSO-E. Part of the project portfolio was presented in the TYNDP 2012, but reassessed within the framework of TYNDP 2014. Of the investments presented in TYNDP 2012, the majority remain on schedule however, some projects have changed in terms of commissioning date, status or in project detail. Delays are mainly caused by time consuming permitting processes. The projects geographical location can be seen in figure below.

Furthermore ENTSO-E has received 3 submissions related to 3rd party project in the Baltic Sea Region.

Two storage projects did fulfil the ENTSO-E legal rules of submission and Regional Group Baltic Sea has provided assessment for two Pump Storage projects, one in Estonia and one in Lithuania. The projects are described in Chapter 7.7.2.

Results of the analysis show that the investment portfolio presented in this plan gives flexibility and provides a good and functioning infrastructure on track towards the European vision of a competitive internal market and a low-carbon energy future. The planned investment portfolio is robust, resilient and beneficial and with the presented investment portfolio the Baltic Sea region within ENTSO-E will become more integrated with the rest of European electricity market. Due to the high amount of 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 better-functioning markets.

All the analysis have been done based on an approach that assumes all assessed projects realized. This makes the results for each project assessment conservative with the result of low values for some of the benefit indicators. In reality we are observing that many projects are delayed, and in many cases not finding a positive business-case. If assuming such delays in the investment-portfolio, the benefit indicators for the different projects would have been higher.

For the studied Visions some investments in the portfolio were found to give low socioeconomic benefit, however they are important for other needs. If large unexpected changes compared to the assumptions made in the scenarios appear, more investments may also be required. In total the Regional Investment Plan assesses an investment portfolio of about 55-75 billion Euros for the countries within the Baltic Sea Region. Germany is having the largest investment portfolio. The planned investment covers several types of technology.

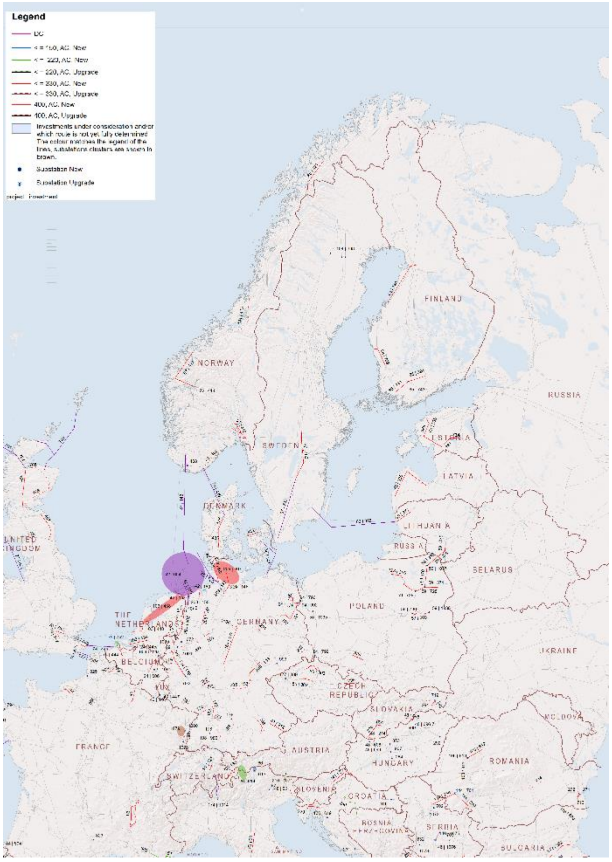

Figure 6 Midterm Projects

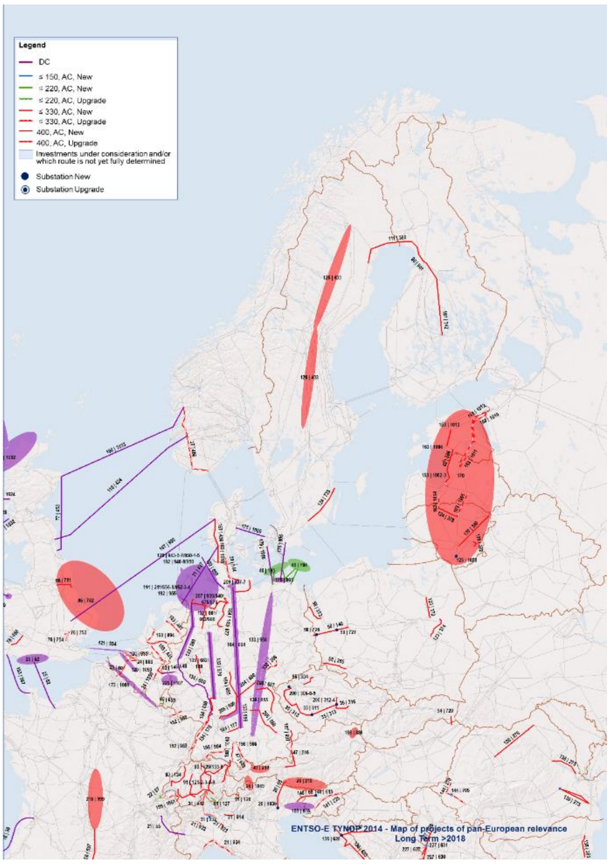

Figure 7 Long term projects

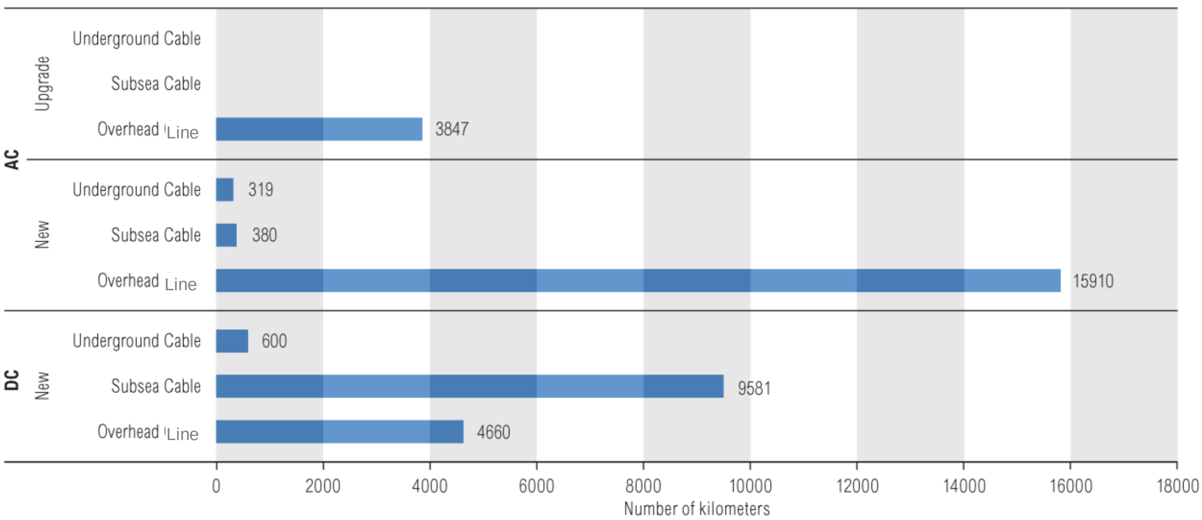

Figure 8 TYNDP 2014 BS region investment portfolio - breakdown per technology

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0.5.1 Main challenges regarding implementation

A major challenge is that the grid development may not be in time if the EU-wide targets are met. Permit granting procedures are lengthy, and may cause commissioning delays. Based on the regional sensitivity analysis delays can cause up to 600 M€ loss in the socioeconomic welfare compared to a situation where all projects are commissioned on time.

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 outages in the existing grid during construction and commissioning to account for voltage upgrading of lines and substations, which could potentially put security of supply at risk temporarily and have a negative impact on trading capacity.

There are also uncertainties regarding the market development on the EU-Russian border which subsequently have a significant impact on the flows on the interconnections to Russia. In addition, a significant uncertainty regarding the generator investments exists.

0.5.2 The resilience of the Plan opens a large choice of options to fulfil the European energy policy goals

Thousands of market situations have been simulated and processed for this TYNDP 2014. Frequent situations, or rare ones that result in particularly extreme flow patterns have been identified for further analysis. This is in order to test the grid's ability to withstand them and define where necessary, the required measures needed to stabilise it. Typically such situations are peak load hours in winter or summer with, extreme but likely, high or low RES generation.

Such thorough investigations were performed for all four visions by 2030.

Thus, TSOs can ensure the proposed investments are adapted and robust. The already proposed grid investments from TYNDP 2012 remain valid with the only exceptions being projects which were in a very early phase in 2012 and have subsequently proven technically infeasible.

The proposed projects cover most interconnector investment needs. Conversely, some additional reinforcements are still to be designed to cover investment needs specific to the most ambitious scenarios of RES development by 2030.

The following map sums up the situation in this respect. The boundaries where the project portfolio is sufficient to cover the target capacity in all Visions are in green, insufficient in all Visions in red; otherwise it is in orange. Where boundaries are orange or red, the Plan may need to be improved, still all the listed projects are prerequisite. In this respect, the project portfolio shows strong resilience and paves the way for the implementation of the 2050 European Energy goals.

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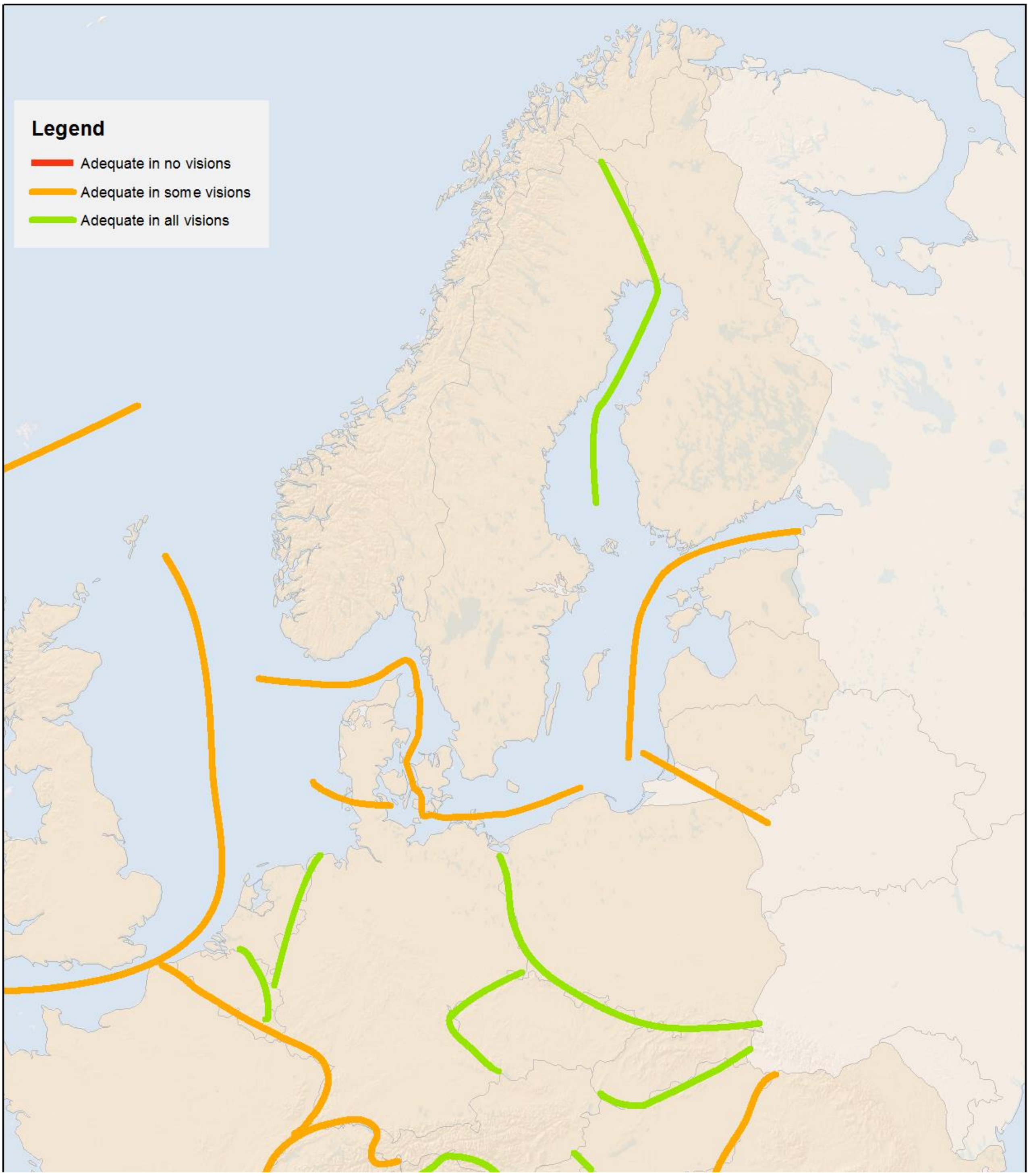

Figure 9 Transmission adequacy by 2030

0.6 The preparation of the TYNDP 2016 has already started

0.6.1 With the TYNDP 2014, ENTSO-E supports the EIP implementation

With the late finalisation of the scenarios, CBA methodology, and 3rd party project submission by Fall 2013, completing the TYNDP 2014 for consultation by Summer 2014 was a challenge. The timely delivery of the TYNDP 2014 is however expected as an important input to the EIP process: a systematic assessment is now available for all transmission and storage PCIs.

0.6.2 The TYNDP methodology keeps improving

For future TYNDPs and assessments, ENTSO-E and all interested stakeholders plan to evolve the CBA further to better match the decision makers' needs.

Especially, it is already foreseen that the present methodology can be improved with respect to the so-called "capacity" value of assets (compared to the "energy" value). Storage projects in particular bring great capacity and flexibility to the power system that will be better reflected in their assessment in the future.

Additionally, the TYNDP 2016 will continue building on the findings of the e-Highways project led by ENTSO-E, and depict further the path to the 2050 master plan.

0.6.3 Energy transition requires grid, grid requires everyone's support

A major challenge is that the grid development may not be in time if the RES targets are met as planned by 2030. Permit granting procedures are lengthy, and often cause commissioning delays. Approximately 1/3 of the projects shown in TNDP 2012 are delayed, with the most frequent reason being difficulties in gaining permits and seeking public consent.

If energy and climate objectives have to be achieved, it is of outmost importance to smooth the authorisation processes. In this respect, ENTSO-E welcomes Regulation 347/2009 as there are many positive elements in the permitting section which will facilitate the fast tracking of transmission infrastructure projects including the proposal on one stop shop and defined time lines.

More thorough analyses is however required to ensure the measure can be successfully implemented in particular in relation to whether the timelines proposed are achievable, particularly in the context of the public participation process and the potential for legal delays. One must also notice that the supporting schemes are limited to the Project of Common Interest whereas there are many significant national transmission projects which are crucial to the achievement of Europe's targets for climate change, renewable and market integration.

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1 Introduction

1.1 ENTSO-E compiles a vision for grid development: the TYNDP package 2014

The European Network of Transmission System Operators for Electricity (ENTSO-E) provides herewith the 2014 release of the Community-wide Ten-Year Network Development Plan (TYNDP).

The objective of the TYNDP is to ensure transparency regarding the electricity transmission network and to support decision-making processes at regional and European level. This pan-European report and the appended Regional Investment Plans (RgIPs) are the most comprehensive and up-to-date European-wide reference for the transmission network. They point to significant investments in the European power grid in order to help achieve European energy policy goals.

Since the 2012 release, ENTSO-E supplies a TYNDP "package", a group of documents consisting of the following:

- the present Community-wide TYNDP report 2014
- the 6 Regional Investment Plans 2014; and
- the Scenario Outlook and Adequacy Forecast (SOAF) 2014.

Collectively, these documents present information of European importance. They complement each other, with only limited repetition of information between documents when necessary to make each of them sufficiently self-supported. Scenarios are comprehensively depicted in the SOAF; investments needs and projects of European importance are comprehensively depicted in the Regional Investment Plans whilst the Community-wide TYNDP reports only synthetic information for concerns and projects of pan-European significance. ENTSO-E hopes to meet the various expectations of their stakeholders, leading to grid development, and detailed perspectives at the same time.

ENTSO-E cannot be held liable for any inaccurate or incomplete information received from third parties or for any resulting misled assessment results based on such information.

The TYNDP 2014 package was consulted during summer 2014 in order to be finalized in December 2014.

1.2 Regulation EC 347/2013 sets a new role for the TYNDP

The present publication complies with the requirements of Regulation EC 714/2009 (the Regulation), in force since March 2011 whereby "ENTSO-E shall adopt a non-binding Community-wide 10 Year Network Development Plan, including a European generation adequacy outlook, every two years".

The Regulation set forth that the TYNDP must "build upon national investment plans" (the consistency to which is monitored by the Agency for the Cooperation of Energy Regulators, ACER), "and if appropriate the guidelines for trans-European energy networks". In addition, it must "build on the reasonable needs of different system users". Finally, the TYNDP must "identify investment gaps, notably with respect to cross-border capacities".

The present TYNDP package also foresees the implementation of Regulation EC 347/2013 (the **Energy Infrastructure Regulation**), in force since April 2013, and normally applying to the TYNDP 2016. **This regulation** organises a new framework to foster transmission grid development in Europe. Regulation EC 347/2013 defines the status of **Projects of Common Interest** (PCIs), anticipates various supporting tools to support the realisation of PCIs, and makes the **TYNDP the sole basis for identifying and assessing the PCIs** according to a standard **Cost-Benefit-Analysis** (CBA) methodology.

The TYNDP is therefore not only a framework for planning the European grid, supplying a long-term vision; it also now serves the assessment of every PCI candidate, whatever their commissioning time.

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1.3 A top-down, open and constantly improving process

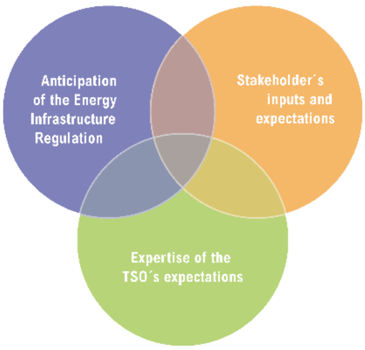

Figure 10 Illustration of TYNDP Process involvement

The first Ten-Year Network Development Plan was published by ENTSO-E on a voluntary basis in spring 2010, in anticipation of the Directive 72/2009 and the Regulation 714/2009. The 2012 release built on this experience and the feedback received from stakeholders, proposing a first sketch of a systematic CBA. For the 2014 release, ENTSO-E launched a large project, founded on three main pillars: **the inputs and expectations from their stakeholders; the anticipation of the Energy Infrastructure Regulation and the expertise of the TSOs**, Members of ENTSO-E.

In the last two years, ENTSO-E organised exchanges with stakeholders at four levels to ensure transparency as much as possible:

- Public workshops and consultations[1]: non-specific conferences and events, where ENTSO-E has been invited to, in total 17 dedicated workshops, in Brussels or regional and 6 consultations paved the construction of the scenarios (the so-called "Visions"), the preparation of the CBA methodology and the production of first results and project assessments. The last consultation on scenarios was concluded in October 2013.
- A "Long Term Network Development Stakeholders Group[2]", gathering 15 members, aiming at debating and finalising the methodology (scenarios, CBA) improvements, regarding the TYNDP itself or grid development more generally. The group contributed in particular to refining the social and environmental indicator of the CBA and rethinking the basis for more transparent scenario development.
- A non-discriminatory framework enabling non-ENTSO-E Members to submit transmission and storage project candidates for assessment. Two submission windows were opened officially in February and in September 2013.
- Dedicated bilateral meetings, especially with Directorate-General for Energy (European Commission), ACER and market players also contributed to share concerns, jointly develop more and more harmonized methodologies and agree on the expected outcomes of the process.

[1] https://www.entsoe.eu/major-projects/ten-year-network-development-plan/tyndp-2014/stakeholder-interaction/
[2] https://www.entsoe.eu/major-projects/ten-year-network-development-plan/tyndp-2014/long-term-network-development-stakeholder-group/

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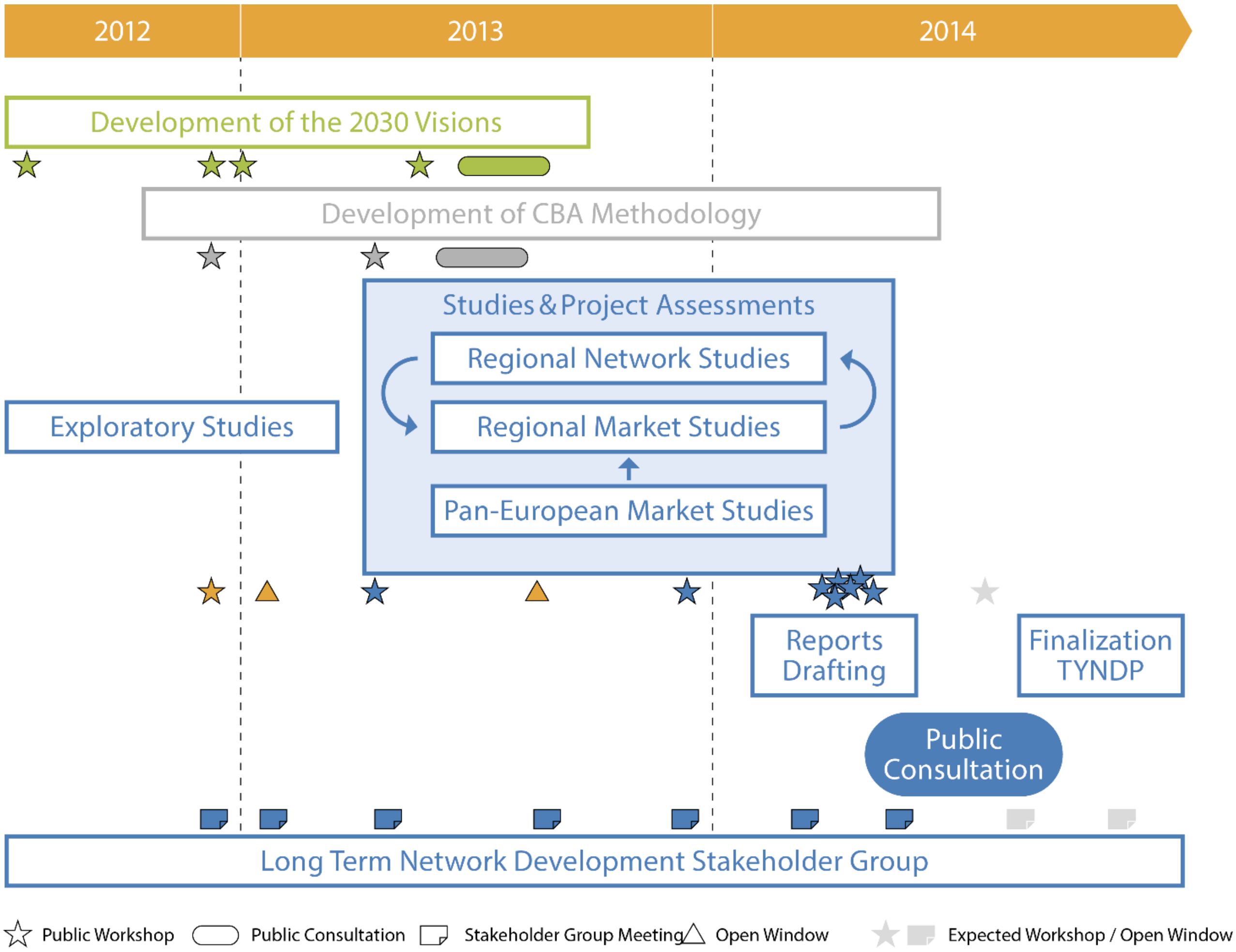

Figure 11 Overview of the TYNDP 2014 process

The preparation of the TYNDP 2014 was a bigger challenge as **ENTSO-E decided to anticipate the implementation of the Energy Infrastructure Regulation** and to support Directorate-General for Energy (European Commission) in starting its implementation:

- ENTSO-E started drafting and consulting the CBA methodology in 2012 and has tested it over the whole TYNDP 2014 portfolio even before the validation of the CBA methodology in September 2014. The CBA is implemented in the TYNDP 2014 for four 2030-Visions. This choice has been made based on stakeholders' feedback, preferring a large scope of contrasted scenarios instead of a more limited number and an intermediate horizon 2020.
- ENTSOE invited non-ENTSO-E Members to submit transmission and storage project candidate for assessment, with the latest submission window, in September 2013.
- ENTSO-E included an assessment of storage projects in the TYNDP 2014 in addition to Transmission projects.

In a volatile environment, the TYNDP and its methodology are bound to evolve. ENTSO-E targets a regular delivery every two years of an enhanced product, introducing methodology improvements to ensure timely and consistent results, achieving efficiency rather than aiming at perfection. The following chart sums up the TYNDP evolution since 2010:

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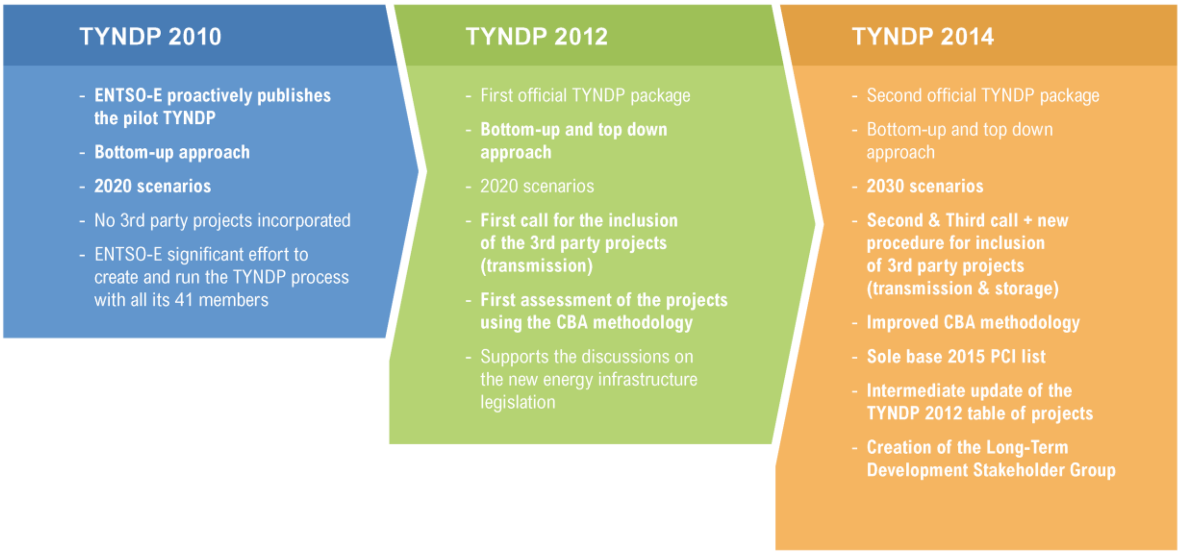

Figure 12 Overview of the TYNDP development over the versions

1.4 How to read the Baltic Sea Regional Investment Plan 2014 report

The document is structured in the following way:

- Chapter 1: Introduction.
- Chapter 2, Methodology describes the regionally specific methods used to elaborate the investment package.
- Chapter 3, Scenarios and study results gives only a synthetic overview of the four scenarios underlying the present TYNDP. (The description of the scenarios and study results in appendixes)
- Chapter 4, Investment needs explores the evolution of grid capacity from the present situation, highlighting the drivers of grid development, location of grid bottlenecks in long term and bulk power flows across these bottlenecks.
- Chapter 5, Investments - Projects portfolio, presents a synthetic overview of all assessed projects. (The technical details of the projects are in Appendix 1)
- Chapter 6, 2030 transmission capacities and adequacy gives an overview about the inter-area transmission capacity adequacy and gives target capacities for different visions by 2030.
- Chapter 7, Environmental assessment sums up the environmental impact of the assessed projects.
- Chapter 8, Assessment of resilience, sets the assessed projects in larger and farther-looking perspective.
- Chapter 9, Monitoring of Regional Investment Plan 2012 presents a synthetic overview of projects presented in TYNDP 2014.
- Chapter 10, Conclusion.

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- Appendix 1, Sums up all the information regarding projects included into Baltic Sea Regional Investment Plan.
- Appendix 2, Sums up all the information regarding additional alternative projects of Regional interest.
- Appendix 3, Supplies overview of installed generation and demand in Baltic Sea Region.
- Appendix 4, Presents main results of simulation of Visions.
- Appendix 5, Presents simulation results by synchronous areas in Baltic Sea Region.
- Appendix 6, Presents Network Studies Results
- Appendix 7, Presents results of sensitivity analyses that were studied additionally to four main Visions
- Appendix 8, Sums up project assessment results by different focus areas in the region.

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2 Methodology and Assumptions

2.1 General overview of the TYNDP 2014 process

ENTSO-E has taken into account stakeholder feedback from the previous TYNDP releases and developed an enhanced methodology for TYNDP 2014. The process was developed with input from all of the regional groups and working groups involved in the TYNDP, whilst also ensuring equal treatment for TSO projects and third party projects.

This chapter outlines the TYNDP macro-process, including methodological improvements developed for the 2014 edition of the TYNDP. The improvements are deemed necessary in order to ensure compliance with the implementation of the Energy Infrastructure Package (Regulation (EU) No 347/2013), which was enacted in 2013 and formalised the role of the TYNDP in the Project of Common Interest selection process.

Figure below provides an overview of the TYNDP 2014 process; the yellow stars represent stakeholder workshops held during this two-year process.

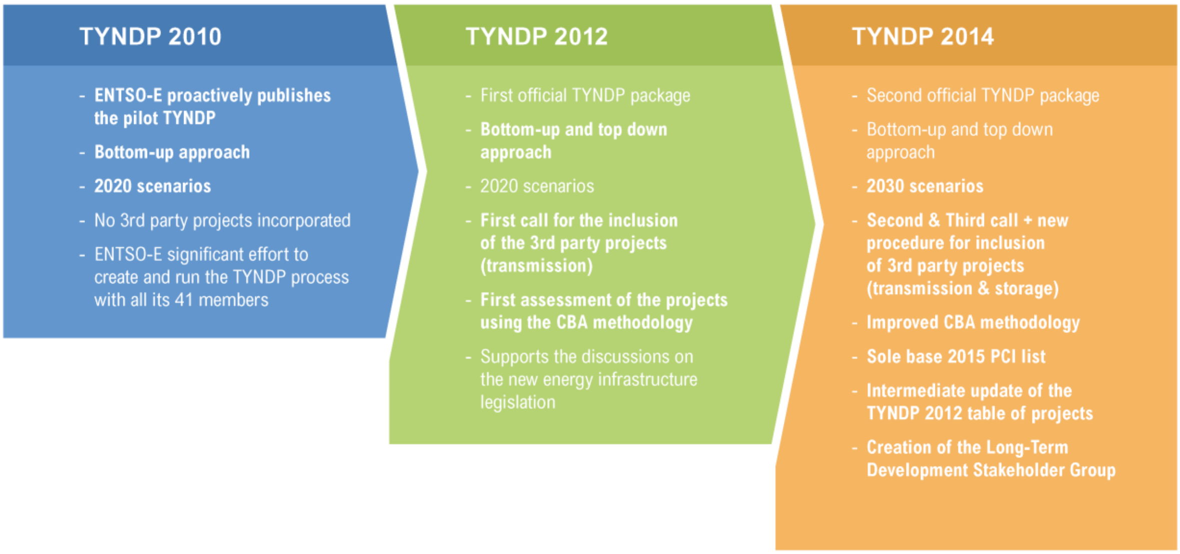

Figure 13 Overview of the TYNDP 2014 process

2.1.1 Scenarios to encompass all possible futures

The TYNDP 2014 analysis is based on an extensive exploration of the 2030 horizon. The year 2030 is used as a bridge between the European energy targets for 2020 and 2050. This choice has been made based on stakeholder feedback, preferring a large scope of contrasted longer-run scenarios instead of a more limited number and an intermediate horizon of 2020.

The 2014 version of the TYNDP covers four scenarios, known as the 2030 Visions. The 2030 Visions were developed by ENTSO-E in collaboration with stakeholders through the Long-Term Network Development Stakeholder Group, multiple workshops and public consultations.

The Visions are contrasted in order to cover every possible development foreseen by stakeholders. The Visions are less forecasts of the future than selected possible extremes of the future so that the pathway realised in the future falls with a high level of certainty in the range described by the Visions. The span of the four Visions is large and meets the various expectations of stakeholders. They differ mainly with respect to:

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– The trajectory toward the Energy roadmap 2050: Visions 3 and 4 maintain a regular pace from now until 2050, whereas Visions 1 and 2 assume a slower start before an acceleration after 2030. Fuel and CO2 price are in favour of coal in Visions 1 and 2 while gas is favoured in Visions 3 and 4.
– The consistency of the generation mix development strategy: Visions 1 and 3 build from the bottom-up for each country's energy policy with common guidelines; Visions 2 and 4 assume a top-down approach, with a more harmonised European integration.

The 2030 visions are further developed in the SOAF report and chapter 3 of the present report.

2.1.2 A joint exploration of the future

Compared to the TYNDP 2012, the TYNDP 2014 is built to cover a longer-term horizon which 41 TSOs in the framework of the six Regional Groups have jointly explored both during the exploratory studies prior to the assessment phase.

The objectives of the exploratory studies are to establish the main flow patterns and indicate the subsequent investment needs. When applicable, the exploratory phase resulted in the proposal of new projects, with further justification based the CBA assessment in the TYNDP 2014.

With the validation of Vision 4 in October 2013, further investigation may be necessary to devise appropriate reinforcement solutions to the investment needs identified in the studies. More information on the investment needs can be found in Chapter 4.

2.1.3 A complex process articulating several studies in a two-year timeframe

The articulation of the studies performed within the framework of TYNDP 2014 to assess projects are described in Figure below and in the following section.

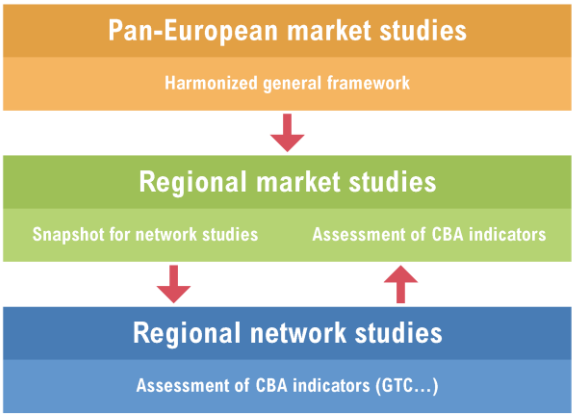

Figure 14 An iterative process towards the preparation of TYNDP 2014

Pan-European market studies have been introduced in the TYNDP 2014 process to improve both the scenario building and the assessment of projects. These studies, performed jointly by a group of TSOs experts from all regional groups, are set-up to both:

– define parameters and datasets necessary to perform the market simulation based on the four 2030 Visions developed.

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- provide the boundary conditions for the regional market studies necessary to ensure a consistent and harmonised framework for the regional assessment of the projects with the CBA methodology.

More details on the modelling and the tools used can be found in sections 2.3 and 2.4 of the report.

Building on the common framework set by the pan-European market studies, every Regional Group undertook more detailed **regional market and network studies** in order to explore every Vision and perform the CBA assessment of the TYNDP 2014 projects:

- Regional market studies deliver bulk power flows and pinpoint which specific cases need to be further studied via network studies; they also deliver the economic part of the CBA assessment.
- Regional network studies analyse exactly how the grid handles the various cases of generation dispatch identified during the previous step and deliver the technical part of the CBA assessment.

Further details on the methodology of the regional studies can be found in each Regional Investment Plan.

2.1.4 A TYNDP 2014 built with active involvement from stakeholders

As mentioned in the introduction chapter of the report, ENTSO-E has improved the process of the TYNDP in order to include, in every phase, interactions with stakeholders. These are key in the process because of the TYNDP's increased relevance in the European energy industry and the need to enhance common understanding about the transmission infrastructure in Europe. ENTSO-E organised six public web-consultations and requests for input as well as 17 open workshops at the regional and European levels or bilateral meetings:

Table 1 Example of stakeholder involvement

Phase of the process	Interactions
Scenario building	4 workshops including requests for inputs + 1 two-month public consultation
Definition of the improved 3rd party procedure	1 workshop
Development of the CBA methodology	2 workshops and 2 two-month public consultation
Call for 3rd party projects	1 workshop and 2 calls during the process (last one in September-October 2013)
Assessment of projects	1 pan-European workshop + 7 Regional workshops
Final consultation	1 two-month public consultation + 1 workshop

ENTSO-E has also launched a **Long-Term Network Development Stakeholders Group** (LTND SG), gathering European organisations and incorporating the major stakeholders of ENTSO-E. As views on the TYNDP, the broader challenges facing the power system and the best methods of addressing those challenges differ across countries and regions, the target is to create an open and transparent environment in which all involved parties can discuss and debate.

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A particularly concrete outcome of this cooperation is a specific appraisal of the benefits of the projects with respect to potential spillage from RES generation and the replacement of the former social and environmental indicators by two more specific indicators with respect to the crossing of urbanised areas and protected areas.

The LTND SG also organised a task force to provide recommendations on the involvement of stakeholders in the scenario building for future releases of the TYNDP. The report is published together with the TYNDP 2014 package[3].

2.2 Implementation of Cost Benefit Analysis (CBA)

The prospect of climate change combined with other factors such as the phase-out of power plants due to age or environmental issues has lead to a major shift in the generation mix and means that the energy sector in Europe is undergoing major changes. All these evolutions trigger grid development and the growing investment needs are currently reflected both in European TSOs' investment plans and in the ENTSO-E TYNDP.

In this uncertain environment and with huge needs for transmission investment, several options for grid development have arisen. Cost Benefit Analysis, combined with multi-criteria assessment is essential to identify transmission projects that significantly contribute to European energy policies and that are robust enough to provide value for society in a large range of possible future energy projections, while at the same time being efficient in order to minimise costs for consumers. The results of project assessment can also highlight projects which have a particular relevance in terms of achieving core European energy policy targets, such as RES integration or completing the Internal Electricity Market.

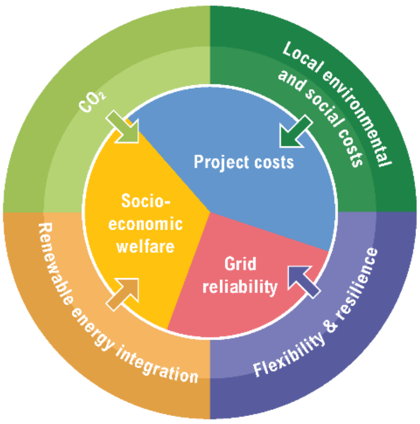

Figure 15 Scope of the cost benefit analysis (source: THINK project)

ENTSO-E developed the Cost Benefits Methodology
ENTSO-E developed a multi-criteria assessment methodology in 2011. The methodology was applied for the TYNDP 2012 and detailed in Annex 3 of the TYNDP. The CBA methodology has been developed by ENTSO-E as an update of this methodology, in compliance with Regulation (EU) 347/2013. It takes into account the comments received by ENTSO-E during public consultation and includes the outcome of an extensive consultation process through bilateral meetings with stakeholder organisations, continuous

[3] Link to the report.

interactions with a Long-Term Network Development Stakeholder Group, the report on target CBA methodology prepared by the THINK consortium, several public workshops and direct interactions with ACER, the European Commission and Member States.

The CBA methodology takes into account the comments received by ENTSO-E during the public consultation of the "Guideline for Cost Benefit Analysis of Grid Development Projects – Update 12 June 2013". This consultation was organised between 03 July and 15 September 2013 in an open and transparent manner, in compliance with Article 11 of Regulation (EU) 347/2013.

More information can be found in the following chapter on the CBA and its implementation in the TYNDP 2014.

2.2.1 Scope of Cost Benefit Analysis

Regulation (ECEU) No 347/2013, in force since 15 May 2013, aims to ensure strategic energy networks[4] by 2020. To this end, the Regulation proposes a regime of "common interest" for trans-European transmission grid projects contributing to implementing these priority projects (Projects of Common Interest; PCIs), and entrusts ENTSO-E with the responsibility of establishing a cost benefit methodology[5] with the following goals:

- System wide cost benefit analysis, allowing a homogenous assessment of all TYNDP projects;
- Assessment of candidate Projects of Common Interest.

The system wide Cost Benefit Analysis methodology is an update of ENTSO-E's Guidelines for Grid Development intended to allow an evaluation of all TYNDP projects in a homogenous way. Based on the requirements defined in the Reg. (EU) No 347/2013[6], ENTSO-E has defined a robust and consistent CBA methodology to apply to future TYNDP project assessments. This CBA methodology has been adopted by each ENTSO-E Regional Group, which have responsibility for pan-European development project assessments.

The CBA describes the common principles and procedures, including network and market modelling methodologies, to be used when identifying transmission projects and for measuring each of the cost and benefit indicators in a multi-criteria analysis in view of elaborating Regional Investment Plans and the Community-wide TYNDP. In order to ensure a full assessment of all transmission benefits, some of the indicators are monetised (inner ring of Figure above), while others are measured through physical units such as tons or kWh (outer ring of Figure above).

This set of common indicators forms a complete and solid basis both for project evaluation within the TYNDP and for the PCI selection process. With a multi-criteria approach, the projects can be ranked by the Member States in the groups foreseen by Regulation 347/2013. Art 4.2.4 states: « each Group shall determine its assessment method on the basis of the aggregated contribution to the criteria […] this assessment shall lead to a ranking of projects for internal use of the Group. Neither the regional list nor the Union list shall contain any ranking, nor shall the ranking be used for any subsequent purpose ».

The CBA assesses both electricity transmission and storage projects.

2.2.2 A multicriteria assessment

The cost benefit analysis framework is a multi-criteria assessment, complying with Article 11 and Annexes IV and V of Regulation (EU) 347/2013.

[4] Recital 20, Regulation (EU) 347/2013 : http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:115:0039:0075:EN:PDF

[5] Article 11, Regulation (EU) 347/2013

[6] Reg. (EU) 347/2013, Annexes IV and V

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The criteria set out in this document have been selected on the following basis:

- To enable an appreciation of project benefits in terms of EU network objectives.
- To ensure the development of a single European grid to permit the EU climate policy and sustainability objectives (RES, energy efficiency, CO2).
- To guarantee security of supply.
- To complete the internal energy market, especially through a contribution to increased socio-economic welfare.
- To ensure the technical resilience of the system.
- To provide a measurement of project costs and feasibility (especially environmental and social viability).

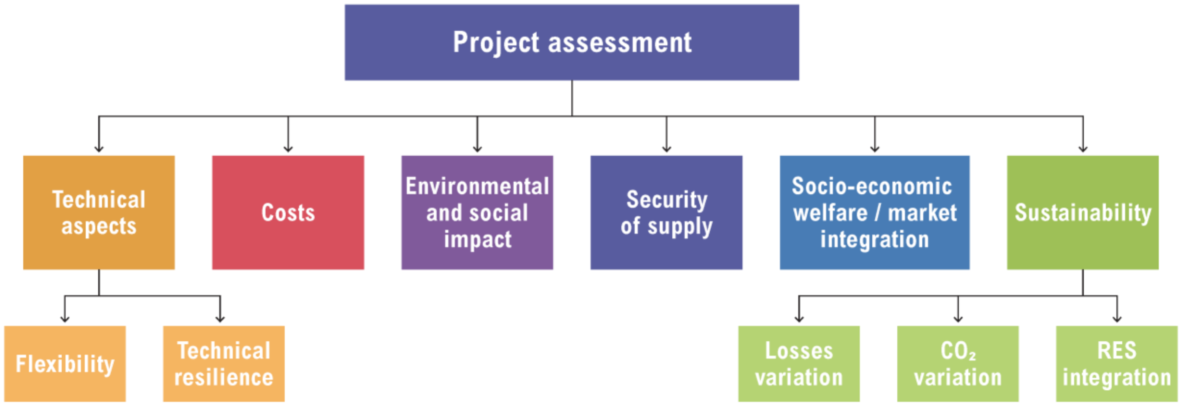

Figure 16 Main categories of the project assessment methodology

The indicators used are as simple and robust as possible. This leads to simplified methodologies for some indicators. Some projects will provide all the benefit categories, whereas other projects will only contribute significantly to one or two of them. Other benefits also exist such as the benefit of competition; these are more difficult to model and will not be explicitly taken into account.

The different criteria are explained below, grouped by Benefits, Cost, impact on surrounding areas and Grid Transfer Capability.

The **Benefit Categories** are defined as follows:

B1. Improved security of supply[7] (SoS) is the ability of a power system to provide an adequate and secure supply of electricity under ordinary conditions[8].

[7] Adequacy measures the ability of a power system to supply demand in full, at the current state of network availability; the power system can be said to be in an N-0 state. Security measures the ability of a power system to meet demand in full and to continue to do so under all credible contingencies of single transmission faults; such a system is said to be N-1 secure.
[8] This category covers criteria 2b of Annex IV of the EU Regulation 347/2013, namely “secure system operation and interoperability”.

B2. Socio-economic welfare (SEW)[9] or market integration is characterised by the ability of a power system to reduce congestion and thus provide an adequate GTC so that electricity markets can trade power in an economically efficient manner[10].

B3. RES integration: Support for RES integration is defined as the ability of the system to allow the connection of new RES plants and unlock existing and future "green" generation, while also minimising curtailments[11].

B4. Variation in losses in the transmission grid is the characterisation of the evolution of thermal losses in the power system. It is an indicator of energy efficiency[12] and is correlated with SEW.

B5. Variation in CO_2 emissions is the characterisation of the evolution of CO_2 emissions in the power system. It is a consequence of B3 (unlock of generation with lower carbon content)[13].

B6. Technical resilience/system safety is the ability of the system to withstand increasingly extreme system conditions (exceptional contingencies)[14].

B7. Flexibility is the ability of the proposed reinforcement to be adequate in different possible future development paths or scenarios, including trade of balancing services[15].

The **project costs**[16] are defined as follows:

C1. Total project expenditures are based on prices used within each TSO and rough estimates of project consistency (e.g. km of lines).

The **project impact on the surrounding areas** is defined as follows:

S.1. Protected areas characterises the project impact as assessed through preliminary studies, and aims to provide a measure of the environmental sensitivity associated with the project.

S.2. Urbanised areas characterises the project impact on the (local) population that is affected by the project as assessed through preliminary studies, aiming to give a measure of the social sensitivity associated with the project.

These two indicators refer to the remaining impacts after potential mitigation measures defined when the project definition becomes more precise.

The Grid Transfer Capability (GTC) is defined as follows:

The GTC reflects the ability of the grid to transport electricity across a boundary, i.e. from one bidding area (an area within a country or a TSO) to another or within a country, increasing security of supply or generation accommodation capacity.

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9 The reduction of congestions is an indicator of social and economic welfare assuming equitable distribution of benefits under the goal of the European Union to develop an integrated market (perfect market assumption).
10 This category contributes to the criteria 'market integration" set out in Article 4, 2a and to criteria 6b of Annex V, namely "evolution of future generation costs".
11 This category corresponds to criterion 2a of Article 4, namely "sustainability", and covers criteria 2b of Annex IV.
12 This category contributes to criterion 6b of Annex V, namely "transmission losses over the technical lifecycle of the project".
13 This category contributes to the criterion « sustainability » set out in Article 4, 2b and to criteria 6b of Annex V, namely " greenhouse gas emissions"".
14 This category contributes to the criterion "interoperability and secure system operation" set out in Article 4, 2b and to criteria 2d of Annex IV, as well as to criteria 6b of Annex V, namely "system resilience" (EU Regulation 347/2013).
15 This category contributes to the criterion "interoperability and secure system operation" set out in Article 4, 2b , and to criteria 2d of Annex IV, as well as to criteria 6e of Annex V, namely "operational flexibility" (idem note 26).
16 Project costs, as with all other monetised values, are pre-tax.

The GTC is expressed in MW. It depends on the considered state of consumption, generation and exchange, as well as the topology and availability of the grid, and accounts for the safety rules described in the ENTSO-E CBA Methodology document. The Grid Transfer Capability is oriented, which means that there may be two different values across a boundary. A boundary may be fixed (e.g. a border between states or bidding areas), or vary from one horizon or scenario to another.

2.2.3 Implementation of CBA in the TYNDP 2014

The CBA methodology shall be validated by EC by end 2014. ENTSO-E has used the TYNDP 2014 as an opportunity to conduct a real-life test of the methodology in order to be able to tune it if necessary. The implementation of the CBA in this trial phase hence focuses on checking the feasibility of its implementation while also answering actual stakeholder concerns.

Every single indicator has been computed for a large selection of project cases. In this respect, the RES – avoided RES spillage – indicator (resp. the SoS – loss of load expectation – indicator) must be completed in order to get the full picture of the benefits of projects with respect to RES integration or security of supply; projects of pan-European significance may incidentally also be key for indirectly enabling RES connection in an area, although no spillage is entailed resp. to solve local SoS issues. However, the pan-European modelling implied by the CBA is too broad to capture these effects and underestimates the benefits. This is commented in the projects assessments sheets, whenever appropriate.

Projects assessments against four contrasted Visions enable the applicability of the methodology to be tested in markedly different scenarios. The practical implementation shows the importance of finalising the planning phase before running every project assessment.

Performing more than 100 project assessments against four Visions is sufficient to compare the relative values of all projects for all criteria measured, mitigating the need for analysing an intermediate horizon or technically implementing NPV computation.

The CBA clustering rules have been fully implemented, although they proved challenging for complex grid reinforcement strategies. Essentially, a project clusters all investment items that have to be realised in total to achieve a desired effect. Therefore, a project consists of one or a set of various strictly related investments. The CBA rules state:

- Investment items may be clustered as long as their respective commissioning dates do not exceed a difference of five years;
- Each of them contributes to significantly developing the grid transfer capability along a given boundary, i.e. it supports the main investment item in the project by bringing at least 20% of the grid transfer capability developed by the latter.

The largest investment needs (e.g. offshore wind power to load centres in Germany, the Balkan corridor, etc.) may require some 30 investments items, scheduled over more than five years but addressing the same concern. In this case, for the sake of transparency, they are formally presented in a series of smaller projects, each matching the clustering rules, with related assessments; however, an introductory section explains the overall consistency of the bigger picture and how each project contributes to it.

2.3 Market study methodology

Market modelling is based on regional Vision 1, 2, 3 and 4 datasets.

The visions 1 and 3 are prepared by National Transmission System Operators based on each member states National development plans and applying a set of guidelines developed by ENTSO-E. The Vision 4 dataset is prepared by ENTSO-E and derived from the Vision 3 dataset, applying Vision construction guidelines. Furthermore, special increase of RES was assumed on ENTSO-E level in order to reach a share of

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renewable and carbon-free electricity consistent with EU view towards carbon neutral Europe 2050. BTC values (Bilateral agreed Transfer capacities) were collected centrally by ENTSO-E.

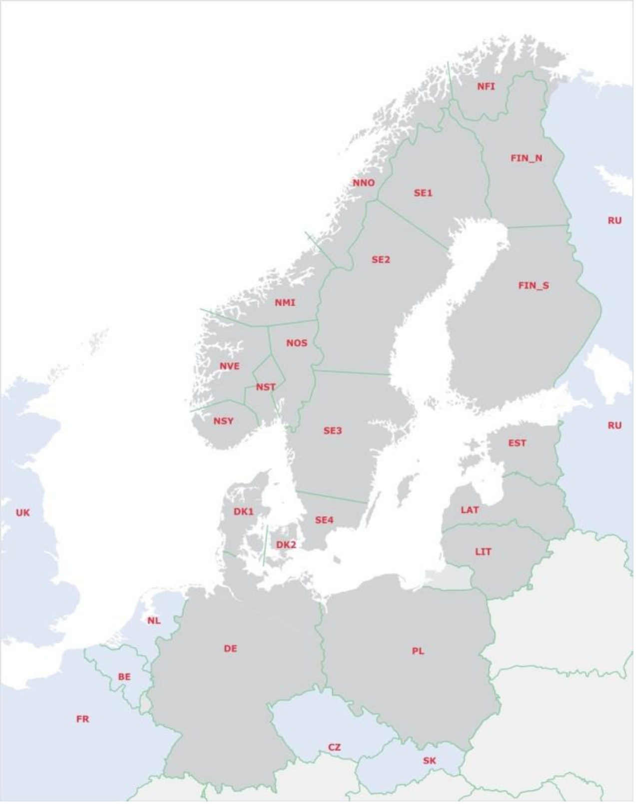

Figure 17 Modelled areas in BID

There are three kinds of areas in the regional market models (see also the map on left):

– Regional areas (dark-grey) are modelled as detailed as possible, including detailed modelling of power plants and consumption. Some regional areas are different from the actual market price zones; this is to monitor internal flows within price zones.
– Perimeter areas (blue) are modelled with data from ENTSO-E (PEMMDB) for European countries, for Russia and Belarus modelling approach as described below was used.
– Other areas neighbouring areas (grey) are not modelled but their flows to regional areas and perimeter areas are taken from Pan-European simulations (PEMS) and used in regional simulations.

Modelling of third countries (Russia, Belarus)
Analysis of the interaction of the Baltic Sea (BS) power market with the Russian power market is subject to several interesting factors, most notably:

– Interaction of two different market designs – energy-only market with zonal prices in the BS region vs. energy + capacity market with nodal prices in Russia
– The effect of evolution of fuel – most importantly, the price difference of natural gas between the BS region and Russia
– Role of the CO2 cost in the trade

Table 2 Modelling Of Russian Electricity Market in Different Visions

Description	Vision 1	Vision 2	Vision 3	Vision 4
Market development	Poor market integration between Russia and Europe. Lower CO2 cost in Russia.	Poor market integration between Russia and Europe. Lower CO2 cost in Russia.	Market integration between Russia and Europe, including gas and CO2 pricing	Market integration between Russia and Europe, including gas and CO2 pricing
Generation development	Power generation in Russia mostly based on old capacity	Power generation in Russia mostly based on old capacity	Power generation equipment in Russia modernized significantly, but based on conventional generation (CCGT)	Power generation equipment in Russia modernized significantly, including a lot of RES

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In the analysis, the effect of different developments in the interaction of the BS region and Russia are assessed via a sensitivity study. Market studies assume market-based power flow between the BS region and Russia, where Russia is modelled as a price function with a base price and hourly variation factors. This study assumes the exchange to be based on an efficient market mechanism, i.e. capacity payments and other cross-border fees are not assumed to affect the trade.
The exact price level in Russia (and anywhere else, for that matter) is naturally complicated to predict. Since there were no common assumptions for modelling of Russian, Belorussian developments at Pan-EU level, RGBS used assumptions, described in the table above.

2.3.1 Tools Used for Market and Adequacy Studies

Market and adequacy (source of the SoS indicator) studies in the Baltic Sea region are based on the following models:

- BID - a main tool for market modelling.
- SAMLAST - used for additional assessment of Nordic (northern and central) projects.
- MAPS – used for numerical assessment of Security of Supply

BID

The BID model is a fundamental model that estimates the price by calculating the intersections between supply and demand. The model has a regional structure with specified transmission capacity and trading regime between the regions. For each region, there are specified demand curves with some price elasticity for a number of consumer groups. The supply curve is constructed as a merit order curve defined by production capacities and short term marginal costs.

Description of the modelling of RGBS countries:

- consumption - time series (8760 h) for each area
- hydro (reservoir), each market area represented by one aggregated hydro generator if such generation exists.
- hydro (run-of-river), each market area represented by one aggregated hydro generator if such generation exists
- hydro (pumped storage) - explained below
- thermal and nuclear generation are aggregated for similar units having the same fuel and technical characteristics.
- Wind and solar time series (8760 h) derived from ENTSO-E climate database. Wind offshore and onshore have different time series and vary from country to country.

Pump storage facilities and production capacity measured in MW (discharge) were specified for each market area individually. Following limitations were acknowledged by RGBS:

- pump storages cannot have energy limitations;
- pump storages are optimized pr. week. (i.e. charge – discharge = 0);
- charge MW (pump capacity) is specified as % of discharge MW. This % is the same amount for all pump storages in the model.

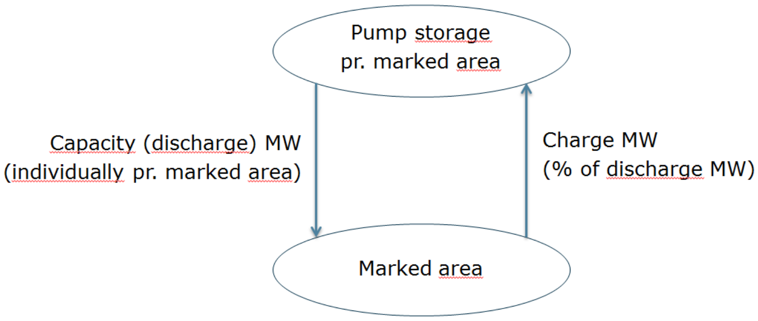

Figure 18 Modelling of pump-storages

SAMLAST

Samlast is used for additional analysis for northern projects in Norway, Sweden and Finland. Northern projects means, the projects in North surround the Polar Circle, which are characterised by electrically and geographically being a long distance from the remaining RGBS area and are projects in a meshed AC grid.

Samlast is a combined market model and grid model analysis tool. The Samlast model is based on the EMPS model (EFI's Multi Area Power Scheduling), but it also performs load flow calculations using EMPS's market solution as a starting point. The EMPS model 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.

Due to historical reasons only the Nordic grid part is currently modelled in Samlast which restricts the use of the program for the whole region. The model contains a detailed model of the Nordic and Baltic market areas and prices from BID simulations for the rest of system. Hence the BID model provides boundary conditions for the Samlast model. This means prices for countries other than Norway, Sweden, Finland and the Baltics are exactly the same in both models.

Different characteristics of the models are very important for the correct modelling of the Nordic projects. Some of these characteristics are:

- 47 hydro years in Samlast, (1 in BID);
- More detailed hydro in Samlast;
- BID simulations are simulated with start stop-cost, which is not done in Samlast;
- BID has more detailed time resolution;
- Detailed grid (modelling of the physical grid) modelling in Samlast.

MAPS

The MAPS model is used for assessment of Nordic, Baltic and interconnections from Nordic to Continental Europe. The MAPS is a model to analyse the adequacy in power systems. Demand and generation is modelled in each area with limited transmission capacity between areas with a maximum of 100 areas.

The MAPS model uses stochastic processes in combination with optimisation functions, specially fitted for large scale power systems. The geographical area that is being modelled is the same as in BID model.

The demand is modelled with a duration curve of maximum 1080 hours of peak period. The generation is described in power plant unit level. For each unit a F.O.R. (Forced Outage Rate) has to be included. The rate for the same type of production units could differ from country to country and even within a country. Each specific plant has its own rate. Together with a description of the transmission between all the modelled areas, following results can be calculated with MAPS:

LOLE – Loss of Load Expectancy (Called LOLP "loss of load probability" in MAPS)
Probability that at least one consumer is disconnected due to generation capacity deficit.

LOLE is measured in percent or hours per year. Accepted criteria value in Nordel is 0,001 or 9 hours/year.

Security of Supply = Value (Euro/h) * LOLE (h)

ENS – Expected energy Not Supplied (Called EUE– Expected Unserved Energy in MAPS)
It is an amount of energy which cannot be delivered due to generation capacity deficit. ENS is measured in MWh.

The reference case that we use for BID will be modelled for starters to see how the system reacts and which areas that fulfil the accepted criteria for LOLE. Depending on the results, only the projects connected to the critical areas will be assessed. Different types of high load sensitivities will also be simulated (i.e. 10-20% higher load in the whole system) to see how the system copes with the load increase.

2.4 Network Studies Methodology

Network studies shall answer the questions:

- Will the initial transmission system be adequate for dispatch of generation and load given in every hour from the market study in normal operation conditions, i.e. N-0, and observing the well-known N-1 rule?
- If not, then additional transmission system investments are proposed, compared and evaluated for all relevant cases until the planning criteria of the transmission system is fulfilled. Studied cases have explored a variety of dispatch situations: frequent ones, as well as rare ones which result in particularly extreme flow patterns.

RGBS has adapted a method where the market model simulations and power flow calculations are integrated. For every simulated market situation a load flow calculation is performed. This gives insight into the utilisation of the grid over a broad spectrum of market situations and gives a better understanding of the performance of the grid.

2.4.1 Market Studies as an Input to the Network Studies

In the Baltic Sea region market and network studies are performed in fully integrated way, where all market modelling time steps are transformed to grid model and hourly calculations are performed. Or as a second option, in some cases, the grid model is already a part of the market model and the grid simulation is performed simultaneously with market simulation. The general approach of integrated network and market studies is described below.

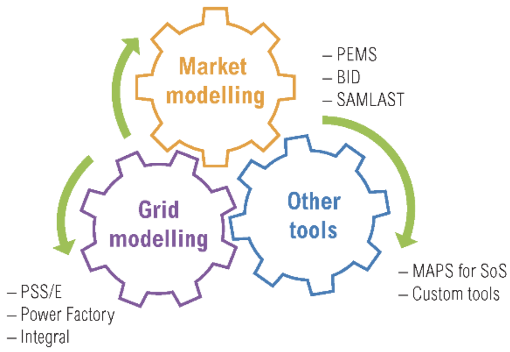

Figure 19 llustration of interaction process of modelling and analysis

The full CBA is applied for all 4 Visions, including a limited number of sensitivities around these. Visions of TYNDP 2014, modelled by RG BS, are based on the four ENTSO-E visions for 2030. When modelling only the RGBS area, this makes it possible to have more detailed model for the whole region rather than the

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large Pan-European model prepared by the expert team of ENTSO-E. The regional groups also use different tools for market and network analysis, with different levels of scope and details, taking benefit of the existing competence and tools. The tools and their collaboration are illustrated on the figure above.

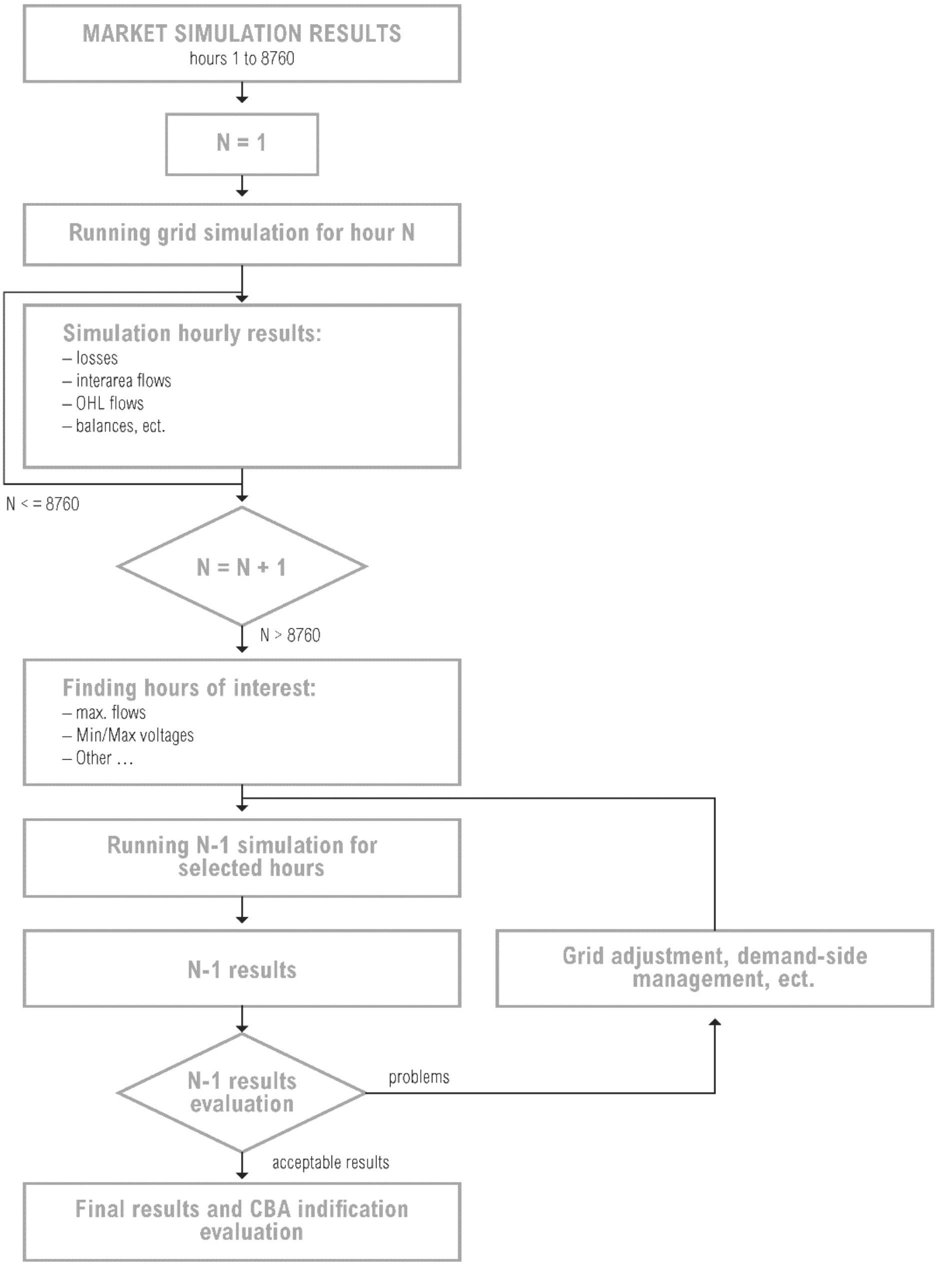

Figure 20 Process chart of hourly network calculations with input from market modelling hourly results

In several cases the hourly calculations were performed to study the grid adequacy in each hour of the year based on the results from the market study. The example of the possible automated analysis routine is described on a progress chart on the right.

2.4.2 Network Studies Tools

The Baltic Sea region consists of 3 different synchronous areas: Nordics, parts of Continental Europe and the Baltics States which are connected to Russian IPS/UPS. Due to this situation the separate grid models for those areas were also used during the assessment phase; the one for Denmark, the second for Continental Europe (Poland, Germany), the third for Nordic and fourth for Baltic. The reason for that is that those subsystems are fully decoupled by HVDC links. As HVDC and AC-PST are fully controllable and determined by means of load flow calculations it has been considered most reasonable to use separate and more detailed models. It also ads more flexibility and makes it easier to make the necessary changes and reinforcements in the grid models. The exchange of data is done within the same modelling software basis, in order to avoid converter issues when changing some relevant data or the ability to convert all necessary data. The models used for analyses have been updated with additional necessary investments to accommodate increased transmission due to the assessed projects (mostly HVDC connectors to the neighbouring systems). Furthermore other grid reinforcements have been made in order to enable generation from increased amounts of renewable energy which is found in some of the different Visions in the grid analyses.

Modelled market areas in the Nordic countries includes Sweden, Norway, Finland and the detail level cover from the 400 kV transmission grid down to 110 kV network. A detailed transmission system model in the software package, PowerFactory, was used for Denmark including both synchronous areas that Denmark is a part of; Denmark-West and Denmark-East. The Baltic power system has strong AC connections to Russian IPS/UPS therefore the modelled areas, additionally to Estonia, Latvia and Lithuania, also cover Russia North-West, Russia Center, Belarus and Kaliningrad area. Model detail level cover from the 330 kV transmission grid down to the 110 kV network in Baltics and down to the 220 kV in IPS/UPS. In Germany and Poland grid calculations were performed within the CCE regional group framework. The calculation results of CCE group have been reflected in the assessment indicators of relevant project.

As several different grid calculation tools and their combinations were utilised, the consistency of results were an important issue to check in order to get trustable and comparable final results.

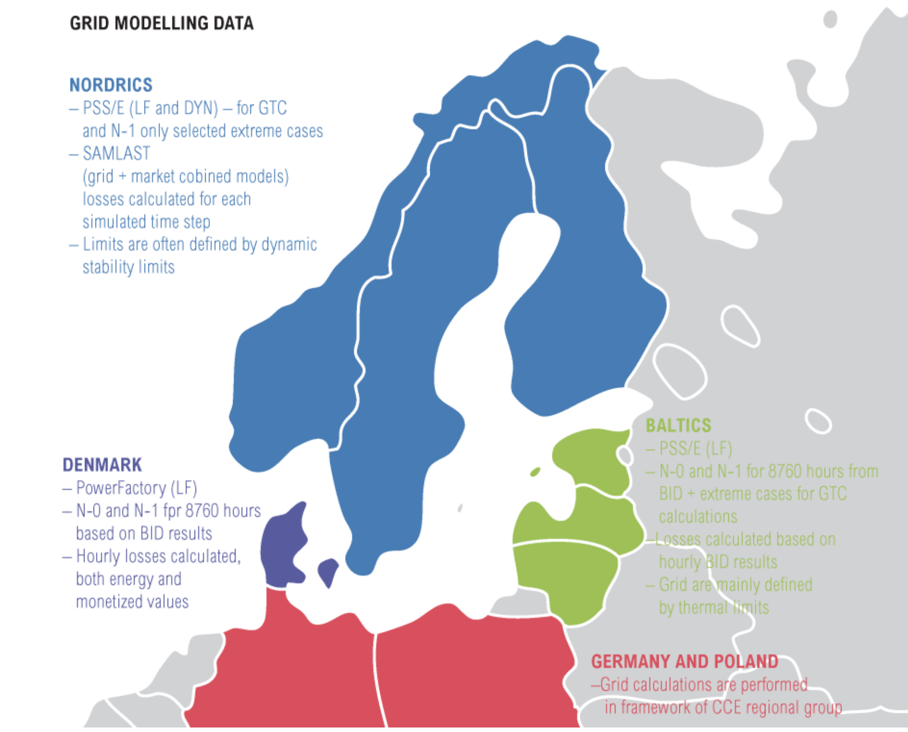

Figure 21 Network models in the region

Tools used for grid analyses:

– PSS/E - for load flow, contingency and dynamic analysis
– SAMLAST - (integrated market and grid model) – losses and simplified load flow calculations in northern Nordics
– PowerFactory - for more detailed grid analyses and was used with representation of Denmark-West and Denmark-East;
– Custom-made tools - enabling automation of workflow and interaction between different models. Hourly calculations and N-1, N-1-1 automation tools.

3 Scenarios and study results

3.1.1 Regional Description of Scenarios

The chapter is giving overview of demand and generation development in different visions and main assumptions used in different sub-regions (synchronous areas), main generation sources and their allocation and background of demand evolution in different areas. Visions 2 and 4 are compiled having top-down approach; consequently not all national development plans and reasonabilities have been taken into account. It could become obvious as an inconsistency at national or subregional level, but based on the assumptions of top-down Visions, assumptions provide consistency with the vision at European level. Based on these assumptions, regional analyses in conjunction with additional generation in Vision 4 have been focused on interconnection capacities between countries and market areas, rather than grid connection solutions of particular units. The Visions vary in wide range and are interpreted by TSOs/involved parties on following way:

1. The Vision 1 is slow progress and it is also based on National TSO input for less favourable economic and finance conditions based on common guidelines. The Vision 1 is bottom up vision based on national energy policies and research and development schemes, no evolution in demand response, no commercial break through of electric plug-in vehicles, low level of heat pumps, the NPPs are regulated by national policies and no changes on storage facility. The CO_2 price is low and high primary energy prices.

2. The Vision 2 is money rules vision with more liberalized electricity market conditions in whole Europe but still less favourable economic and finance conditions remain. The Vision 2 is top down vision which is more slightly adjusted from Vision 1. It is EU top down view where European focus on energy policies and research and development schemes are applied, electricity demand should be higher as in Vision 1, more favourable conditions for electricity vehicles with flexible charging, NPP developments based on public acceptance and no changes on storage facilities. The CO_2 price is low and high primary energy prices.

3. The Vision 3 is bottom up vision based on national TSO input and reflects national energy policies and research and development schemes as well as favourable economic and finance conditions are expected. Electricity demand should be higher as in Visions 1 and 3, more favourable conditions for electricity vehicles with flexible charging, NPPs developments according national view, and planned decentralised storage. In the Vision 3 low CO_2 prices and low primary energy prices.

4. The Vision 4 is most ambitious of all four Visions and it focus on Green revolution when RES are expected as base generation and fossil fuels remains as secondary generation and for keeping a balance in power system. The Vision 4 is prepared by expert team of ENTSO-E and by framework it is a top down. In this Vision very favourable economic and financial conditions are expected, European focus on energy policies and research and development schemes, electricity demand is the highest comparing to other visions, very favourable conditions for electricity vehicles (with flexible charging and generation), much more heat pumps implemented, developments of NPPs by public acceptance, new centralised hydro storage with decentralised storage. In terms of CO_2 prices it has assumed high (93 Euro/t) but at the same time low primary energy prices.

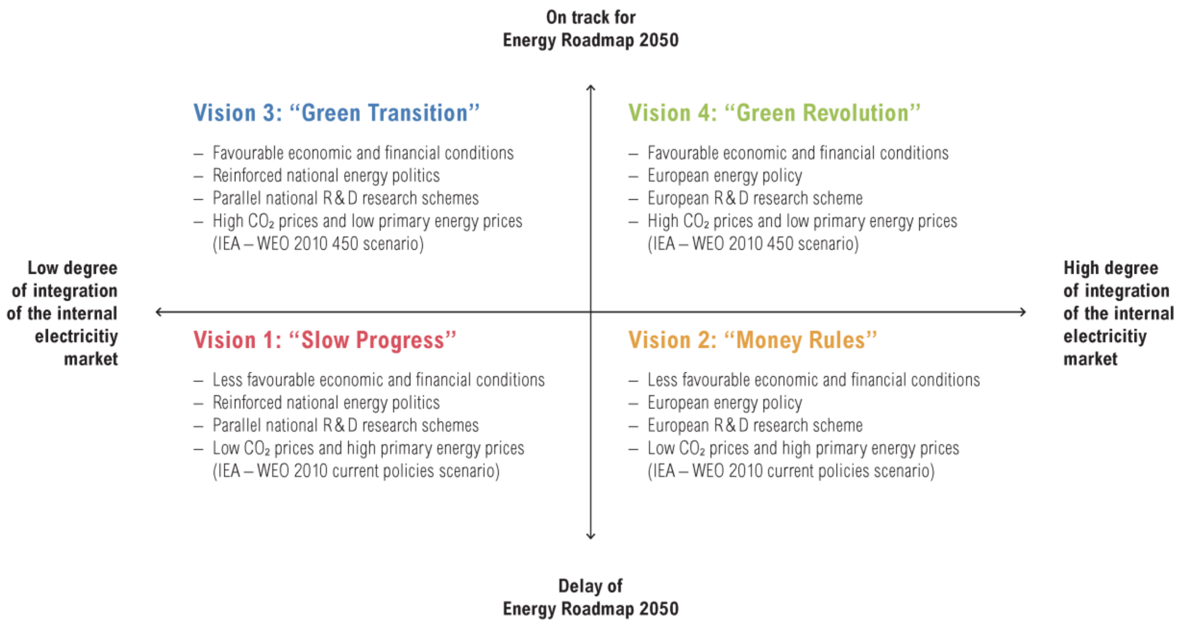

Figure 22 Main parameters of Visions

3.1.2 Generation, consumption in Baltic Sea region

The demand is higher from Vision 1 till Vision 4. As Vision 1 is less favourable conditions for economic growth in all countries of RGBS the demand is at the lowest value on vision 1 and for whole Baltic Sea region around 1180 TWh. In Vision 4 the demand reaches peak. It caused by the highest increase of demand within Baltic Sea Region, what is expected around 1390 TWh. The assumed difference in consumption between Vision 1 and Vision 4 is around 200 TWh what also shows the possible deviation of real consumption around 16 % up or down.

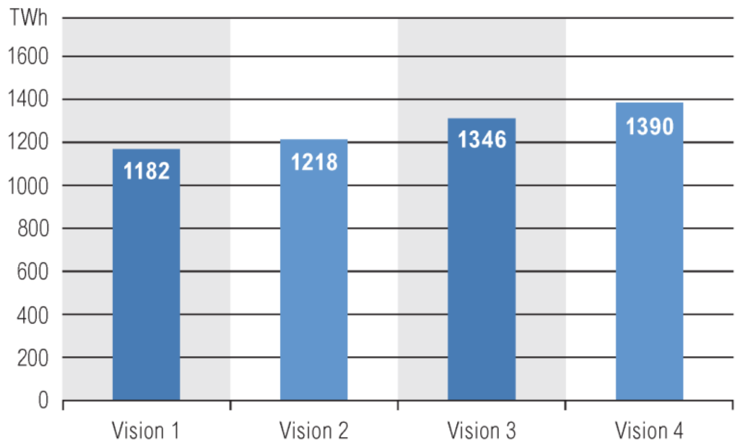

Figure 23 Demand Sum, Baltic Sea Region, TWh

The pie charts below show a difference between installed capacities on particular Vision in Basltic Sea area. The installed capacity is growing up through all Visions and the difference from Vision 1 to Vision 4 is 173 GW. The installed capacities are shown in a way that Vision 4 is the highest amount of installed capacity per generation type what is also 100 % of total capacity, compared to other vision in the figure above. The rest of Visions are compared to Vision 4 and white shares in pie charts for Visions 1, 2 and 3 show a difference of installed capacity versus Vision 4. It means also that the installed capacity of generation in Vision 1 and 2 is smaller by 29 % comparing to vision 4 as well as in Vision 3 the total installed capacity is smaller by 11 %. In the Vision 4 the highest amount of installed capacity comes from Wind (Off-shore and On-shore wind farms distributed among the Baltic Sea region) which is going to be increased from 24% in Vision 1 to 42 % in Vision 4. The wind farms are main future energy source towards carbon neutral Europe. The installed capacity of hydro remains quite equal in all Visions except Vision 4 where additional installed capacity of hydro was set. Hydro resources are limited by water inflow and depend on whether condition in different years. The development of hydropower plants are limited by geographical conditions. The installed capacity of Natural Gas is increasing almost two times in Visions 3 and 4, compared to Visions 1 and 2. In Baltic Sea region natural gas has been used in combined heat power plants and it ensures heating requirements during the winter periods. Natural Gas power plants also can balance unpredictable wind farm production or cover demand instead of hydro when water levels are restricted. From the pie charts it can be seen that it is not expected any dramatic increase of installed capacity of Sun, Nuclear and Oil in Baltic Sea region and the levels remain almost equal in all four Visions. The Biomass and Biogas developments are higher in Vision 4 (around 6 %) in case very favourable economic conditions will be achieved and the European schemes support Biomass and Biogas generation within Baltic Sea region and whole EU. RGBS expect that the installed capacity of Solid Fossil is decreasing from 13% in Vision 1 to 10 % in Vision 4. In general it is assumed that fossil fuels are decreasing and new generation of RES will replace those.

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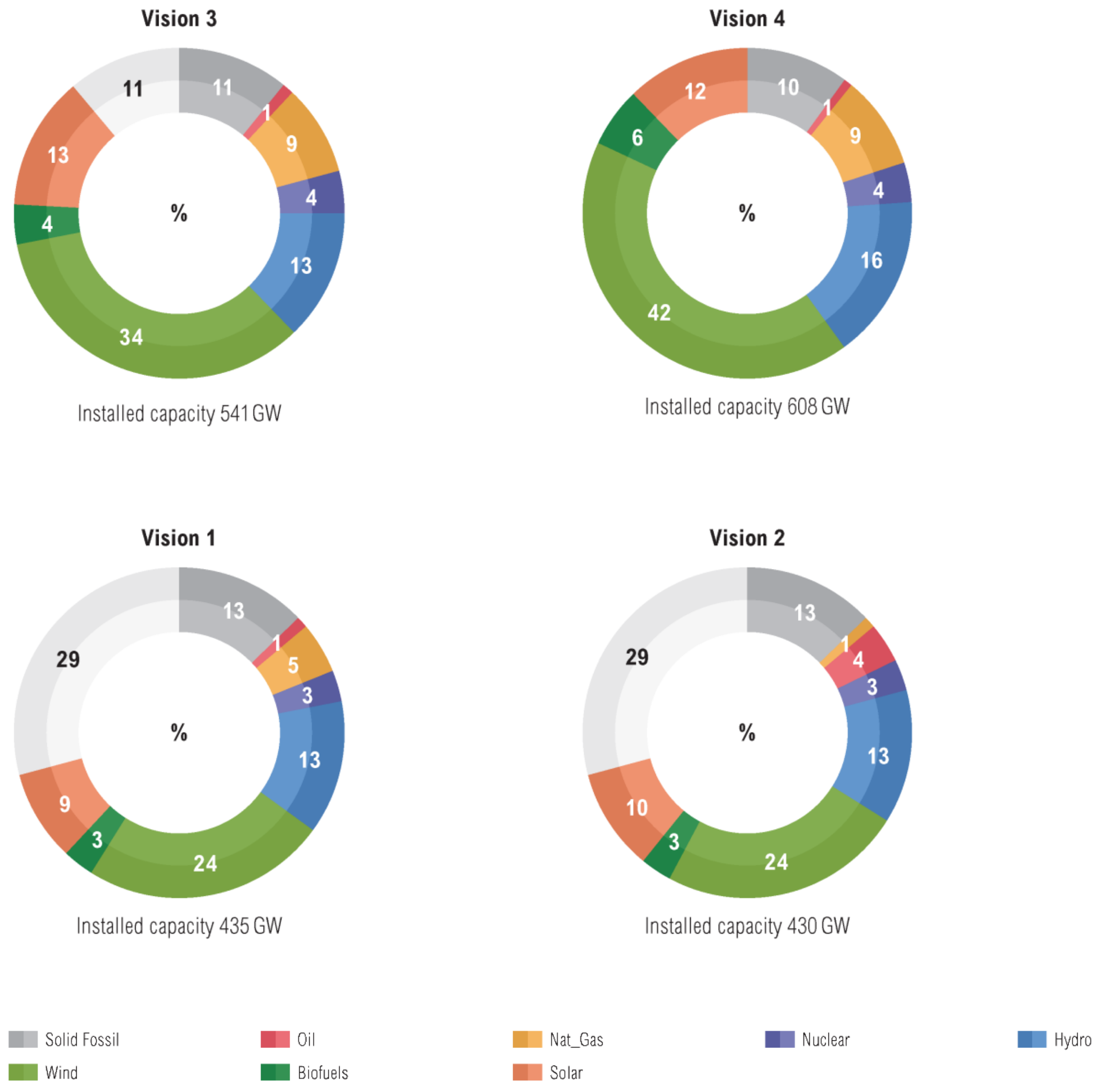

Figure 24 Installed generating capacity in Baltic Sea Region in Visions 1, 2, 3 and 4, shares installed capacity by fuel types. White area represents difference in total installed capacity from Vision 4.

The generation capacity mix in a future European power system is dependent on the incentives applied by central and local authorities. With the right incentives like subsidies and price of carbon emissions it is possible to achieve a certain direction in the development of power generation facilities in Europe. The four visions are made to span the possible future development and analyse the consequences of these development trends. The demand for the four visions is shown in Figure above. Due to different anticipated development trends the demand will be different in the different visions. The total generating capacity and generation mix will reflect the anticipated future for each vision. Total generation capacity will increase for each vision and total generation capacity for Vision 4 will be 608 GW. Figure above shows the generation mix which is referred to the total generation capacity of 608 GW in Vision 4. The amount of renewables is larger in the green visions and will increase from 49 percentage points in Vision 1 to about 76 percentage points in Vision 4. The amount of coal generation capacity will not decrease with more than 3 percentage points while generation capacity from natural gas plants will increase from 5 to 9 percentage points. The increase in generation capacity will then equal the anticipated increase in demand in the different visions.

3.1.3 Inter-area transmission capacities

The new projects of TYNDP 2014 that are being analysed are given below on the map. There are 2 types of assessed projects: ones that are included into reference case and assessed with TOOT approach and others that are analysed as additional projects to the reference case with PINT approach. Reference case includes all the TYNDP 2012 projects (incl. reassessed projects) except cancelled ones. Additionally new project candidates were included. The map below is showing transmission capacity situation of 2030 with all capacities in the reference case. Reference capacities between price areas include both existing interconnections, projects from TYNDP 2012 and new project candidates.

Capacity increases of immature and alternative projects are not included into reference case, but analysed separately. Discussion of these projects is given in appendix 8.

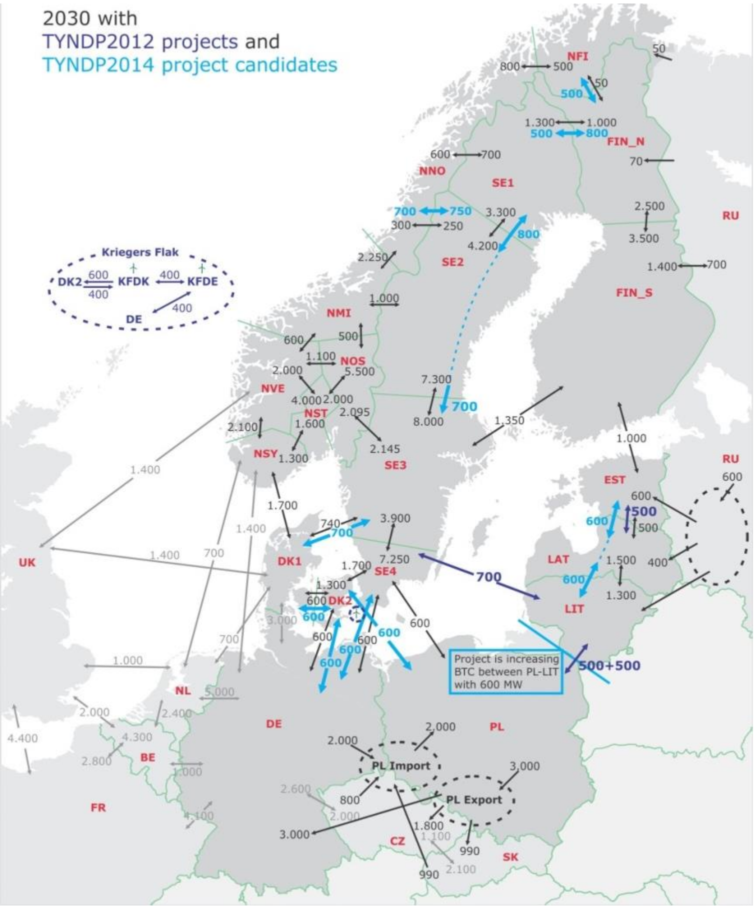

Figure 25 Interarea transmission capacities used for Visions analyses and project assessment in Baltic Sea region for studied cross-sections

3.2 Market study results of different visions

The chapter is giving an overview of generation, balances and differences in prices and flows in different visions at regional level. The results are fully based on regional analyses, performed by Regional Group Baltic Sea and cannot be directly compared with results of other regional or Pan-European studies, since different models and computation methods were used.

The Baltic Sea region has an interesting generation mix that makes it favourable to build interconnectors to Central Europe. A large amount of hydropower with variable annual inflow will give a large energy surplus in some years and deficit in other years. To utilize hydropower systems and thermal based generation systems in an optimal way it is important to have enough transmission capacity between the areas.

Appendix 3 shows the expected installed capacity in all Visions for Baltic Sea area and appendixes 4 and 5 the annual generation and balances are presented for Baltic Sea area.

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3.2.1 Generation

Produced energy volumes from different generation types is given in a figure below.

3.2.2 Market Study Results, Vision 1

The vision 1 dataset is originally submitted to ENTSO-E by all national LACs (Long term Adequacy Correspondents) applying a set of guidelines developed by ENTSO-E. It reflects a slow progress in energy system development with less favourable economic and financial conditions.

Appendix 3 shows the expected installed capacity in all Visions for Baltic Sea area.

In Vision 1 there is a relevantly strong generation share from thermal and nuclear power plants. RES increase is assumed to be rather modest than quick, compared to Vision 4. The biggest RES contribution comes from hydropower, then from wind and at last from solar. As can be seen, the Nordic countries Norway, Sweden and Finland have a considerable amount of hydropower generation. For other countries there is a mix of generation based on fossil fuel and the merit order between gas and coal/lignite is very important for the results obtained.

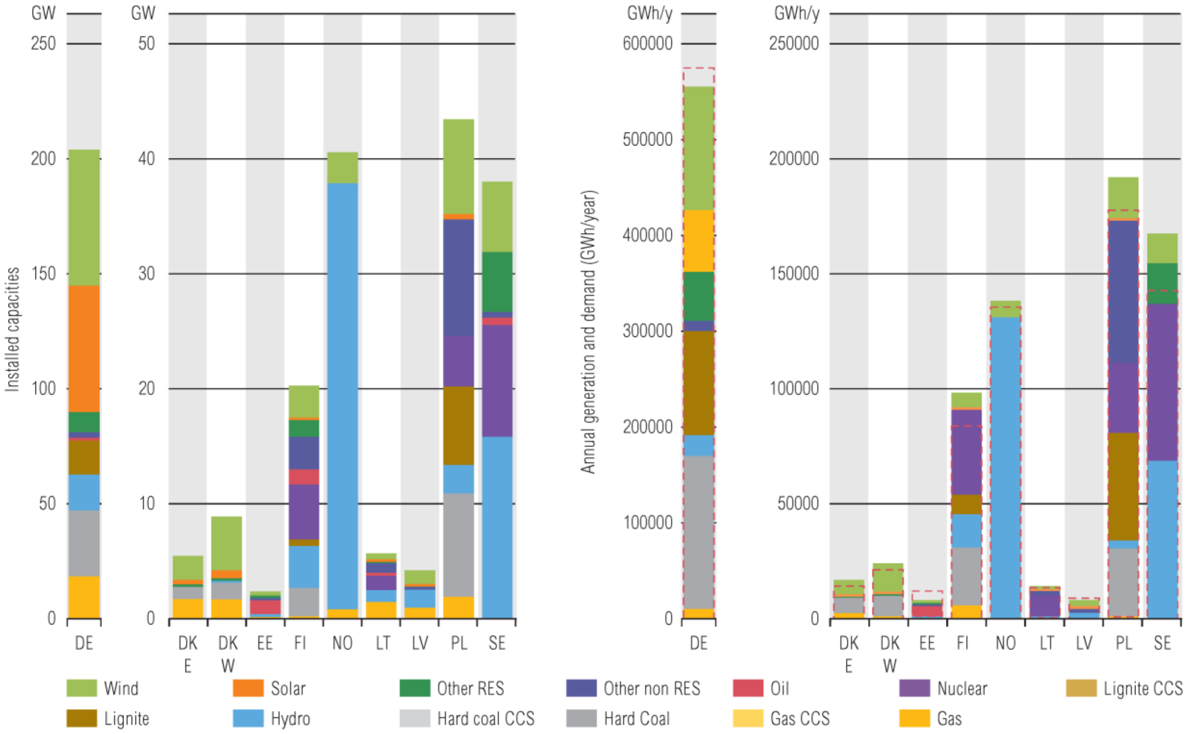

Figure 26 Vision 1 annual generation and demand (GWh/year); installed capacities (GW). For EE „oil" means oilshale."

There are no big developments in pump storages in case of Vision 1, therefore also the annual generation from pump storages is very low.

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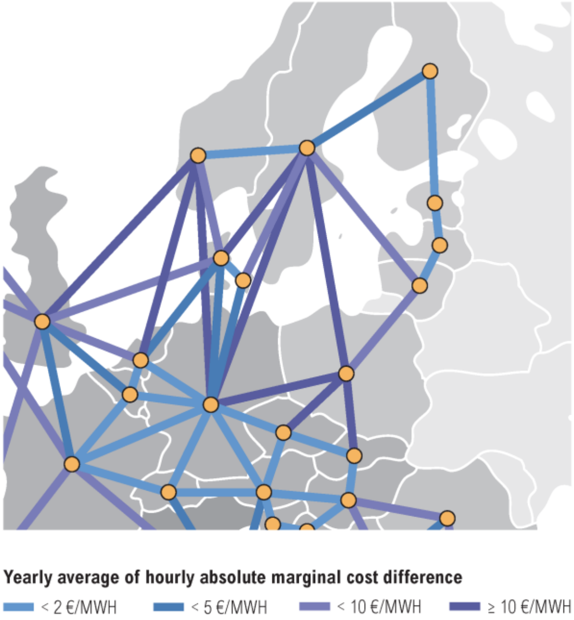

Figure 27 Vision 1 Yearly average marginal cost difference in Baltic Sea region

Figure above shows the simulated average price difference in the Baltic Sea region. The largest price differences are between Nordic countries and Central Europe. But a large price differences can also be found between Poland and Germany.

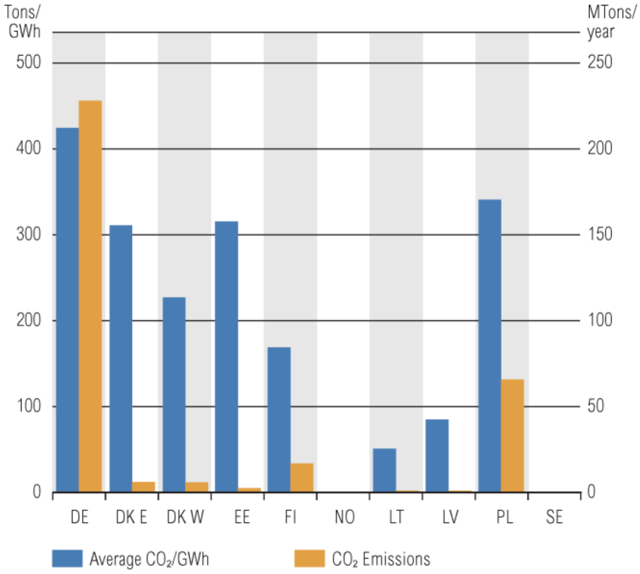

Figure 28 CO2 emissions in vision 1 in RG BS (MT/year)

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Figure 28 above shows the simulated CO2 emissions from electricity generation in vision 1 in Baltic Sea region. The largest emitters are Germany and Poland due to the highest consumption in the region and a large share of fossil-based thermal power generation. In Norway and Sweden, emissions are close to zero since vast majority of generation is covered with CO2 neutral sources, mainly hydro, wind, biomass and nuclear power.

3.2.3 Market Study Results, Vision 2

In Vision 2 the generation share from thermal and nuclear power plants is higher than in Vision 1. RES increase is quite small, compared to Vision 1. The biggest RES contribution comes from wind and solar, then from hydro. There are small developments in pump storages therefore also the annual generation from pump storages is slightly higher than in Vision 1. In general, due to precondition for Vision 2 that assumes hard coal is preferred to gas and economic and financial conditions are less favourable than in Visions 3 and 4, there are no big changes between Vision 1 and Vision 2. Thus, increase of demand in Vision 2 causes the increase of generation from thermal power plants.

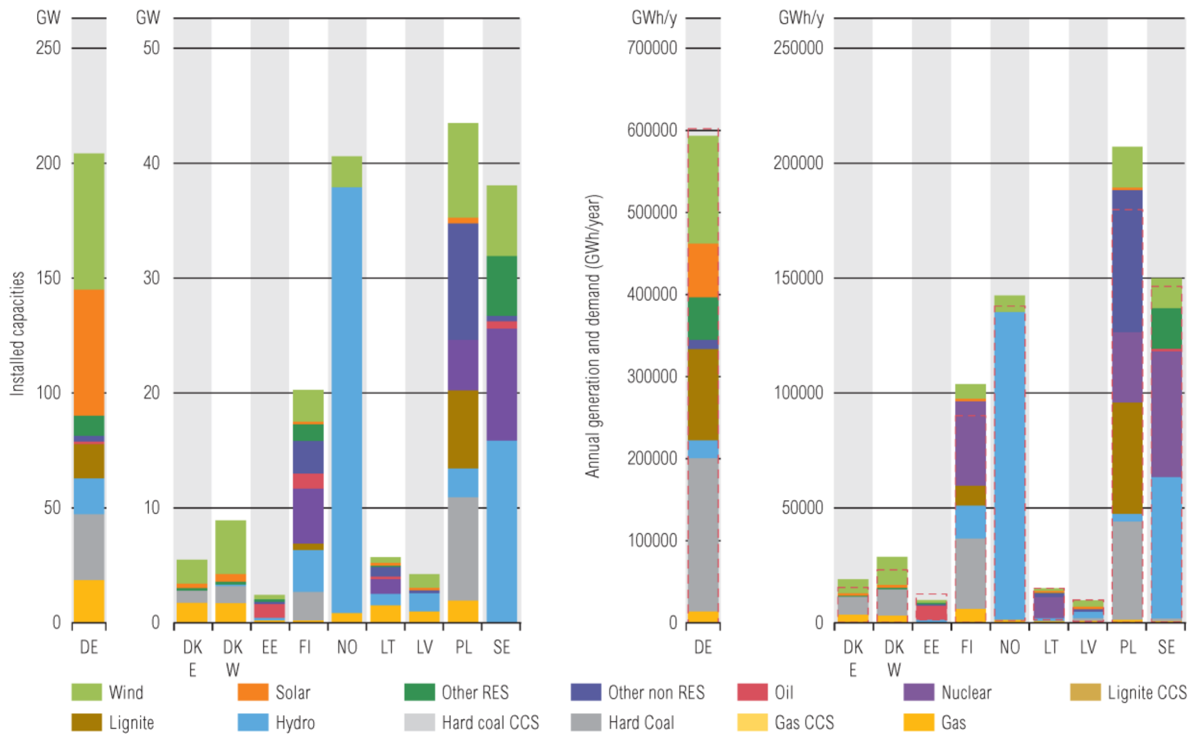

Figure 29 Vision 2 annual generation and demand (GWh/year); installed capacities (GW). For EE „oil“ means oilshale.“

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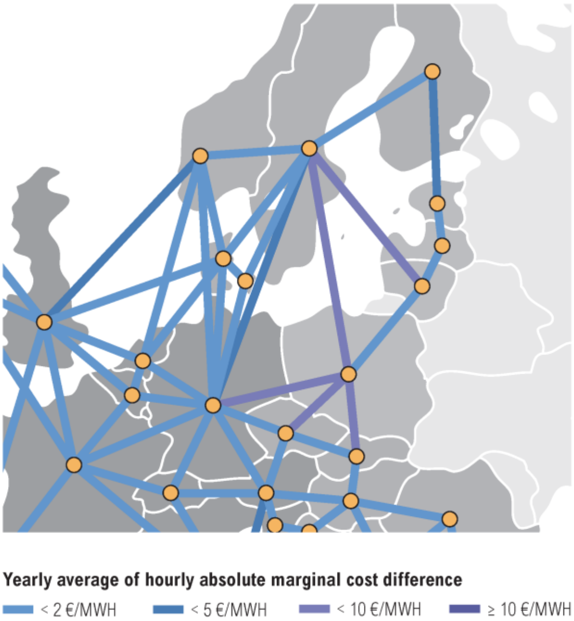

Figure 30 Vision 2 yearly average marginal cost difference in Baltic Sea region

Figure above shows the simulated average price difference in the Baltic Sea region. The largest price differences are between the Nordic countries and Central Europe. But a large price differences can also be found between Poland and Germany.

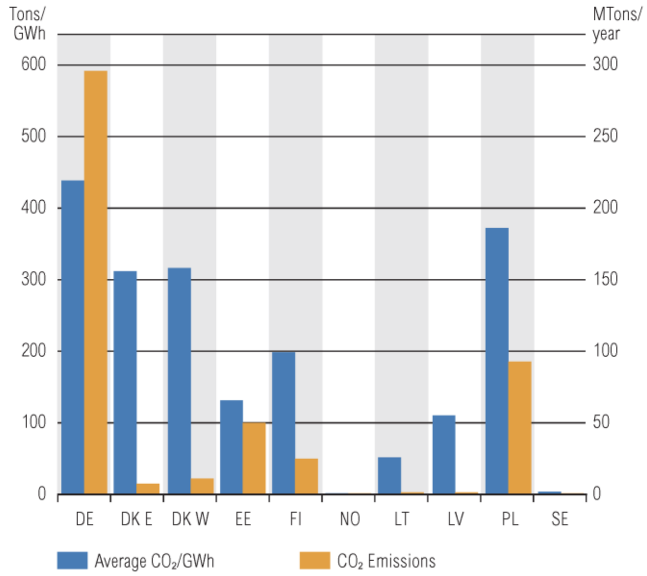

Figure 31 CO2 emissions in vision 2 in RG

Figure above shows the simulated CO2 emissions from electricity generation in vision 2 in Baltic Sea region. Overall in Baltic Sea region, vision 2 has the highest CO2 emissions of the four visions.

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3.2.4 Market Study Results, Vision 3

In Vision 3 the generation share from thermal power plants is much less, than in Vision 1 and 2 and the vision has considerable increase in RES generation. However, there is increase of generation from gas power plants compared to Vision 1 and 2. The biggest RES contribution comes from wind, hydro and biomass. There are no big developments in pump storages and the annual generation from pump storages is even less than in Vision 1. Thus, the biggest share of demand is mainly covered by RES generation in Vision 3

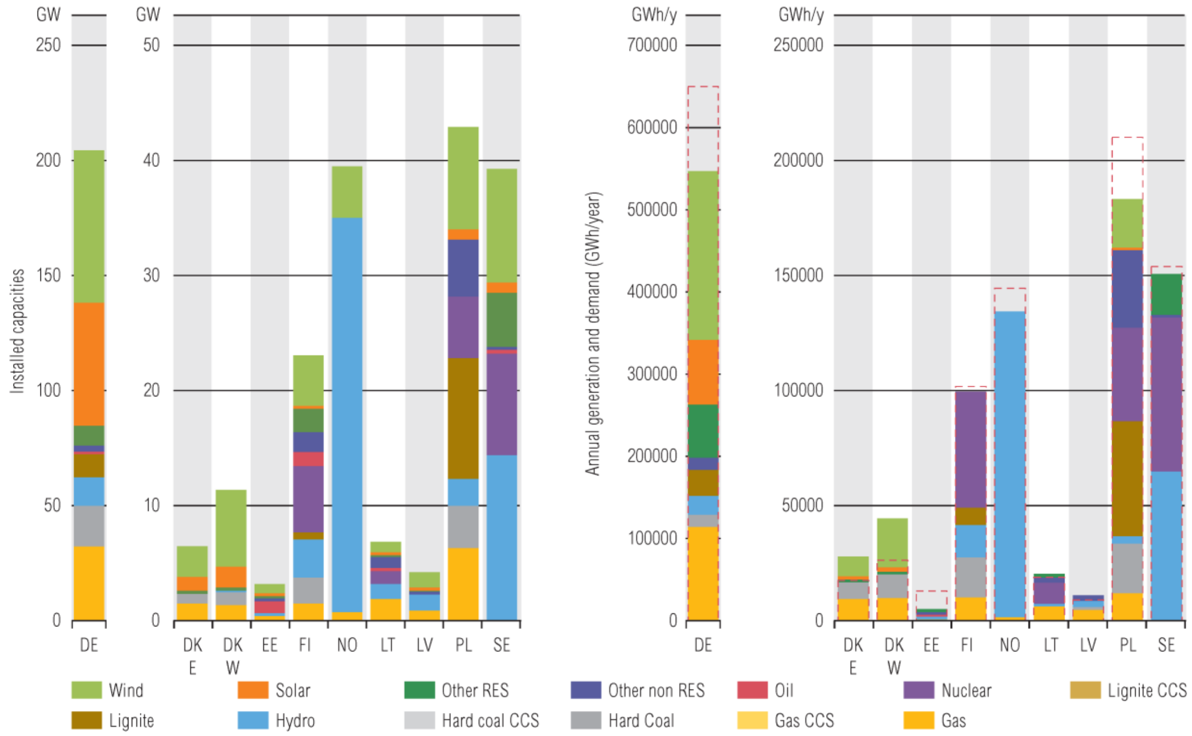

Figure 32 Vision 3 annual generation and demand (GWh/year); installed capacities (GW). For EE „oil“ means oilshale.“

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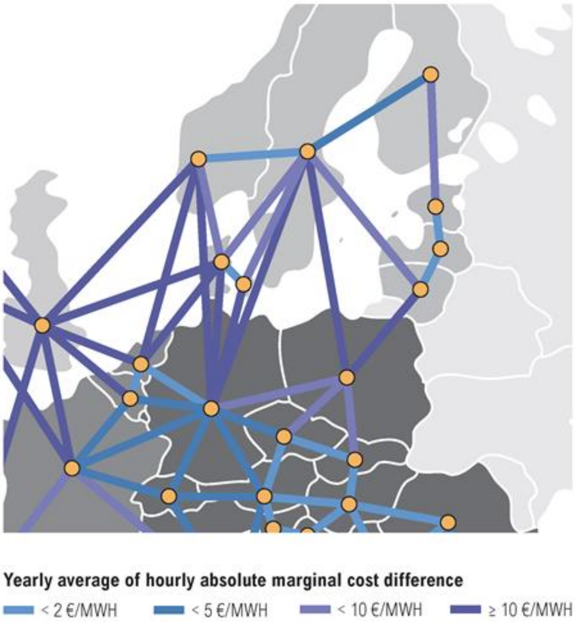

Figure 33 Vision 3 yearly average marginal cost difference in Baltic Sea region

Figure above shows the simulated average price difference in the Baltic Sea region. The largest price differences are between Nordic countries and Central Europe. But a large price differences can also be found between Poland and Germany.

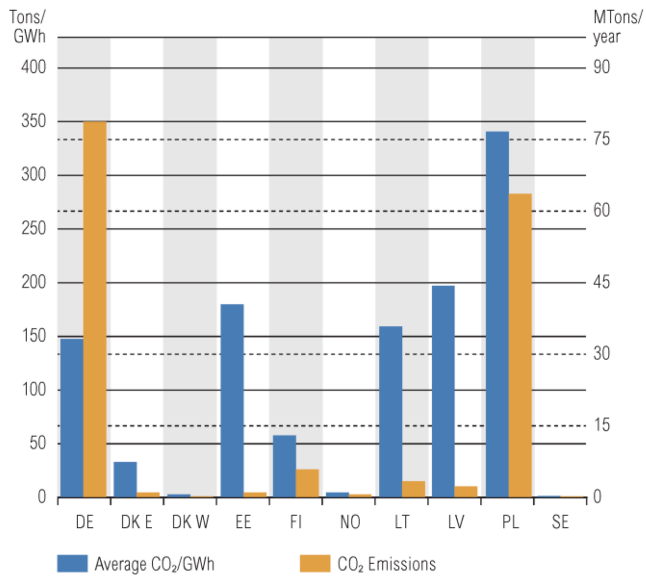

Figure 34 CO2 emissions in vision 3 in RG BS (MT/year)

Figure above shows the simulated CO2 emissions from electricity generation in vision 3 in Baltic Sea region. Overall in Baltic Sea region, CO2 emissions in Vision 3 are significantly lower compared to visions 1 and 2 due to higher amount of CO2-free generation and gas running before coal in the merit order.

3.2.5 Market Study Results, Vision 4

In Vision 4 the generation share from thermal and nuclear power plants is not far different from Vision 3. The increase of RES generation, mainly wind and biomass can be seen compared to Vision 3 and as in Vision 3 the biggest RES contribution comes from wind, hydro and biomass. There are some developments in pump storages; therefore the annual generation from pump storages is also higher than in Vision 1, 2, 3. The biggest share of demand is mainly covered by RES generation in Vision 4.

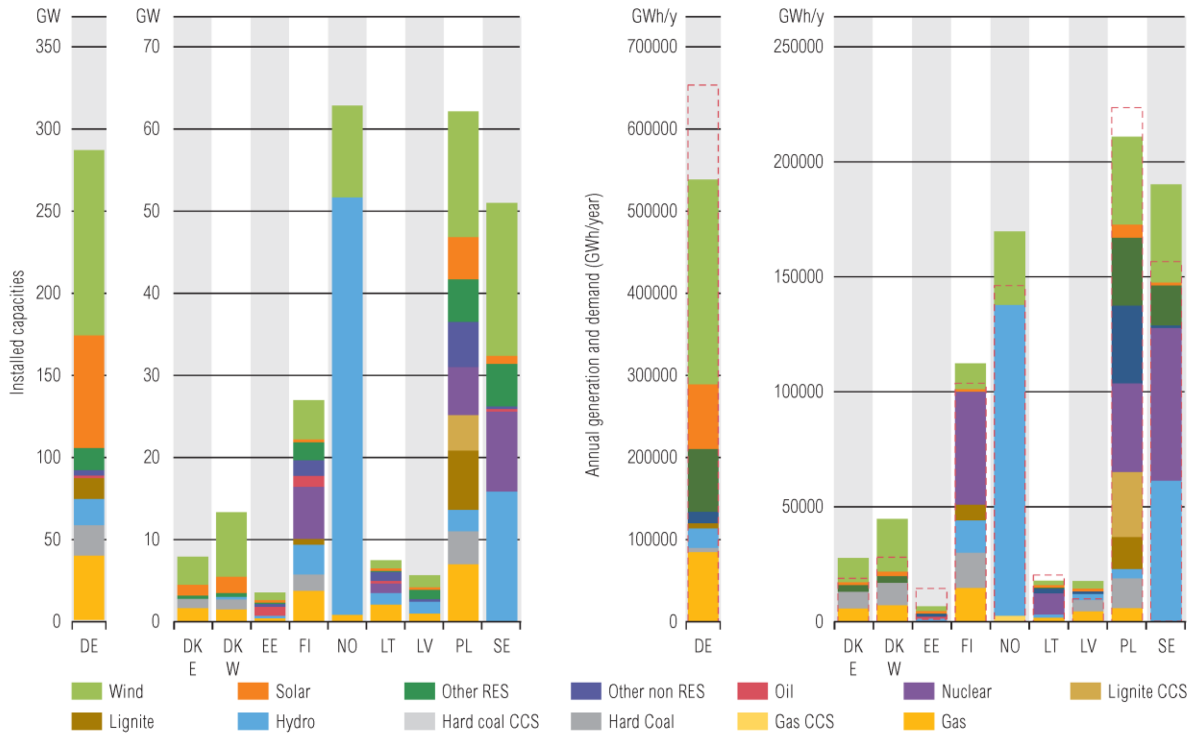

Figure 35 Vision 4 annual generation and demand (GWh/year); installed capacities (GW). For EE „oil" means oilshale."

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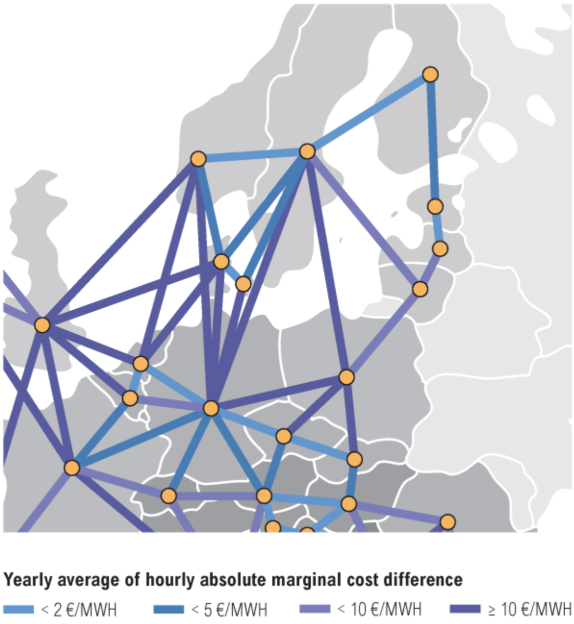


Figure 36 Vision 4 yearly average marginal cost difference in Baltic Sea region

Figure above shows the simulated average price difference in the Baltic Sea region. The largest price differences are between Nordic countries and Central Europe. But a large price differences can also be found between Poland and Germany.

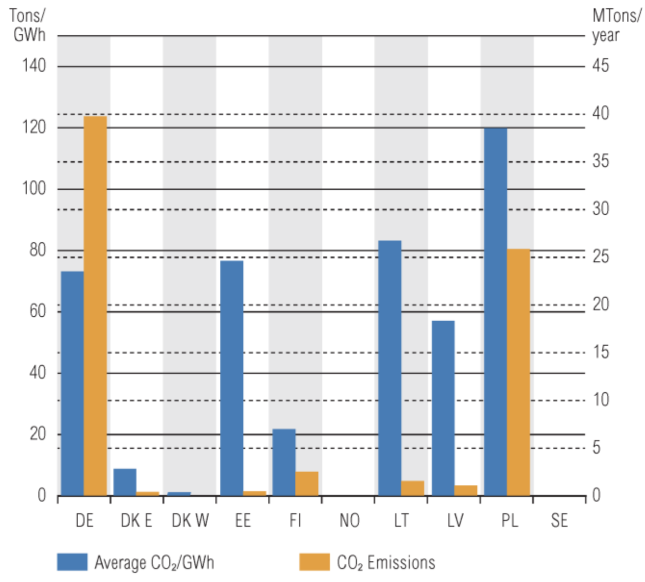


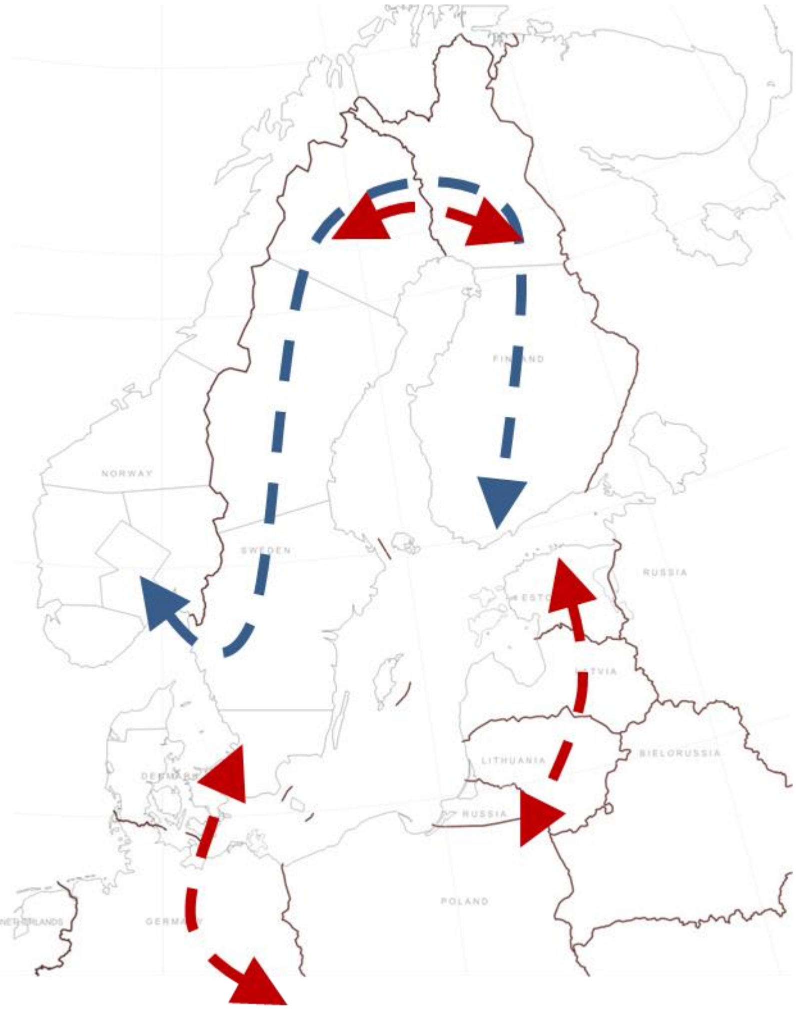
Figure 37 CO2 emissions in vision 4 in RG BS (MT/year)

Figure above shows the simulated CO2 emissions from electricity generation in vision 4 in Baltic Sea region. Overall in Baltic Sea region, CO2 emissions in vision 4 are lowest of the four visions due to high increase in renewable electricity generation compared to Vision 3.

3.3 Network Studies Results

The output from the network studies are technical characteristics such as observed line-loadings over a year, voltage variation of observed busses, check of violations of technical limits in case of N-1 and N-1-1. These characteristics relate to and are obtained from the network modelling studies.

Additionally to the load-flow results, the dynamic stability issues shall be taken into consideration, especially for the Nordics system because of the characteristics listed below. The Dynamic issue characteristics are illustrated with blue line and the thermal and steady state stability issues are marked with red color.



- Long transmission distances between South Finland and South Sweden/Norway
- Angle and voltage stability (dynamic) often limiting factor of transmission capacity in Nordics
- Remote parts of the system weakly meshed and on lower operational voltages (weak networks)
- Use of system protection schemes to enhance transmission capacity (dynamic measures to enhance load-flow transport)
- Thermal overloadings and steady state issues observed in case of heavy flows with red colorus. Baltics 330 kV North-South network, Sweden-Finland AC connections, Scandinavia-CE.

Figure 38 Load flow and dynamic issues areas in the Baltic Sea region.
Blue – dynamic issues, Red – loadflow and steady state issues.

For illustrating Scandinavia-Continental Europe flow limits there is a case study done for Denmark interconnectors with the necessary internal grid reinforcement. Annual hourly calculated grid/lines flow duration curves and comparison with applied limits is used for analysis. More detailed step-by-step descriptions and the results are given in Appendix 6 under Study Case 1.

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For Baltic States it is not possible to provide sufficient transmission capacity without the new projects implementation on the North-South corridor. An example illustrating a snapshot with an influence of Estonia-Latvia 3rd interconnector is given more detailed in Appendix 6 under Study Case 2.

In case of heavy East-West flows in northern Scandinavia it is possible to see the Finland-Sweden 400kV AC network overloading in case of an outage if new project(s) are not implemented. The example of the snapshot study is given in Appendix 6 under Study Case 3 and it is illustrating the effect of AC 3rd 400kV connection between Finland and Sweden.

Previously described study cases present examples of the network study with the focus on possible system evolution by 2030. The system evolution implies implementation of additional investments due to increased transmission capacity with the neighboring system and integration of significantly more wind power and RES.

3.4 Comparison of the 2030 visions

The total yearly consumption in the RGBS region for Vision 1 is approximately 1200 TWh and for Vision 4 1400 TWh. The larger consumption in Vision 4 compared to Vision 1 reflects the higher consumption in the Baltic countries (~11 TWh), the higher consumption in the Scandinavia countries (~45 TWh) and the higher consumption in the continental counties (~175 TWh).

The total yearly consumption in the Baltic Sea region excluding Germany and Poland varies between 474 and 507 TWh in different Visions. 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.

The increase of RES in Vision 1 is evident, but not ambitious for the long time period till 2030. The main change in installed capacity in Baltic Sea region is the increase of wind production capacity. The increase of wind goes from 140 GW in Vision 1 to 230 GW in Vision 4.

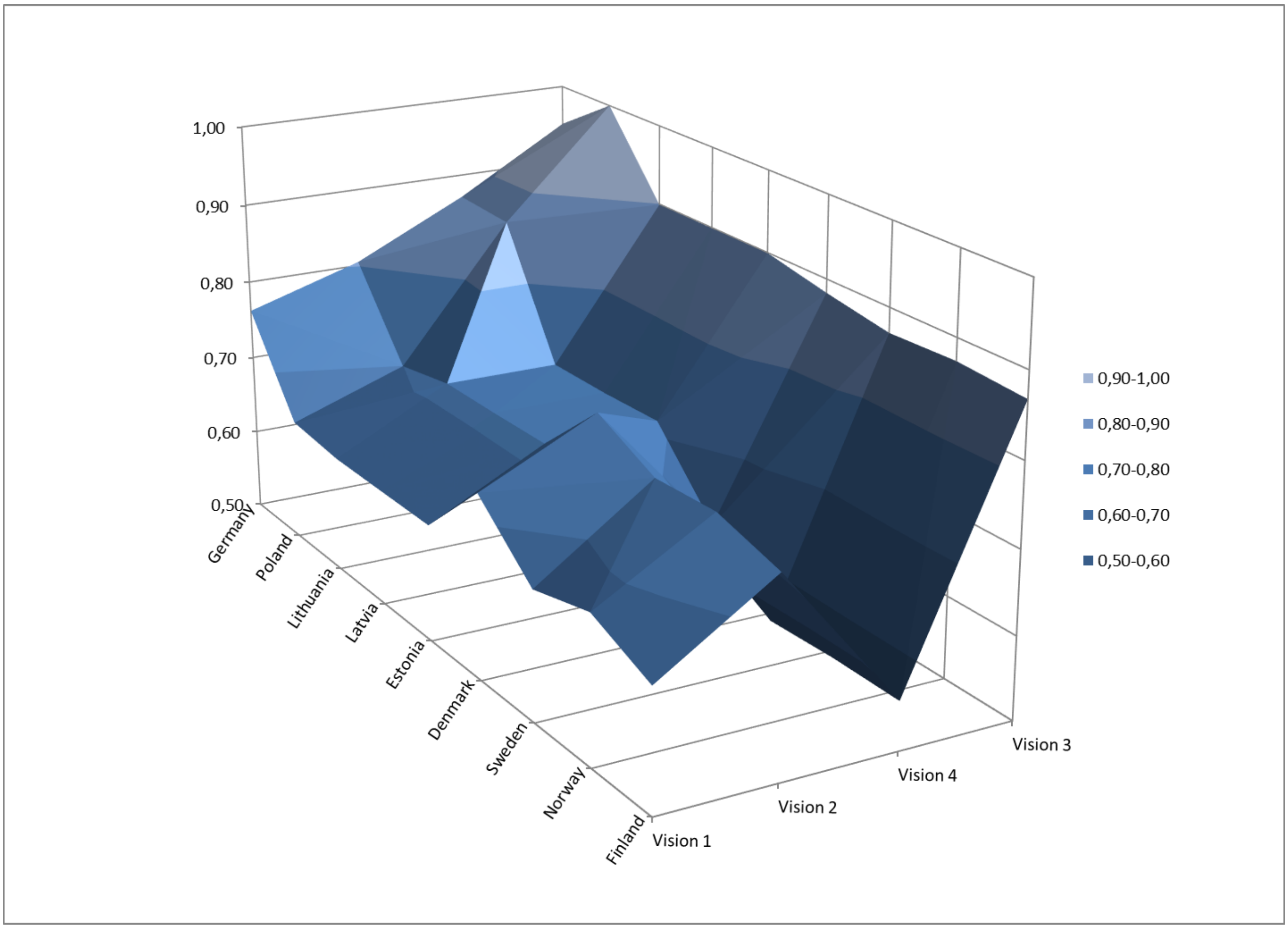
The high CO2 emissions in Vision 1 (~320 MTons) are mainly driven by the usage of fossil fuel power plants in continental countries. The higher amount of renewables and the lower usage of fossil fuel power plants in continental countries leads to lower CO2 Emissions in Vision 4 (~70 MTons).

In total the RGBS is an exporting region in Vision 1(~43 TWh) and an importing region in Vision 4 (39 TWh).

The Baltic countries are importers both in Vision 1 (~3 TWh) and in Vision 4 (~2 TWh) . The export from the Scandinavian countries strongly increases from Vision 1(~46 TWh) to Vision 4(~72 TWh) due to new RES production capacity. The continental countries are small importers in Vision 1 (~0,2TWh) and huge importers in Vision 4 (~109TWh). The higher consumption and lower usage of fossil fuel power plants leads to the increase of imports between Vision 1 and Vision 4.

3.4.1 Price differences

In Baltic Sea region there are visible common features that characterize all 4 visions by means of price differences. Generally the prices have tendency to increase from north (Nordic countries) towards south (continental Europe) direction. This is clearly visible in case of vision 3 and 4. Average price is also considerably higher in Vision 1 compared to Vision 4. The overall price difference among Visions is mainly caused by additional renewable capacities installed into the system, especially to Nordics and Baltic States Systems, but also caused by fuel prices and availabilities of fuels in particular areas. The highest prices compared to other countries in the region are found in Germany. The following figure illustrates the dynamics of the average energy price differences in the region in case of different visions and different countries. The values of the prices are given in PU values where the unit 1 value is as the highest average energy price in the system among all four visions. The price differences are illustrated as a landscape graph with price contour colours.



	Vision 1	Vision 2	Vision 4	Vision 3
Germany	0,76	0,80	0,87	0,95
Poland	0,65	0,70	0,87	1,00
Lithuania	0,64	0,71	0,71	0,90
Latvia	0,64	0,71	0,71	0,90
Estonia	0,64	0,71	0,72	0,90
Denmark	0,72	0,79	0,63	0,88
Sweden	0,66	0,75	0,56	0,87
Norway	0,68	0,76	0,56	0,87
Finland	0,65	0,74	0,56	0,87

Figure 39 Relative price levels by vision and area.

3.4.2 Bottlenecks

The largest bottlenecks appear on boundaries between Scandinavia and Central Europe and North – South flows from North Scandinavia to Southern Scandinavia, where interconnectors are loaded in range of 80-90%. Also interconnections from Baltics to Scandinavia are heavily utilized, close to 70%. Also the congested hour's results follow the same trend with relative loading correspondingly. To illustrate the most heavily loaded interconnectors, duration curve figures are given in next chapter.

According to the results most utilized interconnectors are placed between Scandinavia and Continental Europe, Baltics and Nordics or Central Europe and cross-section, north to south of Scandinavia and Finland-Sweden.

4 Investment needs

4.1 Present situation

The map shows diverse level of Net Transfer Capacities (NTC) in the Baltic Sea Region. The NTC is the maximum total exchange program between two adjacent control areas that is compatible with security standards and applicable in all control areas of the synchronous area, whilst taking into account the technical uncertainties on future network conditions.

NTC values for the same equipment change under different conditions, for example the topology of the network or the load pattern at the given point in time that the study is conducted.

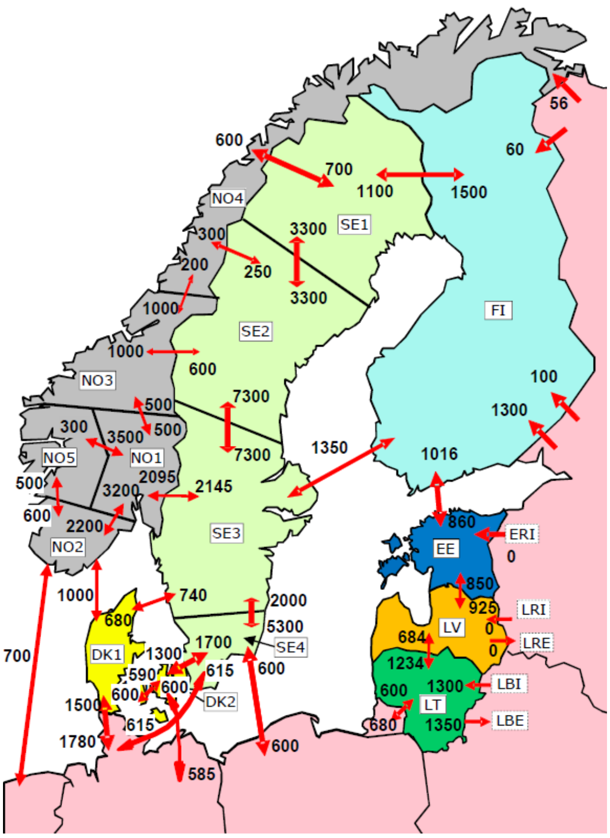


Figure 40 Illustration of Net Transfer Capacities in BS region (April 2014). Source: Nordpool Spot

The Baltic Sea Region comprises nine countries in three separate synchronous systems. The Nordic power system is hydro dominated with most of the hydropower plants located in Norway and northern Sweden. The difference of energy balance of countries in the region between wet and dry year is significant. The continental system and the Baltic States are currently thermal power dominated areas. Denmark and Germany stand out with a high share of wind power. During an average year Finland and Lithuania have 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 currently.

The highest NTCs in the region are in the borders of Germany, and highest after that mainly between Norway, Sweden and Finland, with NTCs in a range of between 2000 and 4000 MW. This is based on the historically close electricity market integration between Nordic countries.

The Baltic States are connected to Nordics via Estlink 1 and Estlink 2 cables, which ensure NTC up to 1000 MW. Internally to the Baltic Region; relatively equal NTCs are maintained between all Baltic States. There are also many interconnections between Nordic countries and Continental Europe. This is because there has been a high price differential between the areas, due to high levels of cheap hydro production in Norway and high levels of electricity consumption on the Continent. Currently, the NTCs between individual Nordic countries and Central Europe are up to 2500 MW. Germany and Poland are included in the Baltic Sea region and the countries in Central Europe and it should be noted that countries in Central Europe are more tightly connected, with NTCs reaching 2000-4000 MW. Such high NTCs allow load flow circulation in different grid modes and ensure secure power system operation in all cases, especially in those cases where emergencies occur.

The Baltic Sea Region has electricity cross-sections with third party countries, namely; Russia, Belarus and Kaliningrad. In this case, NTCs are limited from a system operation perspective in the Baltic States. NTCs from Finland and Lithuania, to third party countries are in the range of between 1000 and 2000 MW.

4.2 Drivers for power system evolution

The three main drivers for system evolution in the Baltic Sea region are market integration, integration of RES as well as conventional generation and security of supply. These drivers are followed by the refurbishment of aging equipment. One of the biggest challenges regarding the main drivers is that there is a large uncertainty regarding the generation investments. On the EU-Russian border there is also uncertainty regarding the market development. Until early 2010’s the direction of flow has been steady from Russia since Russian prices have been clearly below prices in the BS region, but in a future with more equal prices due to more similar generation portfolios, CO_2 price and fuel price changes, there may be less import or even export at times when the electricity price is higher in Russia or low in Baltic Sea region. In the South-Eastern part of the BS region the integration of the Baltic countries with the Nordic and European electricity market can also have an impact on the border transfer between Russia and the neighbouring countries.

In Germany with the decision of a nuclear phase-out by 2022 the structural changes needed in the generation portfolio also results in the generation pattern changing which again will affect electricity prices and subsequently the power flows of the whole Europe.

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4.3 Main Bottlenecks possibly developing in the coming decade

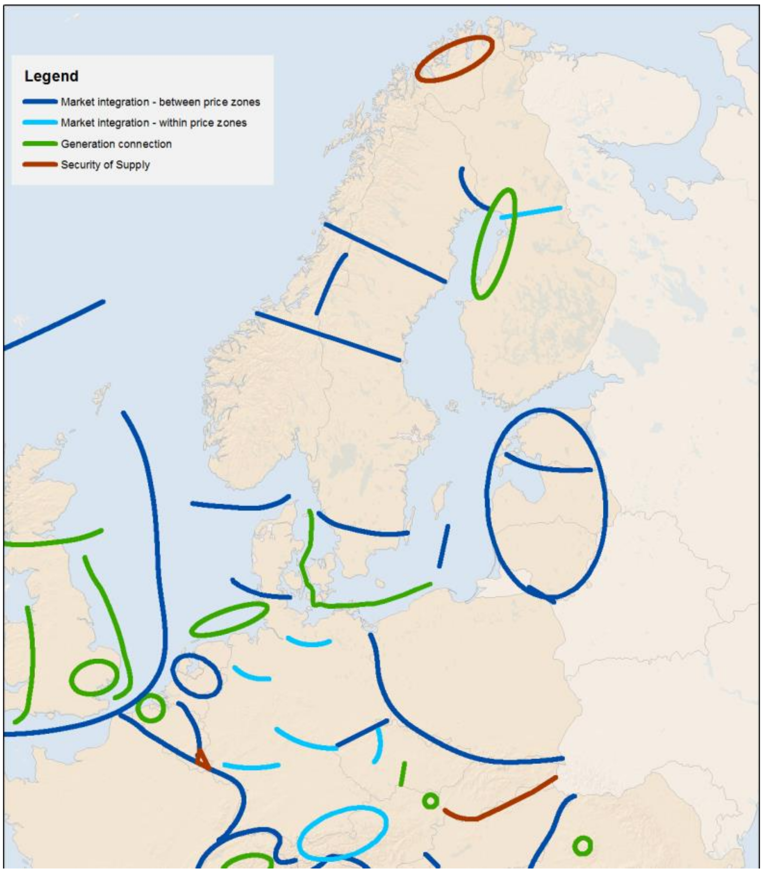

Figure 41 Maps with possible bottlenecks in the region

NB: when a boundary can be flagged with more than one concern, market integration prevails over generation connection and security of supply.

Figure above shows bottleneck location in the coming decade (unless new transmission assets are developed), i.e. the grid sections (the "boundaries"), the transfer capability of which may not be large enough to accommodate the likely power flows that will need to cross them unless new transmission assets are developed.

In order to ease the understanding, the likely bottlenecks are presented in three areas:

1. **Security of supply;** when some specific area may not be supplied according to expected quality standards and no other issue is at stake.
2. **Direct connection of generation;** both thermal and renewable facilities.
3. **Market integration;** if inter-area balancing is at stake, distinguishing what is internal to a price zone and what is between price zones (cross-border).

4.4 Drivers for grid development

4.4.1 Generation Connections

In the long-term change in the generation mix in the Baltic Sea region drives the system development in a large extent. It is both due to integrating the renewables in relatively remote locations away from the consumption centres and due to enabling the usage of Nordic hydropower to supply Nordic surplus to

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central Europe when wind power is not produced and absorbing the surplus produced by the wind power when there is excess of it in Northern central Europe.

The figure below shows the expected boundaries based on connection of new generating facilities.

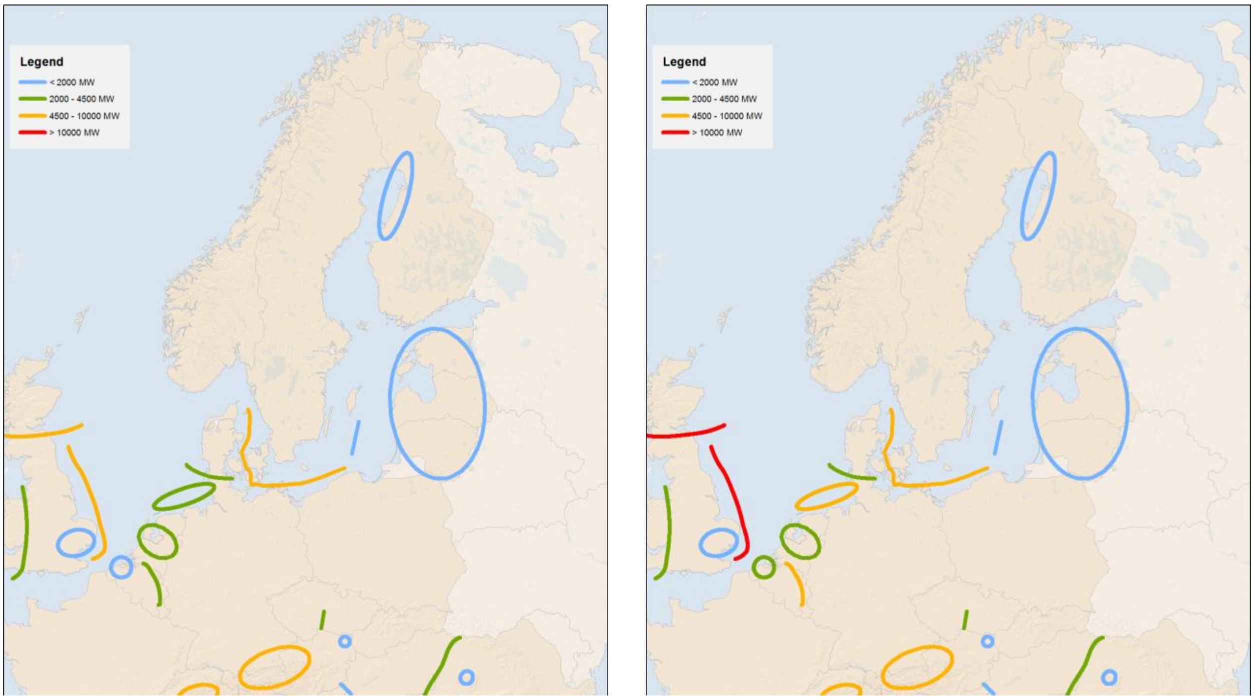

Figure 42 Map of bulk power flows related to generation connections – Vision 1 (left); Vision 4 (right)

New wind power plants are planned to be built almost all around the region, but mainly concentrating on the coastal areas as well as in the highland areas in the Northern part of the region. 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 changes in the power flow patterns.

In Finland there are plans and decision-in-principle to build two new large nuclear power units and in Sweden there are discussions about whether 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.

Vision 4 envisages massive construction of new renewable generation. The main share is wind power (both on- and offshore), solar and biofuels-fired generation. At the same time large amounts of coal, lignite and oil-shale based units are decommissioned.

Solar generation is connected mainly to the distribution level and its impact on the transmission grid is moderate compared to other sources of RES generation.

Wind generation has the highest growth in Germany, Sweden, Poland and Norway. Difference between Vision 1 and 4 is more than 84 GW in the whole Baltic Sea region, which again shows the large uncertainty related to wind generation development. Grid connection of such amounts of new generation causes a need massive grid reinforcements and also construction of new grid. Because the studied time-horizon deals with

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a distant future, all necessary reinforcements are not fully studied as exact connection locations are hypothetical.

In addition, additional natural gas fired CCGT (ca 25 GW) and nuclear units are assumed in vision 4, but grid reinforcements have in most cases local nature. Natural gas fired units have major growth in particularly Germany and Poland, replacing coal/lignite fired generation sources. In addition to Vision 1, further development of nuclear power is shown in Finland and Poland in Vision 4.

Vision 4 is compiled from a top-down approach; consequently not all national development policies and preferences have been taken into account. The intent has been to provide a consistent vision on European level, not necessarily on local or National levels. Based on these assumptions, regional analyses in conjunction with additional generation in Vision 4 have been focused on interconnection capacities between countries and market areas, rather than grid connection solutions of particular units.

The major difference between Visions in terms of generation capacity is the amount of installed capacity in the region; from ca 435 GW in vision 1 to ca 608 GW in vision 4. The shift goes towards intermittent renewable energy sources, having lower utilisation than conventional generation sources. The produced energy in the region is increasing from about 1240 TWh in vision 1 to about 1375 TWh in vision 4, Grid connection of such additional capacity in Vision 4 needs both local reinforcements for particular power plants, but also further development of interconnections between different market areas to allow the most economically feasible utilisation of different generation sources. The main challenges in the area is related to additional wind generation and ensuring that power can get from the Nordic area to central Europe.

4.4.2 Market Integration

The creation of the Internal Electricity Market (IEM) will eventually require the harmonisation of all cross-border market rules so that electricity can flow freely in response to price signals. Market integration is leading to more and larger power flows across Europe, it is therefore a main driver of the grid development across Europe. The flows that trigger grid development in 2030, in Visions 1 and 4, are shown in figure below with the boundaries significant to market integration.

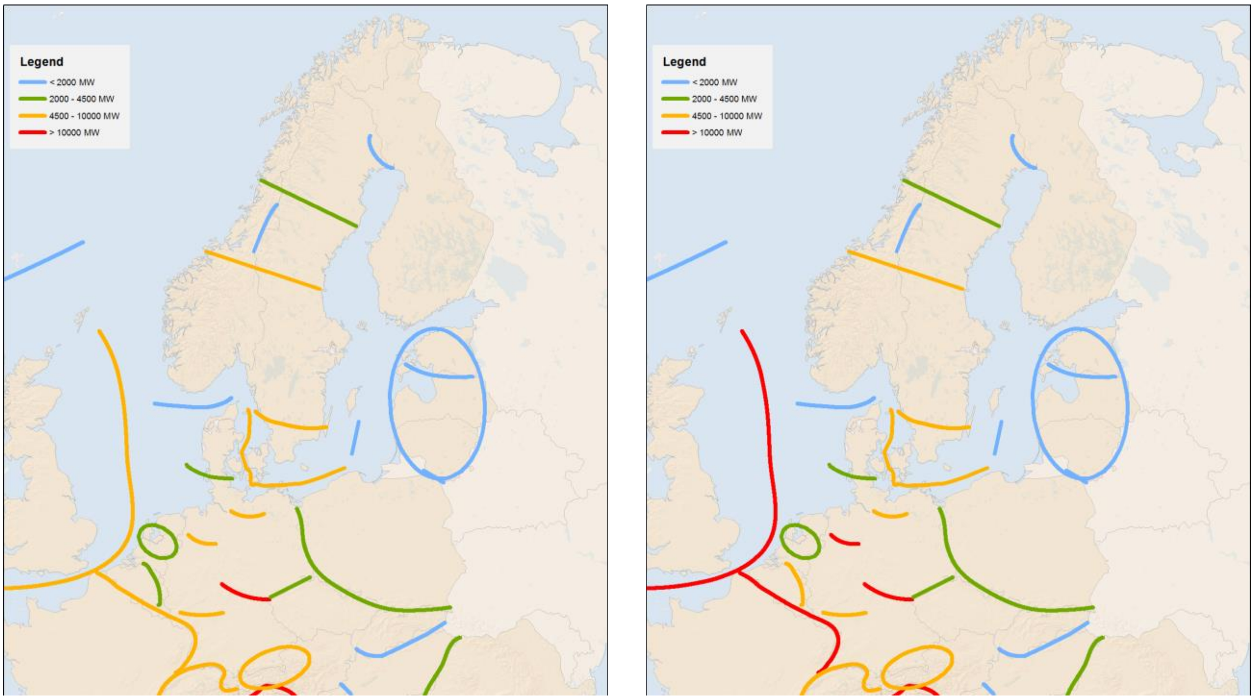

Figure 43 Map of bulk power flows related to market integration - Vision 1 (left); Vision 4 (right)

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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 utilise the benefits of the countries' diverse generation type portfolios. Bottlenecks currently still exist between the hydropower dominated areas of Norway and Northern Sweden and the thermal production dominated Southern Finland, Southern Sweden and Denmark.

More capacity between the Nordics and Continental Europe is vital to serve the expected change in transmission patterns due to the increase of wind power in Continental Europe and the change in power balance in Germany led by the closure of all nuclear production by 2022. 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.

Vision 4 is a green vision with a considerable amount of new renewable production and hydro pumping power to match the need for fast regulation. In such an environment the inter-area transmission capacities will play a crucial role, not only for transfer of energy but also for making regulating power available for the whole system. New wind power must be built where there are possible available areas, many times offshore, and this will often be far from the consumption centres. With a high CO2 price, energy production from coal fired thermal power plants is substituted by renewable production with low variable production cost. Price differences are generally higher than in Vision 1 and the socio-economic benefit of new transmission capacity is also higher. Ancillary services must be available throughout the interconnected market areas and this put strain on transmission capacities that are already highly utilized for energy transfer in Vision 4. To have a functioning and integrated market both for energy and ancillary services, transmission capacities must be dimensioned to handle both to a much larger extent than in Vision 1.

4.4.3 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.

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

Both vision 1 and 3 assume self-sufficiency in terms of installed capacities, but reliably available capacity is considerably lower in vision 4 in the Baltic Sea area. It means that the assumption behind visions guarantee adequate generation and grid for all Visions.

The major shift from thermal to intermittent renewable power generation is assumed in Germany in vision 4, compared to vision 1. Consequently in certain market conditions without new interconnections the loss of load expectation (LOLE) can be detected based on analyses in some areas of the region, internal congestions inside market areas were not taken into account. The most vulnerable, caused by shifts in the installed capacities, is Germany where LOLE can reach up to 0,06% (10,5 GWh).

The figure below shows the expected boundaries related to the security of supply concerns.

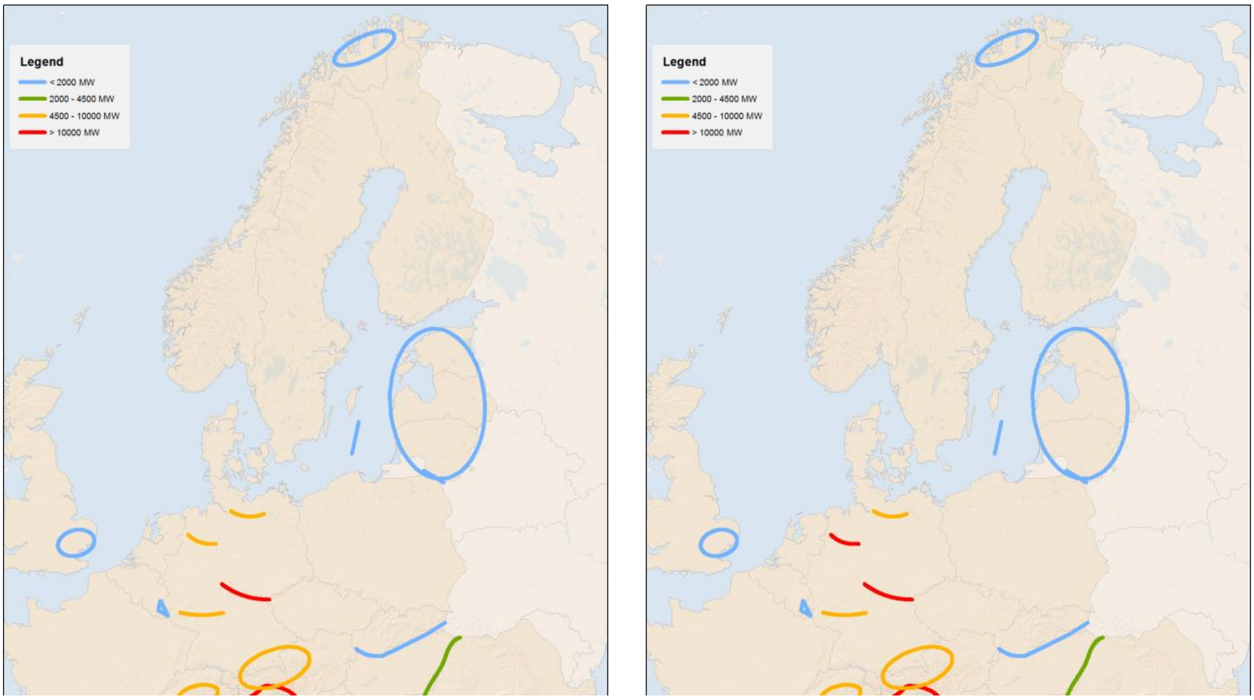


Figure 44 Map of bulk power flows related to security of supply - Vision 1 (left); Vision 4 (right)

In vision 1 LOLE up to 0,003% (90 MWh) for Northern Norway is observed, derived from weak local transmission grid in the area. In vision 4, increased generation capacity in this region eliminates risks to security of supply.

Other concerns with security of supply have more local nature and are assessed by other methods than LOLE.

It can be concluded that security of supply in Baltic Sea area is good in all visions. The main reason for this is the strong network between different areas and basic assumptions behind the 4 visions, where self-sufficiency in terms of installed capacities in vision 1 and 3 and the high amounts of renewable energy sources in vision 4 in a lot of countries combined with a strong internal grid between countries in the Region.

4.4.4 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 densly populated areas it is increasingly more difficult to get acceptance for overhead lines. This could lead to a wider use of cables in the future.

4.5 Bulk power flows

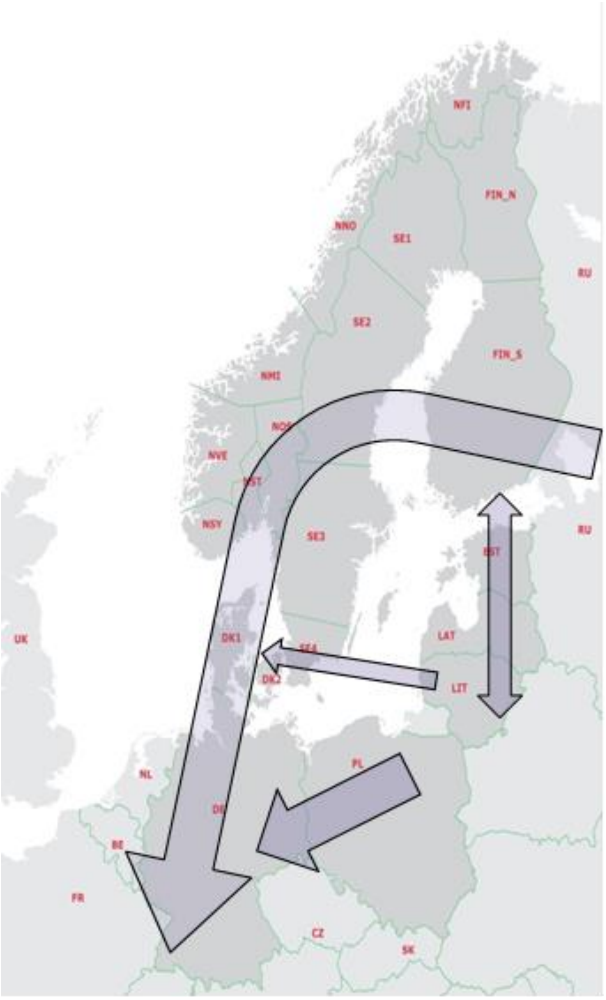
Vision 1 and 2 - Large East-West flows; North to South flows

In total the Baltic Sea Region is an exporting region in both Visions 1 and 2. The largest exporting countries are Sweden, Poland, Finland and Denmark. Small export comes also from Norway and Latvia. The biggest importer is Germany and relatively big importer also Estonia, compared to its annual consumption. The dominant energy flows are North-South directional, towards continental Europe and Great Britain. Energy flows are shown on the figure below.

Vision 3 and 4 - Nordic surplus exported to Central Europe; large North-South flows: bidirectional East-West flows

In total the Baltic Sea Region is an importing region in both Visions (39 TWh in Vision 4). The balance in different countries follow the same pattern, but respectively export from exporting countries and import from importing countries is higher than in Visions 1 and 2. The higher consumption and lower usage of fossil fuel power plants leads to the increase of imports between Vision 1 and Vision 4. The main importers are continental countries in Vision 4 (~109 TWh).

The main transmission corridor is through Nordic countries to Central Europe, but also corridor through Baltic countries and Poland serve as an additional support for North-South flows. The bulk power flow directions in different visions are illustrated on the following pictures.



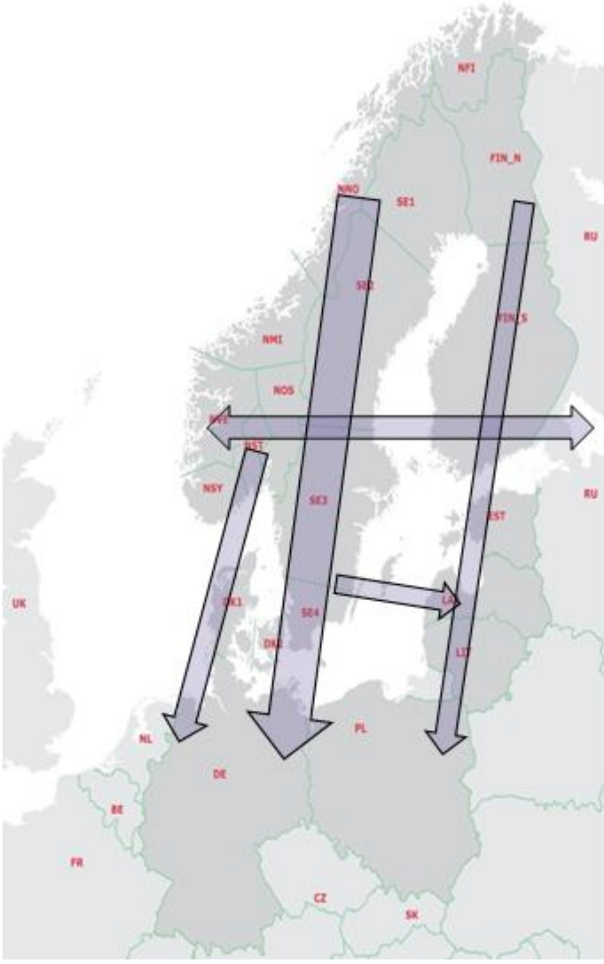


*Figure 45 Main flow directions in different Visions (*Visions 1 and 2 – on the left; Visions 3 and 4 – on the right)

The overall and informative pictures are shown in Summary but more detailed duration curves of the main regional cross-sections are shown on figures below. These show the duration curves in the different visions between Nordic area and Continental Europe, Between Baltics and Continental and between Nordic area and Baltic area.

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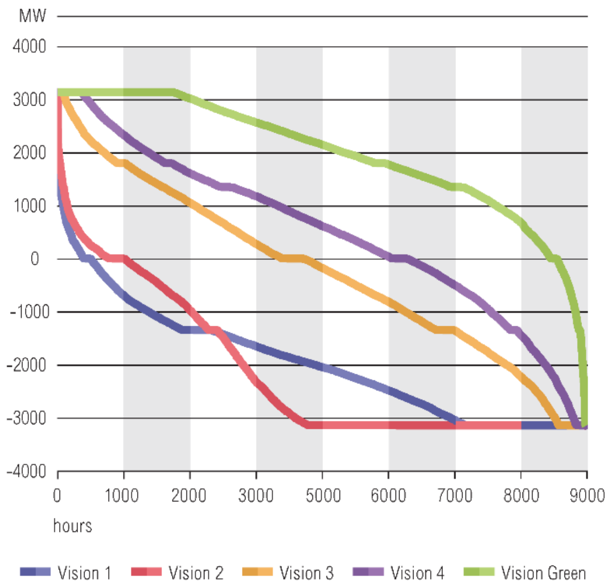

Figure 46 Duration curves at cross-sections Sweden-Finland, MW

As seen from bulk power flow analysis (see Figure above) electrical cross-section between Sweden and Finland displays wide range of utilisation patterns over the range of Visions it was studied in. The most flexible utilisation of the cross section is to be found in Vision 3 and Vision 4 – in these visions cross section between Finland and Sweden serves both importing and exporting needs. On the other hand in these visions, characterised by rather extreme relocation of generating units and increased role of distributed generation in the region, electrical cross section between Sweden and Finland seldom gets used to its full capacity since generation (especially in Finland) has gone closer to consumer in the form of distributed and RES generation developments.

Baltic Sea Green Vision is characterised by decreased utilisation of nuclear and thermal power generation units in Finland. In this case, as it can be seen from duration curve (see light blue graph) Finland has become large energy importer and electrical cross section between Finland and Sweden is operating predominantly in direction Sweden to Finland and cross section is utilised up to its maximum capacity more than one third of utilisation time.

Vision 1 and 2 are characterised by more conservative and traditional generation development based on common guidelines. In these scenarios Finland is strong energy exporting country, which is especially accented in results of Vision 2 where cross section Sweden – Finland is utilised on its maximum capacity in direction to Sweden more than 50% of the simulated time.

All Visions result in logical utilisation of the cross sections with seasonal changes in power flow directions, predominant flow direction from Finland to Sweden and less than 2000 simulated hours of operation on the maximum capacity on opposite direction in Baltic Sea Green Vision.

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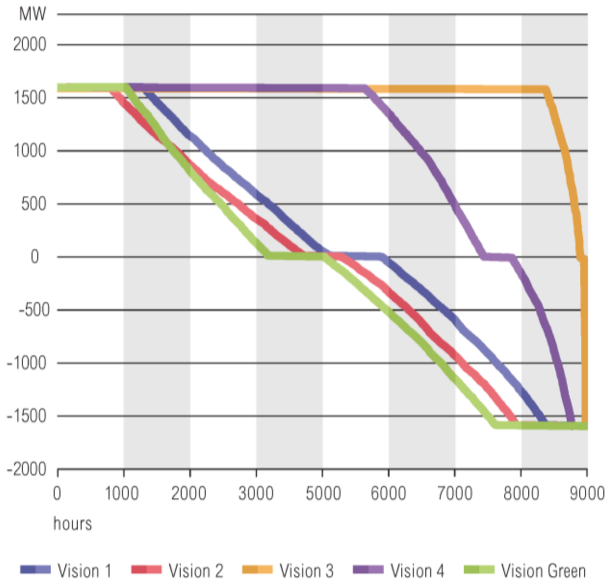

Figure 47 Duration curves at cross-sections Baltics to Central Europe, MW.

The interconnection capacity of 1600 MW envisages synchronous connection between Baltics and Central Europe (see figure above). Studies for establishing synchronous interconnection are not finalized and therefore the maximum capacity is theoretical value used only in market modelling. As long as further studies are not completed, the target capacity is 1000 MW with asynchronous cross-section.

In more conservative Vision 1, Vision2 and Green Vision situations this interconnection is utilised more balanced in both directions, with predominant seasonal changes in power flow direction and with relatively small number of simulated hours of maximum capacity utilisation modes.

Rather extreme Vision 4 and Vision 3, characterised by huge development of RES and distributed generation in the Baltics region completely changes the power flows in the region. Interconnection between Baltics and CE is utilised at full capacity more than 5000 simulated hours per year providing energy export from Baltics.

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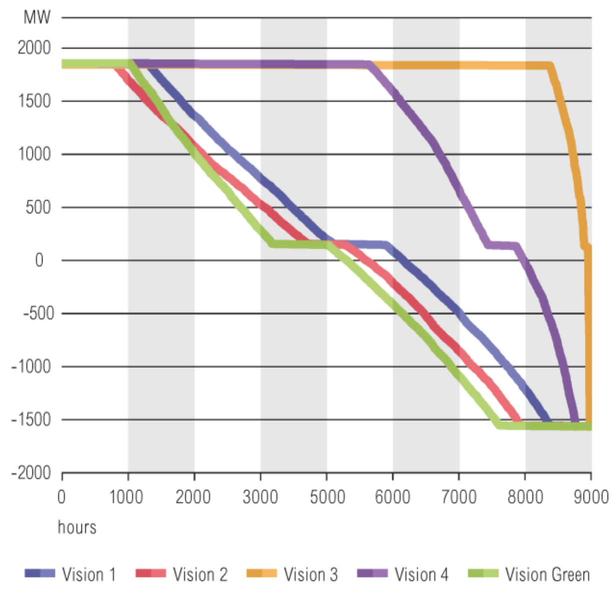

Figure 48 Duration curves at cross-sections Nordic to Baltics, MW

Electrical cross section between Nordic countries and Baltics is comprised exclusively of highly controllable DC links. This controllability can be observed in the duration curves with cross section being utilised in both directions (import and export) depending on energy market situations and also in reasonable small amount of operation time at maximum capacity. Exceptions to this rule are again being extremes of planning simulations - Vision 3 and Vision 4 where cheap RES energy of Nordics is being rushed to Central Europe on all possible energy transfer routes, including DC links towards Baltics. Therefore in these simulations one can observe predominant direction of flow away from Nordics and maximum link capacity utilisation time exceeding 5000 simulated hours out of 8000.

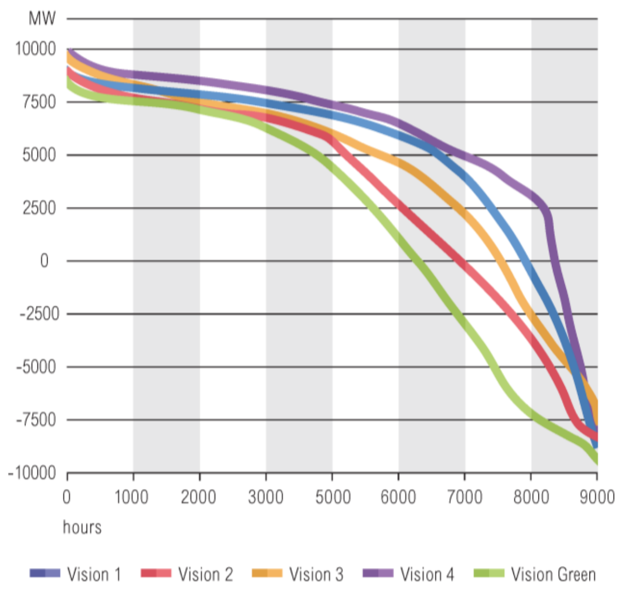

Figure 49 Duration curves at cross-sections, MW. Denmark is split based on synchronous areas: Denmark West in Continental Europe and Denmark East in Nordic synchronous area.

Interconnection between Nordics and Central Europe is comprised predominantly of controllable DC links, but unlike in the case of Baltics to Nordics interconnection this cross section has wide corridor and is interconnecting different countries/power systems with wide variety of dominating energy production and demand patterns thus providing for smoother overall utilisation pattern of the cross section in general. Therefore one can observe very uniform cross section utilisation pattern regardless of modelled Visions. But off course Vision 4 is the most extreme case of export from Nordics to CE, with total cross section in the export mode for more than 85% of simulated time, Green Vision being the most flexible vision with cross section operating equally in export and import modes during the simulated year. The most obvious quality of the combined cross section between Nordics and Central Europe is its adequacy to current and foreseeable power transfer tasks, however individually some of the DC links in the combined cross section are still utilised quite heavily and might require strengthening in future.

4.6 Conclusions

The common regional analyses show a need for reinforcing the cross-regional interconnections between the Continental part of the region with the Nordics system more tightly with the rest of the European system. There are also large flows in North-South direction through the whole region, which implies more transmission capacity both in the internal grids to ensure usage for the cross-border connections and more cross-border connections.

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5 Investments

5.1 Criteria for Project Inclusion

5.1.1 Transmission projects of pan-European significance

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 AC line 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 above mentioned 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 an output of at least 1 GW / 1000 km² of generation; or
- Securing load growth for at least ten years for an area representing a level of consumption greater than 3 TWh / yr.

A refined project definition and a substantial evolution of the portfolio

Around 30% of the investments from TYNDP 2012 are now only depicted in the Regional Investment Plans.

First, as highlighted in section 2.2.3, the stricter CBA clustering rules led to a refined list of projects in the TYNDP 2014. Some TYNDP 2012 projects included investments with a commissioning gap of longer than five years. Some secondary investments are hence presented only in the Regional Investment Plans and their supporting role for the project of pan-European significance is recalled in the comments on the latter in the TYNDP.

Besides, the new focus on 2030 and the time constraints of systematically assessing all projects with the CBA methodology and the four Visions validated quite late in 2014 has led ENTSO-E to focus on the longer-run projects and mitigate assessments efforts for mid-term projects. Decisions for these projects have already been made; construction works may have even started so their assessment is of limited interest for all stakeholders. As a result, most mid-term projects, except when they have a PCI label or when their assessment is relevant, are only presented in the Regional Investment Plans, whereas projects to be completed after 2020 have been given priority, taking advantage of the limited resources.

5.1.2 ENTSO-E and Non ENTSO-E Member Projects

Most of the transmission projects are proposed by licensed TSOs, who are members of ENTSO-E. In the framework of transmission system development, it is possible however that some transmission projects are proposed by ‘third party’ promoters. In light of Regulation (EU) 347/2013[17], entered into force on 15 May 2013, which makes the ENTSO-E TYNDP the sole basis for the electricity Projects of Common Interest (PCI) selection, in 2013 ENTSO-E developed the “Procedure for inclusion of third party projects – transmission and storage – in the 2014 release of the TYNDP[18]”, hereafter called the Third Party Procedure.

In the Third Party Procedure, ENTSO-E categorises third party projects, which must be projects of pan-European significance, into three different forms promoted by:

- Promoters of transmission infrastructure projects within a regulated environment, which can be either promoters who hold a transmission -operating license and operate in a country not represented within ENTSO-E, or any other promoter.
- Promoters of transmission infrastructure projects within a non-regulated environment: promoters of these investments are exempted in accordance with Article 17 of Regulation (EC) No 714/2009
- Promoters of storage projects.

Projects proposed by non-ENTSO-E promoters are assessed simultaneously by ENTSO-E according to the same cost benefit analysis methodology adopted for TSO projects.

ENTSO-E received 33 applications and in total the TYNPD 2014 assesses 24 projects proposed by non-ENTSO-E Members (13 transmissions projects and 11 storage projects). Out of the 24 projects accepted in the TYNDP 2014, 19 are listed as Projects of Common Interest (nine transmission and 10 storage projects).

5.1.3 Regional investments

Regional investments are investments which have an effect on the grid at a regional level, even though they are not necessarily cross border. They are not included in the TYNDP as such some but can support TYNDP projects when regional grid reinforcements are needed for the commissioning of a pan-European project.

[17] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:115:0039:0075:EN:PDF

[18] https://www.ENTSO-E.eu/major-projects/ten-year-network-development-plan/tyndp-2014/

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5.2 Project Portfolio

The next two maps will display geographically all projects proposed in the region, divided into two periods (2014 – 2018 and 2019 – 2030).The maps show basic information regarding locations, routes and technology. When the precise location of an investment is not yet clear, a bubble then shows where the investment is likely to occur.

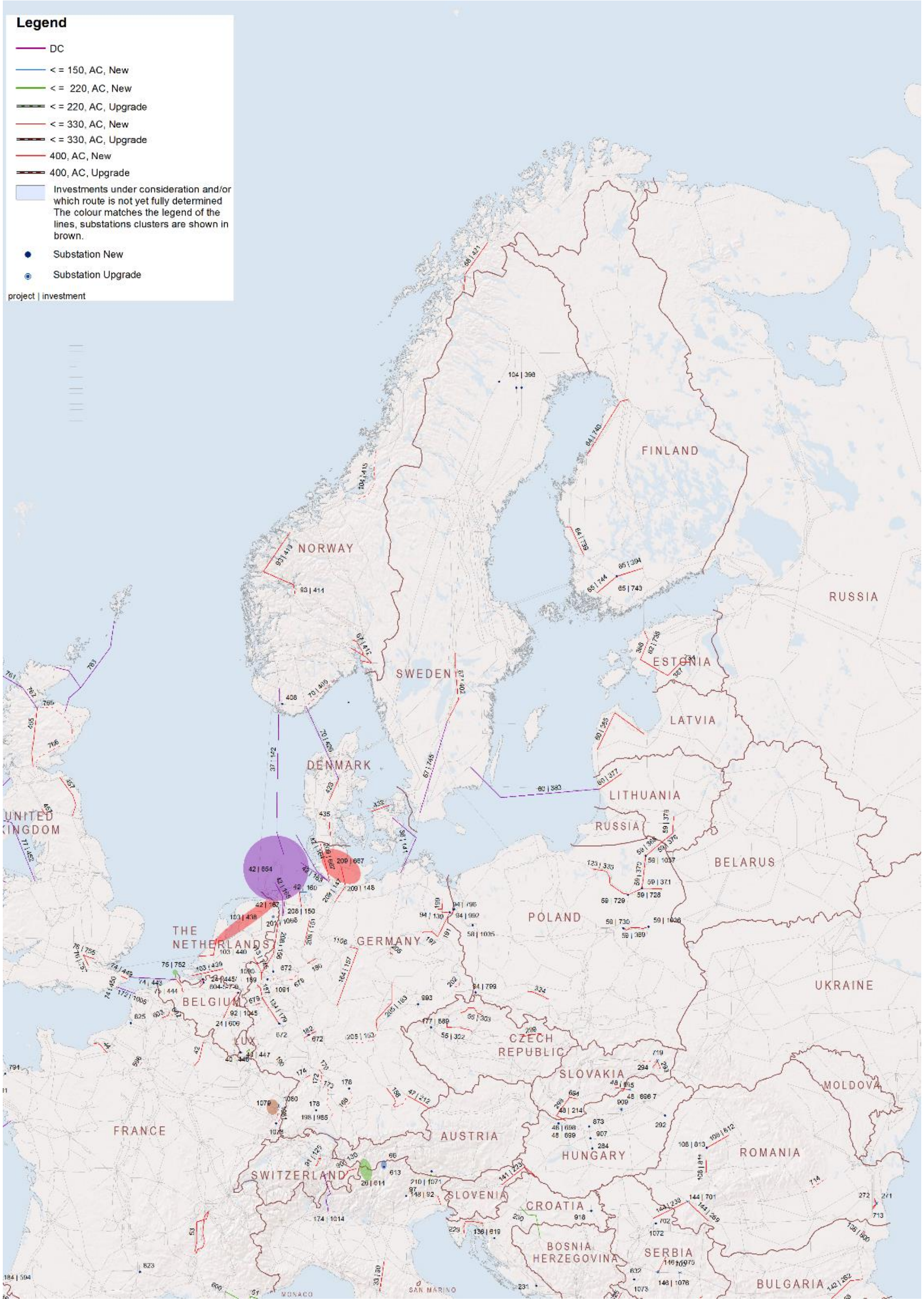

Figure 50 Midterm projects

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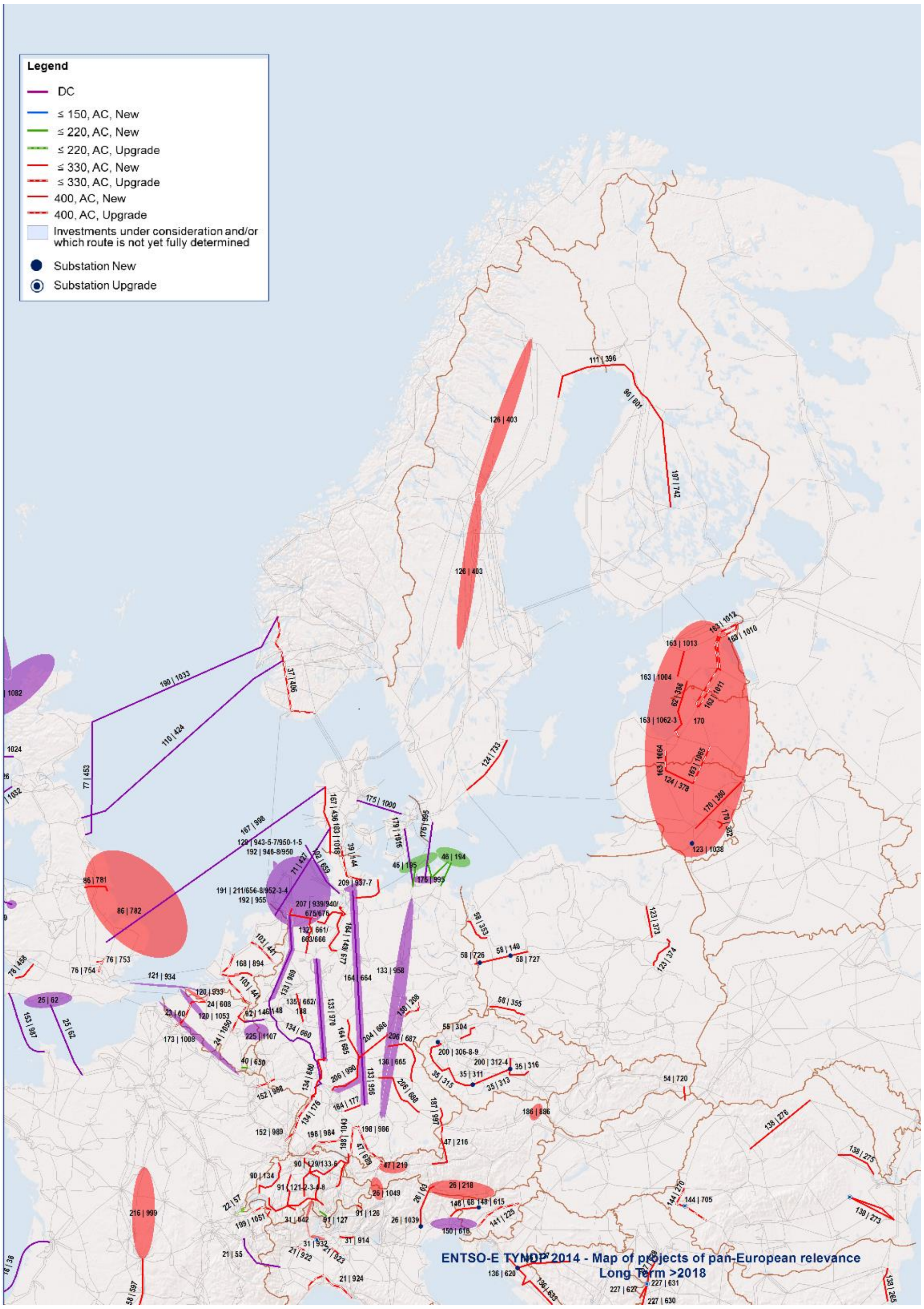

Figure 51 Long-term projects

5.2.1 Projects of common interest

Regional group Baltic Sea has 7 PCIs. Five projects are cross-border projects from which some is increasing capacity on the boundary, some is connecting new wind offshore parks to main transmission grid, some is reducing main bottlenecks within Baltic Sea Region and contributing market integration between countries and some is contributing connection of isolated Baltic States to Continental Europe networks and Nordic countries networks. Separately to transmission projects RGBS has two projects which have got PCI status and they are promoting Pump storage developments in Baltic Sea Region and at the same time they are 3rd party projects which are more described below. Following PCI projects relate to Baltic Sea Region:

1. PCI Denmark – Germany; it is an interconnector between Germany and Denmark via offshore wind parks (currently known as Kriegers Flak Combined Grid Solution)
2. Cluster Estonia-Latvia; an interconnector between Kilingi-Nomme (EE) and Riga (LV), currently known as 3rd Interconnector)
3. PCI Estonia/Latvia/Lithuania synchronous interconnection with the Continental European networks
4. Cluster Latvia – Sweden capacity increase (currently known as NordBalt project)
5. Cluster Lithuania – Poland; between Alytus (LT) and Elk (PL)
6. PCI hydro –pumped storages in Estonia – Muuga
7. PCI capacity increase of hydro-pumped storage in Lithuania – Kruonis

5.2.2 Projects of Pan-European Significance

The main drivers for transmission system investments in the Baltic Sea region are described in chapter 4. As the result of these drivers projects are now being developed for market integration, RES integration, new generation connection and security of supply. All projects mainly are being built to increase power transmission capacity from North in Baltic Sea region to central part of Europe. Additionally to this more new large HVDC links are planned for connection of Nordic countries to Continental Europe. As we are looking in to the far future some internal grid reinforcements could become necessary additionally to the main interconnectors as well as examples of such projects are voltage upgrades on existing transmission lines and new transmission lines.

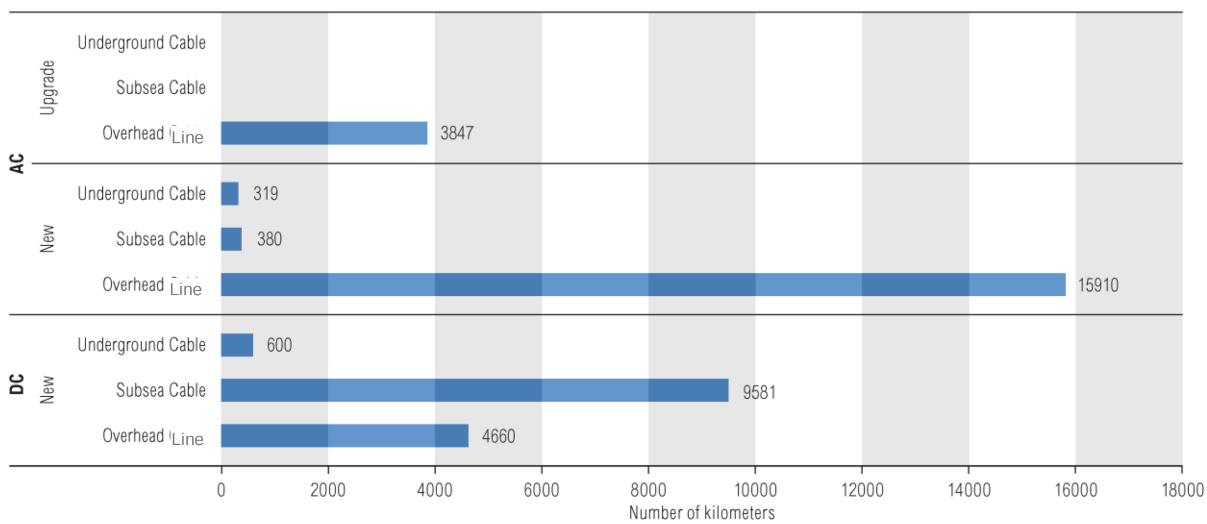

Figure 52 Investment breakdown per technology

From the graph above you can see that for coming time decade (2030) mainly new AC overhead lines are promoted. These types of lines are promoted much more due to well knowledge of technology, easy usable equipment for node connection and transfer, the distances and voltage levels between connection nodes are

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in applicable range and comparative less expensive costs. The DC technology by itself is quite new but it's developing slightly among whole Europe therefore new DC subsea and overhead lines are promoted much less than AC technologies. In general all types of lines described above are mainly promoted because can give the highest increase of GTC and TSOs have knowledge and the best practice how to utilise those for different power system modes as well as these lines are the most efficient looking at the costs and increase of capacity at the same time. These projects are contributing EU 2020-2030 goals and promoting future objectives. To strengthening the existing AC grid in whole Europe less than 4000 km of overhead lines should be upgraded. The rest of AC and DC lines are not promoted significantly and do not show an impact on overall picture.

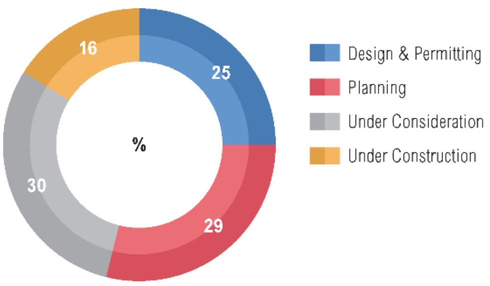

Figure 53 Status of the investments

The very small part of all projects is under construction (16 %) and it is explainable by itself because this is a long term planning report which focuses on a long term objectives. The high shares of projects are under design & permitting (25 %) and planning phases (29 %) what also means that more than half of all projects are in the first stage of project development and are much unclear and unfixed at this level. It gives a signal that comparative high part of projects can be cancelled later or postponed during the coming planning periods. In this Regional Investment plan all these projects can be observed mainly as possible project candidates. 30 % of all projects are under consideration and further developments of them are much more feasible.

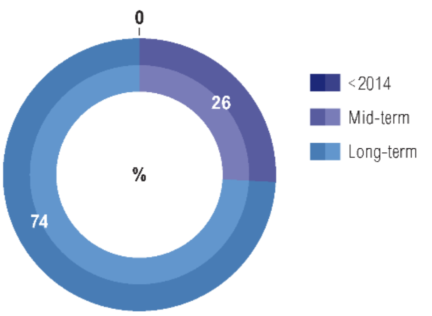

Figure 54 Projects breakdown per commissioning horizon

As it was written above RGBS is focusing on long term horizon therefore about 74 % of all projects are set as Long-term projects with commissioning dates beyond 2019 and according to RegIP 2014 some of them are not assessed as direct projects but more like the project candidates with possible development rotes and capabilities. Mid-term projects are more known and assessed beforehand in different internal studies among TSOs therefore they can be realized according to schedule and only very unexpected reasons can cause the serious delays.

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5.2.3 Investments of Regional Importance

Additionally to Pan-European interest projects in RegIP the RGBS has included few investments of regional importance. These investments mainly are internal grid reinforcements in particular country, some not very clearly defined cross-border projects or the alternative investments which have already been proposed in the TYNDP as well as some of the investments that have high importance for transmission grid operation but they do not directly meet the criteria of CBA to be included in the TYNDP. In the RegIP there are included all foreseen investments which are relevant for sustainable and reliable grid developments on level of RGBS and all the proposed projects of RegIP contribute to further evolution of whole transmission system.

5.2.4 Investments of National Importance

There are in every country of the RGBS region, a lot of more projects and investments that are needed at national level for a secure, sustainable and competitive market, but even so, they do not fulfil the criteria of regional or European significance. All other national projects are included in the National Development Plans.

The National Ten Year Network Development Plans of countries of RGBS can be found in the table below.

Country	Web link address
Lithuania	http://www.litgrid.eu/index.php/grid-development-/electricity-transmission-grid-ten-year-development-plan/134
Latvia	http://www.ast.lv/eng/par_ast/public_reports/development_plan_of_transmission_power_system/
Estonia	http://elering.ee/varustuskindluse-aruanded/
Germany	http://www.netzentwicklungsplan.de/
Poland	http://pse.pl/index.php?modul=10&gid=402
Denmark	http://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/Om%20os/Strategy%20Plan%202012.pdf
Norway	http://www.statnett.no/Global/Dokumenter/Prosjekter/Nettutviklingsplan%202013/Statnett-Nettutviklingsplan2013-engelsk_03korr.pdf
Finland	http://www.fingrid.fi/en/grid_projects/Transmission%20lines%20and%20maintenance%20attachments/National_ten-year_grid_development_plan_Finland2012.pdf
Sweden	http://www.svk.se/Global/02_Press_Info/Pdf/20130429-Perspektivplan2025.pdf

5.2.5 Third party projects

In order to deliver the most comprehensive and up-to-date outlook of the electricity grid up to 2030, ENTSO-E has, based on the stakeholders feedback regarding the 2010 pilot TYNDP and TYNDP 2012, elaborated and made a process for inclusion of the 3rd party projects in the 2014 release of the TYNDP available. As a result, ENTSO-E has received 3 submissions related to the Baltic Sea region, of which 2 are eligible for inclusion in the TYNDP14. These are presented below.

Two storage projects did fulfil the ENTSO-E legal rules of submission and Regional Group Baltic Sea has provided assessment for two Pump Storage projects, one in Estonia and one in Lithuania:

1. PCI hydro–pump storage in Estonia – Muuga;

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Hydro-pump storage uses seawater and the expected installed capacity of power plant is 500 MW. The average annual net generation expected 730 GWh/year. The maximum volumetric flow rate by generation and in the pump mode is 120 m3/s and normal static head is 500 m. Lower reservoir is on the level -500 m in Muuga granite massif. Energy rating of storage is 12 hours. Muuga HPSPP has a strong cross-border impact. Muuga HPSPP is ready to provide system services to all of the surrounding TSO`s and offers different regulation services for various market participants (wind parks, nuclear power plants etc). Ability to produce electricity during peak load and consume electricity during minimum load, the project affects the balance and price of electricity in the electricity market (NPS).

2. PCI capacity increase of hydro-pumped storage in Lithuania – Kruonis;

The additional new 225 MW variable speed (asynchronous) unit on the existing hydro-pumped storage plant in Kruonis, the installed capacity of 900 MW (4 units of 225 MW), is planned. The existing units have 74% of cycle efficiency in maximum power output and can operate in the range of 160-225 MW in generation mode but do not have flexibility in pump mode. The new unit will have pump mode ranging from 110 to 225 MW and cycle efficiency of up to 78%.

5.3 Assessment of the portfolio

5.3.1 Socio-economic welfare

Socio-economic welfare (SEW) is characterised by the ability of a power system to reduce congestion and thus provide an adequate transmission capacity so that electricity markets can trade power in an economically efficient manner. It consists of 3 parts, namely Producer Surplus, Consumer Surplus and Congestion Rent. A project that increases transmission capacity between two bidding areas allows generators in the lower-priced area to export power to the higher-priced area which subsequently levels out the price difference. The new transmission capacity reduces the total cost of electricity supply for the two areas. Therefore, a transmission project in general will increase Socio Economic Welfare.

The Socio-economic welfare of the projects assessed in RGBS depends on the vision investigated. A general trend is that the projects have the lowest SEW in vision 2. Projects have a higher SEW in vision 3 compared to vision 1 while vision 4 gives the highest socioeconomic welfare. These are expected results since the high penetration of renewables in vision 4 require a strong interconnection grid. The high CO2 price of 93 €/ton in vision 3 and 4 makes it very beneficial to utilise as much renewable energy as possible.

In general, many of the assessed projects/visions in the Baltic Sea region are showing an increase of SEW which is less than 30 M€/year.

Vision 1

In Vision 1 the almost half of the all projects are less beneficial than 30 M€/year but still they are very important for European objectives and they are relevant for other possible cases of power system evolution. Seven project candidates (26 % of all projects) individually resulted in a SEW of 100M€ or higher. The highest share of SEW benefit was gained from the projects between Scandinavia and Central Europe.

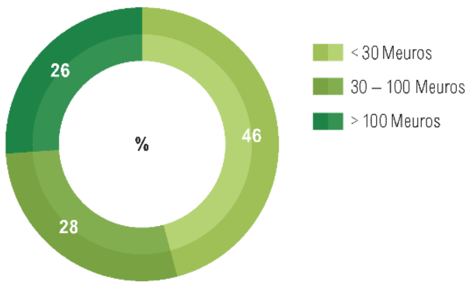

Figure 55 Division of projects by socioeconomic welfare - Vision 1

Vision 2

Vision 2 is characterized by consumption, which is higher than vision 1. The CO2 costs are the same as in vision 1 but some production utilizes CCS-technology. The socioeconomic welfare of many of the project candidates is lower than in vision 1. However – the project candidates DK2-PL, Baltic corridor, Nordbalt phase 1 and Estonia-Latvia 3rd IC have a higher socioeconomic benefit in vision 2 than in vision 1. It also resulted in figures that part of projects in range 30-100 M€/year is decreased comparing to Vision 1 but projects with SEW benefit more than 100 M€/year is increased up to 31 % comparing to Vision 1.

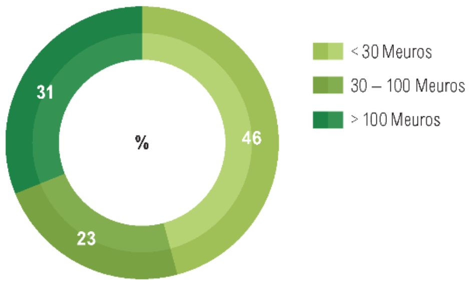

Figure 56 Division of projects by socioeconomic welfare - Vision 2

Vision 3

Vision 3 has the same high CO2 prices as vision 4. Vision 3 has also less renewable generation and less consumption than vision 4. This results in lower project benefits in vision 3 comparing to Vision 4. Actually in Vision 3 all projects are sharing in three equal shares where 26 % of projects give SEW less than 30 M€/year, 29 % of projects are in range 30-100 M€/year and the biggest share with 46 % belongs to project with more than 100 M€/year. These most beneficial projects are the projects connecting the Nordic and Baltic areas with the continental areas: SE4-DE Hansa Power Bridge, DK2-PL and LitPol Link.

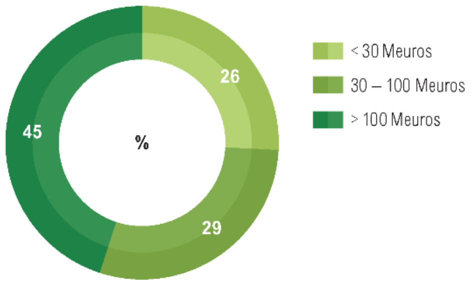

Figure 57 Division of projects by socioeconomic welfare - Vision 3

Vision 4

Most projects have their highest socioeconomic benefit in vision 4. Majority of the projects investigated have a socioeconomic benefit larger than 30M€/year and 69% with SEW of 100M€ or even higher. The high benefits are a result of high price difference between Nordic countries and Continental Europe as well as Baltic States and Continental Europe. In the Vision 4 bulk power flows are directed from North to South. The highest benefit of SEW is found on the Hansa Power Bridge project which is planned between Germany and Sweden. Also the project candidates from Denmark to Germany and Poland and the project candidates between Lithuania and Poland give a very high SEW. A small amount of project (10 %) candidates resulted in socio-economic welfare less than 30M€. These project candidates include "Great Belt 2", a second interconnector between Denmark East and West, the internal enforcement in Sweden and a stronger connection between the Baltic countries.

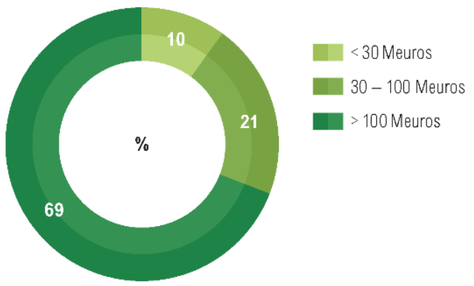

Figure 58 Division of projects by socioeconomic welfare - Vision 4

5.3.2 CO2 emissions

By relieving congestion, reinforcements may enable low-carbon generation to generate more electricity, thus replacing conventional plants with higher carbon emissions. Considering the specific emissions of CO2 for each power plant and the annual production of each plant, the annual emissions at power plant level and perimeter level have been calculated by using a standard emission rate established per generation-technology. Generation dispatch and unit commitment used for calculation of socio-economic welfare benefit with and without the project have been used to calculate the CO2 impact, taking into account the standard emission rates.

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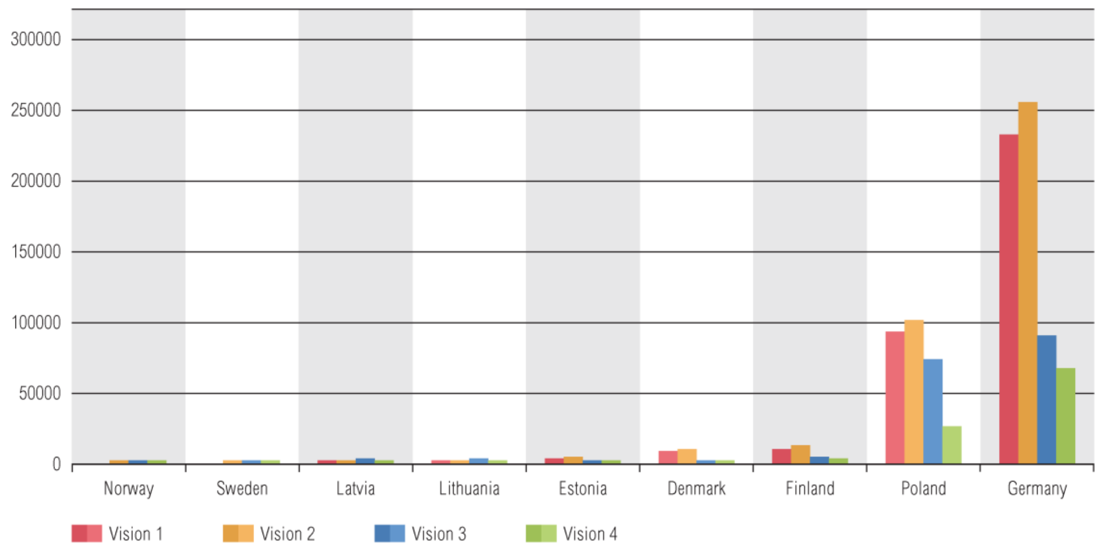

Figure 59 CO2 emissions by country in kton

CO2 emissions are highest in vision 2. The reason is increased electricity demand comparing to vision 1 which should be satisfied by fossil fuel power plants. Further RES integration in vision 3 and vision 4 allows to significantly reduce CO2 emissions despite the growing electricity consumption in the region. Variation in CO2 emissions between visions is highest in Germany and Poland, as these countries are the main CO2 emitters. For example, CO2 emission in Germany drops by 72% in vision 4 comparing to Vision 1.

17% of all the assessed projects in vision 1 reduce CO_2 emissions by more than 500 kilotons per year while 32% of the projects show emission reduction of less than 500 kiloton per year which in unison shows that only for less than a half the assessed projects is a positive CO2 effect caused by renewable energy getting access to larger market and subsequently replaces CO2 emitting production. More than one third of the assessed projects (37%) results in increased CO2 emissions as they enable coal fired generation access to markets where gas fired power plants tends to be the marginal units, and since coal fired production is cheaper than gas fired production in vision 1 this is only natural given the market conditions modelled. Projects between Scandinavia and Central Europe have largest effect of CO2 reduction, over 800kt pr year at maximum because there is a very big difference in generation mix in the Nordics and Central Europe. Renewables and nuclear power from Norway, Sweden and Finland ensure cheap prices and CO2 free generation that, when given access, replaces mainly gas fired generation in Germany and UK.

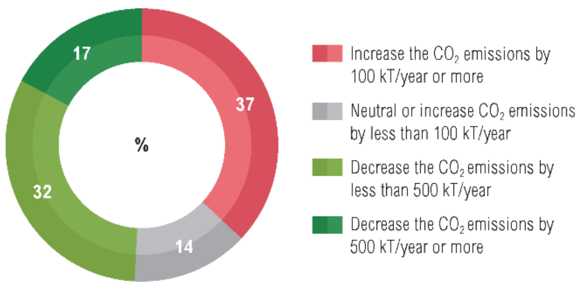

Figure 60 Impact of TYNDP 2014 projects in BS region on the CO2 emissions in 2030 Vision 1

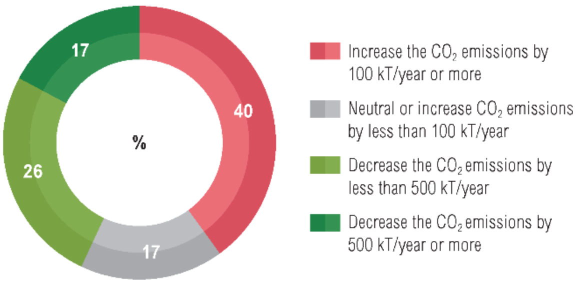

Figure 61 Impact of TYNDP 2014 projects in BS region on the CO2 emissions in 2030 Vision 2

The Vision 2 is very similar to the Vision 1 because the similar input data and modelling rules have been applied. From the pie chart above you can see that the assessment results of the CO2 emissions are varying unimportant compared to Vision 1.

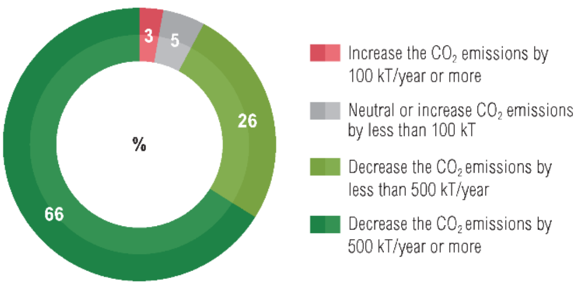

Figure 62 Impact of TYNDP 2014 projects in BS region on the CO2 emissions in 2030 Vision 3

The Vision 3 is much more „green" vision which shows decrease of the CO2 emissions by 500 kT/year or more for 66 % of all projects. In this Vision almost all projects (92 %) give a beneficial decrease of CO2 emissions and it is described by a very high CO2 price (93 Euro/MWh) and significant developments of RES generation. These two factors are influencing the outcome of CO2 emissions indicator. There are some projects which are increasing the CO2 emissions in Vision 3 but this share of projects is very small (3 %). These projects connect the fossil fuel power plants to the transmission network and allow covering a load and a peak load during the cases when lack of RES generation. No positive effect on CO2 emissions is recognized for 5 % of all projects.

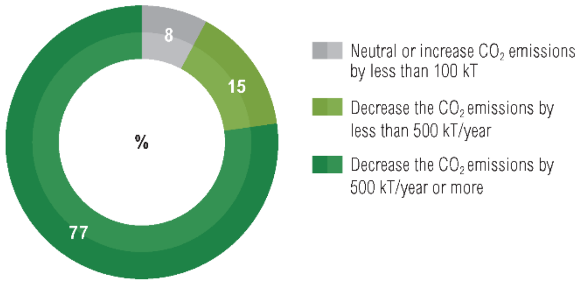

Figure 63 Impact of TYNDP 2014 projects in BS region on the CO2 emissions in 2030 Vision 4

77 % of projects give CO2 reduction more than 500 ktons annually what is reasonable according to very high input of RES. In this Vision the new interconnectors ensure power flows across the whole Europe and it gives a chance production of RES dominate in liberal energy market. Very small share of projects gives no positive effect on CO2 emissions (8 %). On this share relates the projects which connect new CO2 emissions producing power plant with main transmission system to cover a balance in the region where more generation of power plant is required. Due to increase of consumption within whole Europe in some regions to cover a demand increase of CO2 emissions appears because no other options to cover demand in the certain area. Also comparative small share of projects decrease CO2 emissions by less than 500 kT/year (15 %) by the way giving the savings on CO2 pollution. In this Vision all projects have very high benefits of CO2 reduction and the lowest level of the assessment indicators located in a share of no positive effect on CO2 emissions. None of projects is increasing CO2 emissions in whole power system.

5.3.3 RES integration

RES integration is defined as the ability of the power system to allow connection of new renewable power plants and unlock existing and future “green” generation, while minimising curtailment. The RES-indicator is both calculating the RES-effect for:

4. Direct connection of RES generation to a power system and
5. Increasing the transmission capacity between price-areas with high RES generation to other areas, in order to facilitate higher level of RES penetration.

The RES-indicator intends to provide a standalone value showing additional RES available for the system. The indicator measures the influence new grid-investments have on this RES-integration. The benefit-indicator for RES-integration has been calculated by using market models, showing the general influence on curtailment in each price-area.

Slightly more than half of all projects (54 %) are not contributing RES generation directly to the transmission grid and more or less they have a neutral effect on RES integration. Due to restricted RES developments in Vision 1 many projects from RGBS are not influencing RES generation and do not show any gains. By itself the Vision 1 is based on fossil fuel generation and foresees moderate development of RES. The highest values of RES indicator in Vision 1 by an amount of more than 300 GWh per year of reduced curtailment was by projects between Scandinavia and Central Europe and also by projects between the Baltic States and the Nordics. Projects allow distribution of significant amounts of RES production within Baltic States as well as from RES generation areas to consumption centers of the Baltic Sea region. 29 % of the projects are contributing RES generation or direct connection of RES above 500 MW or allow an increase in RES utilization above 300 GWh.

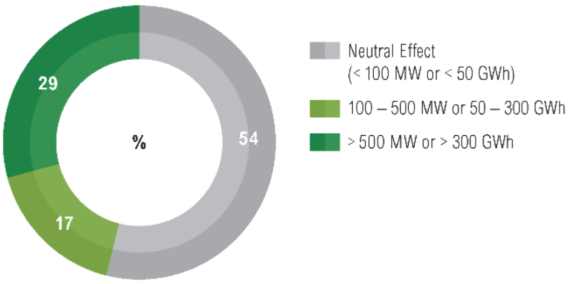

Figure 64 Impact of TYNDP 2014 projects in BS region on the RES integration in 2030 - Vision 1

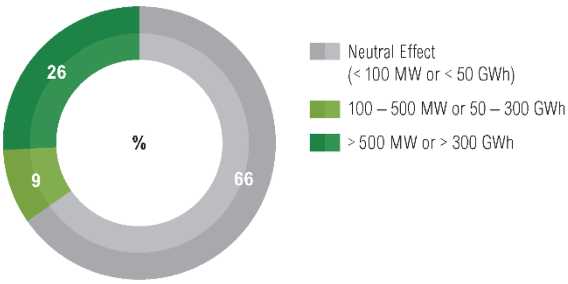

Figure 65 Impact of TYNDP 2014 projects in BS region on the RES integration in 2030 - Vision 2

In Vision 2 the overall consumption is increased but generation sources are still limited and in quite equal level as in Vision 1. In pie chart above the RES generation is decreased due to increase of consumption which should be covered by generation of fossil fuels. Such kind of Vision explains increase of Neutral effect for assessed projects to 66 % compared to Vision 1. From other side it gives indication that 26 % of projects have direct connection of RES more than 500 MW or additional generation of RES more than 300 GWh and this share of projects are decreased.

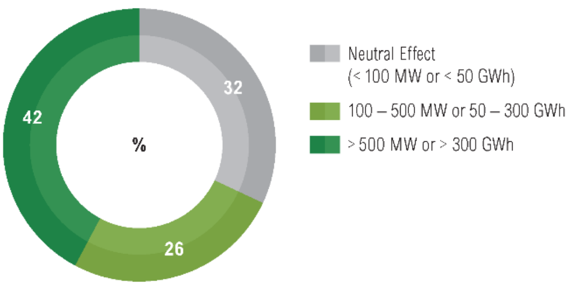

Figure 66 Impact of TYNDP 2014 projects in BS region on the RES integration in 2030 - Vision 3

The Vision 3 is much closer to Vision 4 and in this Vision are the projects which are giving more positive effect on RES generation. The projects with neutral effect on transmission system are decreasing and in this case around more than half of all projects contribute positively to RES integration. In the Vision 3 21 % of all projects allow connect RES to the transmission system from 100 till 500 MW or generate from 50 till

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300 GWh of energy. The share of projects which are contributing RES connection to the transmission network more than 500 MW is 42 %. The projects with the highest increase of RES located between Scandinavian countries and Central European countries.

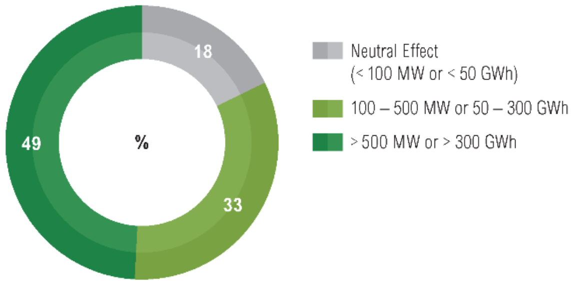

Figure 67 Impact of TYNDP 2014 projects in BS region on the RES integration in 2030 - Vision 4

In Vision 4 the picture is total opposite to Vision 1 and Vision 2. As it was expected the very high developments of RES gives very sharp increase of RES generation. From a pie chart above it can be seen that 49 % of all projects are contributing RES more than 500 MW or 300 GWh. The planned interconnectors ensure power flows from RES within whole Europe and let RES covers a high demand in main consumption centres within whole Europe. Anyway we have to keep in mind that RES capacities in Vision 4 are ambitious and such high generation level of RES is supposed to describe a very green scenario. In Vision 4 only 18 % of project has neutral effect on RES because RES generation dominates within whole Europe. 33 % of projects contributes a generation of RES partly and gives direct connection of RES from 100-500 MW or energy 50-300 GWh. In Vision 4 mainly all projects allow increase the generation of RES and bring us towards EU targets.

5.3.4 Security of supply

Security of Supply is the ability of a power system to provide an adequate and secure supply of electricity in ordinary conditions, in a specific area. The criterion measures the improvement to security of supply when introducing a transmission project (generation or network adequacy). The indicator is calculated as the difference between the cases with and without the project, and was supposed to be defined through either Expected Energy Not Supplied (EENS) or the Loss of Load Expectancy (LOLE).

The Security of Supply-indicator in the regional studies has been calculated by using special model (MAPS) as described in methodology chapter 2. The indicator is more demanding than in the TYNDP 2012, leading to value equal to zero for most of the projects.

Only one project had influence to EENS larger than the present level, Norway-Finmark to North Finland, however many projects are directly related to SoS issues within the modelled areas and have a significant influence to SoS increase in those areas, that were not taken into account in MAPS model, because of model limitations. However using different methodologies and expert assessments SoS increase could be considerable for several projects as described in project result summary under appendix 1 and 8.

Further analysis shows very different issues that can influence SoS:

– Supply of Arctic region and large cities/urbanized areas;
– Baltic States requiring a higher interconnection with EU countries;
– Regions and countries with a negative generation adequacy forecast;
– High energy flows from Nordic countries to Germany and Poland.

5.3.5 Losses

Variation in electrical losses is an indicator of energy efficiency for a power system. The energy efficiency benefit of a project is measured through the reduction of these losses in the system. At constant transit levels, network development generally decreases losses, thus increasing energy efficiency. Specific projects may also lead to a better load flow pattern as they decrease the electrical distance between production and consumption. Increasing the voltage level and the use of more efficient conductors also reduce losses. It must be noted, however, that the main driver for transmission projects is currently the higher need for transit of power over long distances. By making this transit possible, the transmission projects might actually lead to increased losses.

Variation in losses can be calculated by a combination of market and network simulations.

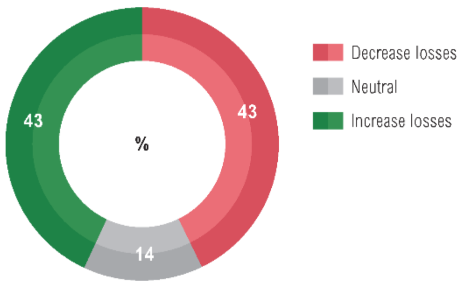

Figure 68 Impact of TYNDP 2014 projects in BS region on the losses variation in 2030 - Vision 1

Slightly less than half of assessed projects lead to increased losses in Vision 1, because of increased flows between distant consumption and production. Overall analysis of the changing structure of network losses for Vision 1 shows that nearly 43 % of the assessed projects have an increasing effect to losses because of increased flows between distant consumption and production areas, enabling previously limited areas to utilize the market environmental benefits. 43 % of the assessed projects lead to decreased network losses. These are projects that are directly connected to new production units (eg. Kriegers Flak) and thus diminish the distance from generators to consumers. In some cases this attributes to projects enabling improved generation evacuation from the generating plants where strengthened grids provide for decrease in losses. Very small share of projects (14 %) shows neutral impact on the network transmission losses. This does not mean that these projects have no influence on the network operation situations, but instead in these cases we usually have balanced impact of the two factors described above – increased transmission of power over long distances AND improved generation evacuation.

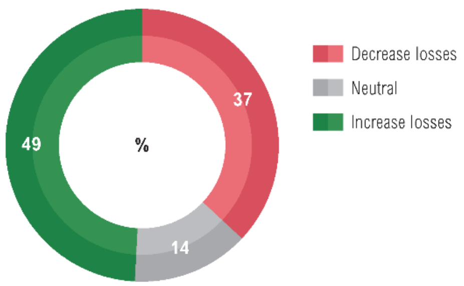

Figure 69 Impact of TYNDP 2014 projects in BS region on the losses variation in 2030 - Vision 2

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The Vision 2 is similar to Vision 1 therefore also the assessment results are quite similar. In Vision 2 the total increase of losses gives 49 % of all assessed projects. Vision 2 has the same share of projects than in Vision 1which give neutral impact on losses (14 % of all projects). The overall increase of losses compared to Vision 1 can be due to higher demand and generation in whole European power system what increases bulk power flows among countries.

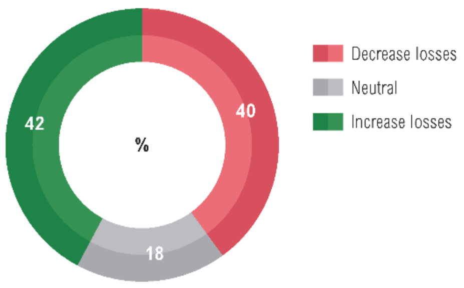

Figure 70 Impact of TYNDP 2014 projects in BS region on the losses variation in 2030 - Vision 3

In Vision 3 42 % of all projects are increasing losses in transmission system. 18 % of all projects give neutral impact on losses and 40 % of projects decrease losses.

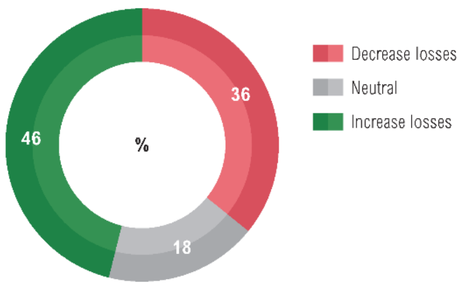

Figure 71 Impact of TYNDP 2014 projects in BS region on the losses variation in 2030 - Vision 4

Overall analysis of the changing structure of network losses for Vision 4 shows that nearly 46 % of the assessed projects enable the increase of the network utilisation and therefore increase network losses due to higher flows in networks. Vision 4 is characterised by bigger RES development than in Vision 1 and in many cases distributed generation is developed to a level when it can not only serve local loads but start to act as energy export and create significant bulk power transits, creating increased transmission losses. 36 % of the new projects lead to decreased network losses. This attributes for projects creating/accepting in the grid of new distributed (including RES) generation closer to consumption nodes and thus diminishing the distances to transmit energy from generators to consumers and sub sequentially decreasing transmission losses. 18 % of the projects show neutral impact on the network transmission losses.

5.3.6 GTC increases

The challenges for the coming decade are to face larger and more power flows across Europe. The new projects are increasing Grid Transfer Capacity (GTC) between market areas to allow for the cheapest generation technologies to get access to larger consumption areas than they have already. GTC increases are expected on many boundaries within Europe and promoters market integration in Europe. The value of increased GTC is driven by need and covers a range of transmission capacity increase projects. Projects of

Pan-European significance are very diverse depending on the specific geography they are inserted in. Globally, greater GTC increases are developed where ever higher power exchange is expected or needs to remove bottlenecks. Need to increase GTC correspond to situation where parallel investments combine to transport energy across a significant boundary where large Bulk Power Flows are expected.

Following graph illustrates the share of number of projects covering different GTC increase ranges in Baltic Sea Region (Nordic countries, Baltic States (Estonia, Latvia and Lithuania), Poland and Germany).

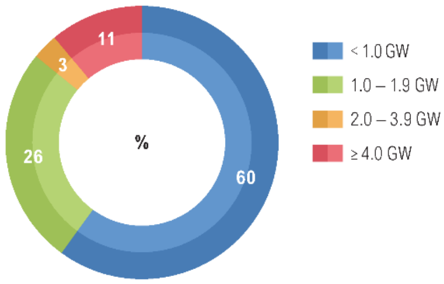

Figure 72 Share of number of projects covering different GTC increase ranges

5.3.7 Resilience

Making provision for resilience while planning transmission systems, contributes to system security during contingencies and extreme scenarios. This improves a project's ability to deal with the uncertainties in relation to the final development and operation of future transmission systems. Factoring resilience into projects will impact positively on future efficiencies and on ensuring security of supply in the European Union.

A quantitative summation of the technical resilience and system safety margins of a project is performed by scoring a number of key performance indicators (KPI) and aggregating these to provide the total score of the project.

Among the benefit indicators calculated through the CBA-methodology the indicator B6 is called "Technical resilience/system safety". This indicator shows the ability of the system to withstand increasingly extreme system conditions (exceptional contingencies). This indicator measures the different projects ability to comply with (1) failures combined with maintenance (n-1 during maintenance), (2) ability to cope with steady state criteria in case of exceptional contingencies and (3) ability to cope with voltage collapse criteria. The scale is divided from 0 to 6 whereas 0 is the worst value and 6 is the best value.

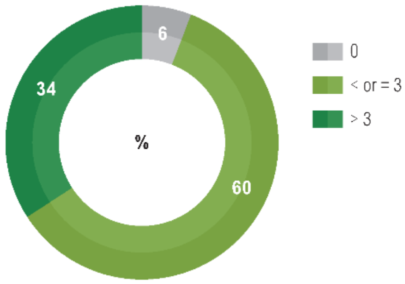

Figure 73 Distribution of resilience indicator

The diagram above clearly shows that only 6 % of the new projects have small contribution to the improvement of technical resilience and system safety. This might relate more to the RES interconnection deep down in distribution networks and thus having little influence in the transmission network operation while the role of these projects in reshaping the generation structure towards environmental goals should not be overlooked and diminished by these humble showings of transmission network resilience. However almost half (60 %) of the new energy projects have significant improvement of the resilience and system safety while more than one third of all projects (34%) show huge improvements of system resilience and safety, giving solution to facing failures in maintenance states, facing exceptional contingency cases and improving voltage profiles and quality. On the other hand such showings about the new network projects clearly show how weak and inadequate today’s networks are in face of challenges of near future and how important it is to implement newly conceived network development projects.

5.3.8 Flexibility

The indicator B7, called "Robustness and flexibility" shows the ability of the system meet even those transmission needs that differ from present projections. Projects should offer robustness and flexibility to ensure persistent transmission network operation and functioning markets in a large variety of possible futures and cases. This indicator measures the different projects ability to comply with (1) important sensitivity cases, (2) ability to comply with commissioning delays and local objection to the construction of the infrastructure (3) ability to share balancing services in a wider geographical area (including between synchronous areas); these three factors are known as Key Performance Indicators (KPI’s). The scale is divided from 0 to 6 whereas 0 is the worst value and 6 is the best value.

The flexibility and robustness indicators are equal in all visions and these indicators have been evaluated according to sensitivity cases and detailed snapshots chosen by RGs. The diagram shows that the highest share of projects (51 %) seriously increase robustness and flexibility in the transmission system and allow ability to share balancing services in a wider geographical area. 46 % of all projects have smaller contribution overall or large contribution to only one KPI. This part of projects has lover impact on robustness and flexibility what foreseen also the extra discussions of projects importance for next TYNDP 2016. The smallest part of projects, around 3 %, does not improve robustness and flexibility in transmission network. The projects of this part mostly connect a new generation sources to transmission network therefore they are not so relevant for system flexibility and robustness in coming time decade.

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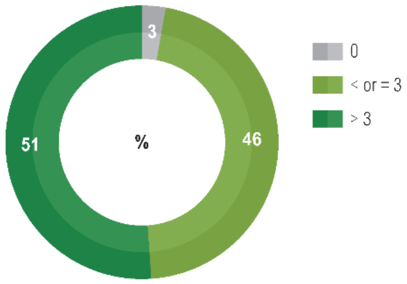

Figure 74. Distribution of Robustness/Flexibility indicator values for BS projects in Vision 4

5.3.9 S1-S2 indicators

The indicators 'social impact' and 'environmental impact' are used to:

- indicate where potential impacts have not yet been internalized i.e. where additional expenditures may be necessary to avoid, mitigate and/or compensate for impacts, but where these cannot yet be estimated with enough accuracy for the costs to be included in indicator C.1.

- indicate the *residual* social and environmental effects of projects, i.e. effects which may not be fully mitigated in final project design, and cannot be objectively monetised;

To provide a meaningful yet simple and quantifiable measure for these impacts, this indicator gives an estimate of the number of kilometres of a new line that might have to be located in an area that is sensitive for its nature or biodiversity (environmental impact), or its or social value (social impact).

It is often difficult in the early stages of a project to assess its social and environmental consequences, since precise routing decisions are taken later. The quantification on these indicators will thus be presented in the form of a range. For the same reason, projects under consideration are not assessed; they are to be scored only in a successive version of the TYNDP when further studies have been done.

The S1 and S2 indicators have been calculated based on TSO's input regarding the routing of projects and on data from the European Environment Agency (Common Database for Designated Areas and Corine Land Cover Urban Morphological Zones[19]).

S1 Protected area

Environmental impact characterises the local impact of the project on nature and biodiversity as assessed through preliminary studies. It is expressed in terms of the number of kilometres an overhead line or underground/submarine cable that (may) run through environmentally 'sensitive' areas. This indicator only takes into account the residual impact or a project, i.e. the portion of impact that is not fully accounted for under total project expenditures.

[19] http://www.eea.europa.eu/data-and-maps/data/urban-morphological-zones-2006
http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-8

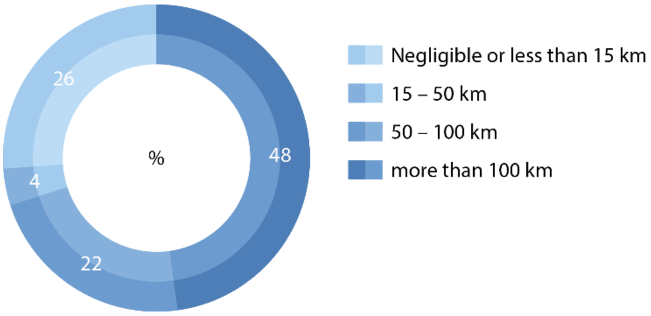

Figure 75 Distribution of S1 indicator values for BS projects

This raw estimation shows that in RGBS approx. a half (48 %) of all projects from project portfolio cross nature protection areas in less than 15 km on rote. It shows a good indication that less than half of all projects do not influence nature protection areas significantly and cross those in small distances on rote. 26 % of projects cross nature protection areas from 15-50 km on rote. By default the projects have been planned to avoid of crossing nature protected areas but the project evaluation results show opposite picture. The amount of projects which are crossing nature protected areas can be decreased in project planning case when other options of project rote can be assessed and explored. In the preparation of RegIP 2014 very raw assessment of environmental impact indicator have been observed therefore in the next step of project evaluation many other possible routes could be proposed. 22 % of all projects influence the nature protection areas in more than 100 km on rote. This part of projects includes the long AC cross-border and internal lines where rote can be optimized during planning stage to decrease the impact on nature. The projects under this share are influencing the nature protection areas very significantly and further evolution of these project candidates can be observed more theoretically.

S2 Urban Area

Social impact characterises the project impact on the (local) population, as assessed through preliminary studies. It is expressed in terms of the number of kilometres an overhead line or underground/submarine cable that (may) run through socially 'sensitive' areas, urban areas. This indicator only takes into account the residual impact or a project, i.e. the portion of impact that is not fully accounted for total project expenditures. The project portfolio shows that the highest part of projects (65 %) cross urban areas up to 15 km of total projects route or in general the project protfolio shows very poor impact on urban areas. The urban areas have been touched in cases to connect new transmission line with substation which located directly in urban area. The small share of projects touchs urban areas in more than 50 km per project what gives also a conclusion that few projects cross urban areas and can make significant impact on population. In total 13 % of all projects cross urban areas from 15 till 50 km and the influence of these lines on population can caused. These projects also can make influence on urban areas but due to the fact that the projects of these shares can also cross more than one city or urban area the exact amount of impact on population is not clearly definable yet. In the next stage of particular project realization any other right of way possibilities can be explored. The projects which are crossing relatively long distance of urban area can also delay the expected commissioning dates due to strong opposition of population.

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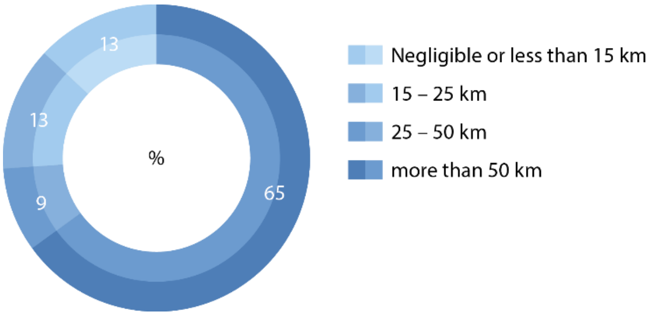

Figure 76. Distribution of S2 indicator values for BS projects

In Baltic Sea region the highest impact on environment of scheduled projects comes from Estonia. The impact on nature is around 30 % of all projects length in Estonia. The one reason for that could be a fact that LV share of projects is also included under Estonia projects because LV part is not divided on graph above separately. The second reason is the fact that according to applied estimations scheduled projects cross quite high amount of nature protection areas.

In range between 10 % till 20 % from whole length of projects on environment has impact to Germany, Poland and Finland projects.

5.4 Project expenditures

Most of the described power system investments are purely transmission infrastructure projects, needed both to operate the system within an adequate security of supply and to integrate the market. This means that the investments are to be financed through congestion rents and grid-tariffs. However, the future power system, including commissioning of renewables and decommissioning of some thermal and nuclear production leads also to a need to enlarge the grid investments.

The scale of the investments needed to arrange the 202020-goals makes this also to a huge financial challenge both for TSO-projects and for third party projects. Programs like the PCI and CEF are therefore most valuable for the project promoters.

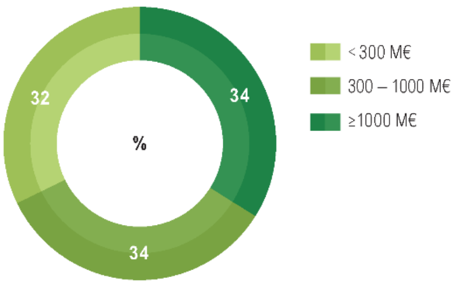

Figure 77 Division of projects by their expenditures in Baltic Sea region regarding long term projects of Pan European significance and Regional interest

As the TSOs are looking into a far future it is in 2030 then the major part of projects have very high expenditures what exceed 100 million Euros. These expenditures include constructions/upgrades of power lines, constructions/upgrades of substations, integration of new pump storage power plants into transmission network and constructions of additional grid equipment’s to ensure at least the same level of security of supply and reliable system operation in case with higher penetration of RES. The TSOs are forecasting, that according to EU objectives towards carbon neutral Europe in 2030, EU power system will change from thermal and nuclear generation in basement to wind, hydro, solar and biomass and biogas in basement. According to EU targets it seems the thermal power plants will remain mainly for balancing and reserves. The very high expenditures are often related to the size of the project like it is in case of Swedish internal grid reinforcements from North to South (SE1-SE2 and SE2-SE3) which covers a long geographical distance in area of Sweden. From some projects is known only idea or objective of development like it is in Baltic synchronization where a count of investments is unclear yet and connection points are not defined but TSOs known that the expenditures of project is very high and it touches Baltic States, Central Europe and 3rd countries. There are also a number of HVDC projects with high investment costs. The mentioned things above require high expenditures in existing transmission network and it is also a challenge for TSOs to provide energy from main generation nodes to the consumption centres. Most of projects consist of several investments which after summing up also give a very high expenditure towards 2030.

Project costs show very wide range, corresponding to the diversity of the projects designs, from less than 0.1 bn Euros till 36 bn Euros. Most of the listed countries have total expenditures on long term projects less than 1 bn Euros but still we have extreme case like Germany which total project costs from around 36 bn Euros. Less than half of countries are expecting more than 1 bn Euros of costs for transmission assets in the coming time period. The costs per country are given in the table below.

Table 3 Total project costs by country

Row Labels	Total cost (bn Euros)
DE	34.8-54.2
DK	3.7
EE	0.2
FI	0.8
LT	0.7
LV	0.4
NO	7.9
PL	1.9
SE	3.6

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6 2030 transmission capacities and adequacy

This chapter confronts investment needs and projects assessments to derive target capacities for every boundary in every Vision. Then, comparing the target capacity and the project portfolio for every boundary, a transmission adequacy index can be supplied.

6.1 Target capacities by 2030

For every boundary, the target capacities correspond in essence to the capacity above which additional capacity development would not be profitable, i.e. the economic value derived from an additional capacity quantum cannot outweigh the corresponding costs.

Synthesizing the investment needs and projects assessments, target capacities can be sketched for every boundary in every Vision. The practical evaluation however is complex; for instance:

- In a meshed grid, parallel boundaries are interdependent and for a very similar optimum, different set of values can be envisaged although only one is displayed.
- The value of additional capacity derives directly by nature on the scenario. A very different perspective for the generation mix in one country compared to present 2030 Visions may give a very different result for target capacities beyond this country's borders.
- The computation is also undermined by the assumptions that must be made for the cost of an additional project on the boundary wherever no feasibility studies are available. Similar costs to former or similar projects must then be considered.

Overall, target capacities are not simultaneously achievable, i.e. building such transmission capacity would not imply they could be saturated all at the same time.

Additionally, ENTSO-E checked whether the interconnection capacity of every country meets the criterion set by the European Council[20] for interconnection development, asking from every Member States a minimum import capacity level equivalent to 10% of its installed production by 2005. Meeting this criterion led to lift up the target capacity between Spain on the one hand and France and UK on the other hand.

The outcome of such computation must hence be considered carefully. Target capacities are displayed as ranges as accurate values can only be misleading. Globally, the maps displayed in this section should be considered rather as illustrative.

[20] Presidency Conclusions, Barcelona European Council, 15 and 16 March 2002.

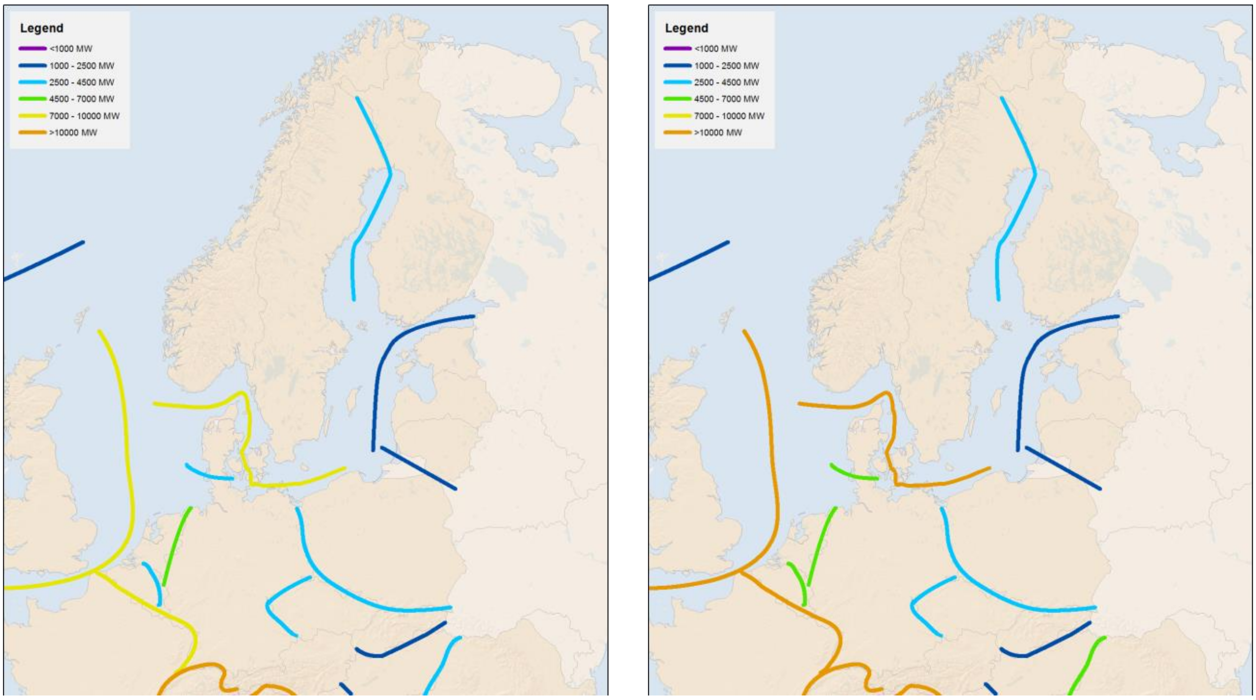

Figure 78 Target capacities by 2030 in Vision 1 (left) and in Vision 4 (right)

Both maps show similar patterns: the magnitude of the target capacities is relatively higher in Visions 3 and 4. The main reason for that is being the relatively higher RES development and higher CO2 price particularly in the boundary between Scandinavia and Continental Europe.

Target capacities fall in the same range of magnitude in both Visions between Finland and Sweden and from Baltic Countries to Nordic countries and Continental Europe. The target capacity between Baltic countries and Continental Europe reflects purely market needs, not taking into account possible synchronization.

6.2 Transmission adequacy by 2030

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

The assessment of adequacy merely compares the capacity developed by the present infrastructure and the additional projects of pan-European significance with the target capacities. The result is synthetically displayed on the following map: the boundaries where the project portfolio is sufficient to cover the target capacity in all Visions are in green; in no Vision at all in red; otherwise, in orange.

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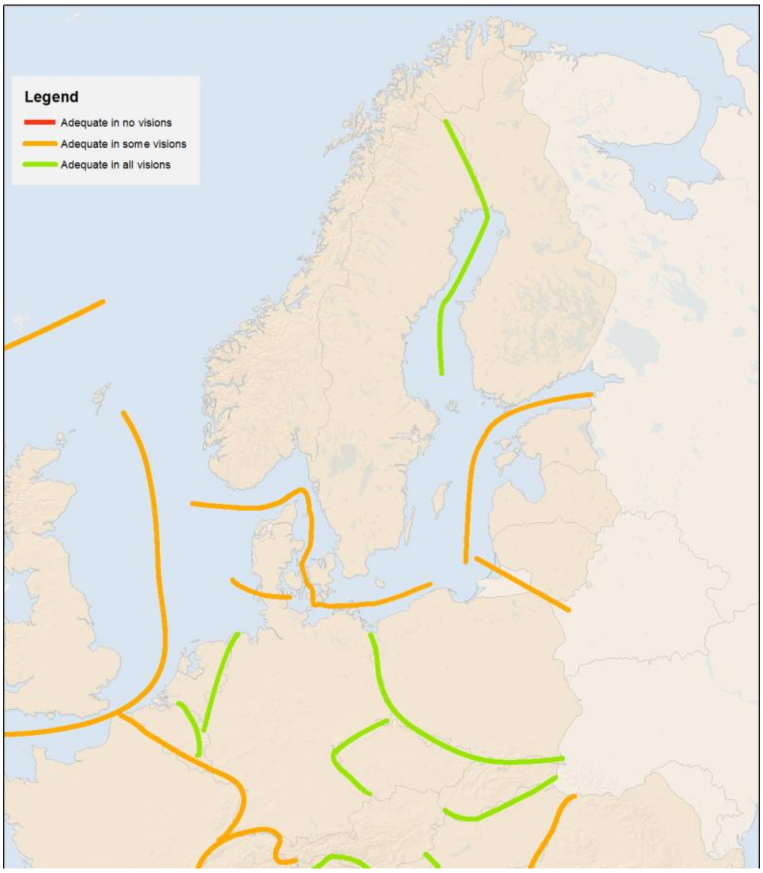

Figure 79 Transmission adequacy by 2030

The proposed projects cover most interconnector investment needs. Conversely, some additional reinforcements are still to be designed to cover investment needs in specific scenarios of system development by 2030. Additionally to the given project candidates some further projects were screened, but not included into the development plan content as being considered as immature and unrealistic to be constructed together with all the rest of the projects at the same time. Also the selection of the projects was done based on preliminary assessment results. More studies have to be performed in the future to find out the exact needs and possibilities of additional alternatives to the selected ones. Special sensitivity cases, especially Baltic Sea Green Vision, show potential for much higher flows on certain boundaries and it is evident that further needs are also strongly influenced by further development path.

The interconnections which should be focused on in future studies are between Scandinavia and Continental Europe and between Baltic countries and Nordic countries and Continental Europe. Additionally, if capacities for the above mentioned interconnections are increased, investments in internal grids will most probably be needed. Most of the boundaries in the region are Adequate in some Visions: there, all the listed projects are prerequisite to meet target capacities goals, but some additional grid reinforcements are required to cover investment needs specific to the most ambitious scenarios by 2030.

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7 Environmental assessment

This chapter supplies a synthetic overview of the environmental assessment of the grid development depicted in the Regional Investment Plan. Detailed environmental assessments are run for every project by their promoters and more information is supplied in the National Development Plans. Compared to the TYNDP 2012, the methodology for assessing the projects has been improved through a fruitful dialog with ENTSOE TYNDP's stakeholders, especially in the framework of the Long Term Network Development Stakeholders Group over the last two years. The outcome is a specific appraisal of the benefits of the projects with respect to potential spillage of RES generation; and the replacement of the former social and environmental indicator by two more specific indicators with respect to crossing of urbanised areas and protected areas.

This enhanced methodology enables to demonstrate strong conclusions: the projects of pan-European significance are key to make an energy transition in Europe – i.e. a significant increase of power generated from RES, CO2 emissions mitigation and a major shift in the generation pattern – possible, with optimised resorting to natural resources.

Assessment results of social and environmental indicator are described in chapter "Project portfolio" therefore here another key statistics and parameters for environmental assessment are to be shown.

7.1 Grid development is key for RES development in Baltic Sea region

One of the most important drivers for the 2030 Visions is RES development. In the Vision 4 the highest amount of installed capacity comes from Wind (Off-shore and On-shore wind farms distributed among the Baltic Sea region) which share from total generation is going to be increased from 24% in Vision 1 to 42 % in Vision 4. The wind farms are main future energy source towards carbon neutral Europe. The installed capacity of hydro remains quite equal in all Visions except Vision 4 where additional installed capacity of hydro storage was set in Norway. Hydro resources are limited by water inflow and depend on whether condition in different years. The development of hydropower plants are limited by geographical conditions.

It is not expected any dramatic increase of installed capacity of solar power in Baltic Sea region and the levels remain almost equal in all four Visions. The Biomass and Biogas developments are higher in Vision 4 (around 6 % share from generation portfolio) in case very favourable economic conditions will be achieved and the European schemes support Biomass and Biogas generation within Baltic Sea region and whole EU.

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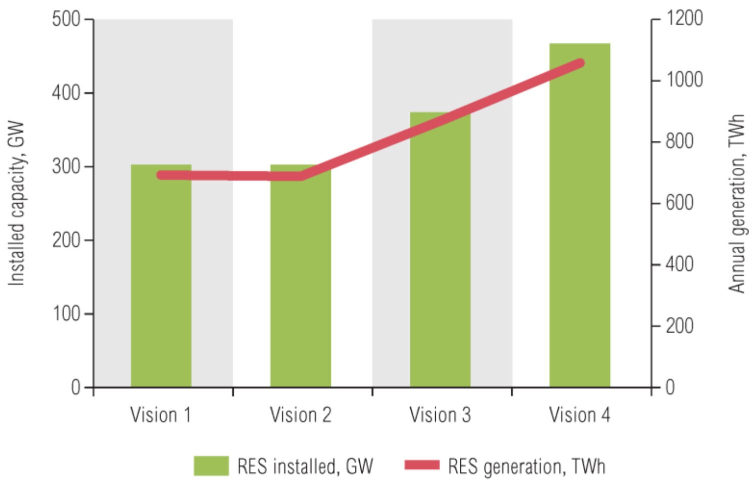

Figure 80 RES capacity and generation in different Visions

From figure above it can be seen the RES vary from around 300 GW of installed capacity in Vision 1 to 460 GW of installed capacity in Vision 4. It shows that RES developments can vary in very wide range and support schemes of national governments and EU can influence RES developments straight. From TSOs of RGBS point of view Vision 4 is ambitious and huge increase of RES is analysed more theoretically as exact connection locations in the region are not known. TSOs of RGBS assumed that Vision 4 could be a farthest point in the planning case of network developments and reachable only with very strong support of EU. The planned increase of RES will need additional grid with its influence on environment and urban areas.

7.2 The Regional Investment plan make ambitious CO2 emissions mitigation targets possible

In regional level the CO2 emissions in Visions 1 and 2 are higher as in Visions 3 and 4. The decrease of CO2 emissions through the Visions is expected due to replacement of CO2 rich fossil fuel generation sources by RES and natural gas. One of the drivers for such development can be considered a change in price of CO2 which vary from 31 Euro/t in Visions 1&2 to 93 Euro/t in Visions 3&4. The smallest shares of CO2 emissions compared to annual generation (less than 0.1 t/MWh) are in Lithuania, Latvia, Norway and Sweden. The reasons for very low level of CO2 emissions are base generation of nuclear as well as high penetration of RES. The overall tendency shows a big decrease in CO2 emissions from Visions 1 and 2 to Vision 3 and 4, mainly due to rapid RES developments in in Visions 1&4. The average CO2 decrease in whole Europe per each project is 890 kilo tons annually in Vision 4. Largest decrease can be observed in Nordics, Baltics and central Europe, where project impact to CO2 decrease exceed 2000 kilo tons annually in Vision 4.

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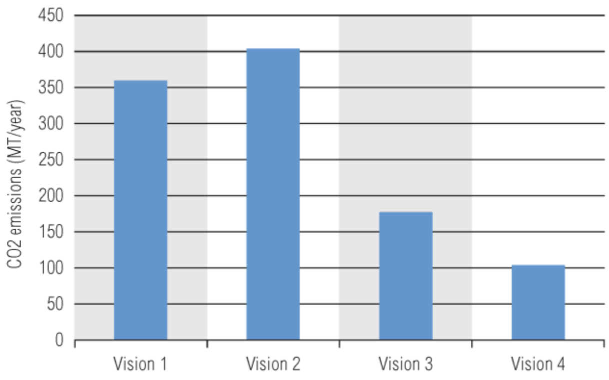

Figure 81 CO2 emissions for Baltic Sea region in all Visions

CO2 emissions by country in different visions are presented under chapter 3 “Scenarios and study results”.

7.3 New transmission capacities with optimised routes

All projects from RGBS project portfolio are considered as project candidates or possible future projects which require more detailed evaluations and assessments therefore exact routes for main part of those are not clearly identified. More or less projects are identified as project candidates to see a possible coming future evolution and ensure security of supply, expand market integration and RES connection in whole power system. That means all projects beyond 2020 can be adapted to decrease impact to environment and nature protection areas.

TSOs optimise the routes to avoid interferences with urbanised or protected areas as much as possible. In densely populated areas, or where a great share of the land is protected, as it is in Denmark and Germany, might be a big challenge. The assessment of the urbanized and protected areas affected by the new lines is described in chapter 6.2.9.

7.4 Mitigation measures taken.

Environmental impact caused by grid development such as new lines and substations construction is an important subject for the TSOs of the region. In order to integrate them in the best way, a big effort is made from the beginning of the planning to minimize the impact. TSOs in cooperation with communities identify all positive and negative effects and define the measures to be taken to avoid, reduce or eventually compensate the negative effects of the development plan.

One possibility to reduce the impact to environment is to use upgrading solutions in order to optimise the existing network, and when it is possible to reduce the total length of overhead lines. When the project planning goes further, one possibility is to plan the new lines using already existing routes, for example using a route for 110 kV line to upgrade the line to higher voltage, thus a larger capacity can be achieved .

For parts of the routes a common tower can be used for both 400 kV and 110 kV voltages, which narrows the needed land space, compared to separate parallel lines.

The effect on the environment needs always to be analysed on a case by case basis. Here are only a few examples of mitigation measures:

1. Line routing on less populated areas and by urban areas
2. For urban areas and crossing urban areas the underground cables can be explored/applied.

3. Tower design. Several TSO's have some design towers implemented on their grid. Design towers can be used mitigating the visual effect of the transmission lines.

Figure 82 Examples of design towers, used to mitigate the visual effect of the transmission lines

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8 Assessment of resilience

Additional to the CBA indicator resilience the RGBS has done sensitivity studies to assess the robustness of the system reference case as a whole. These can be found in Appendix 8 of the report. This can along with the individual project indicators of resilience give a picture of how robust the grid as a whole will be to future developments. This is summed up in the following chapter.

8.1 Visions

The transmission grid is being designed for future requirements, as well as present conditions. To meet this aim, several future scenarios or sensitivity cases are required as a basis for the Ten Year Network Development Plan. The new infrastructure that is planned should fit in with the existing infrastructure, whilst promoting potential future development. To this end, ENTSO-E developed the four visions, which is a framework of four scenarios. Regional specifies are also taken into account within each of the System Development Committee Regional Groups.

Regional Group Baltic Seas has explored eight cases, including both, visions and sensitivity cases.

In the first stage of TYNDP preparation, the Baltic Sea Regional Group has undertaken an Exploration Phase, which includes regionally based main assumptions for future development plans and extreme RES evolution in the whole Baltic Sea area. This vision was called “BS Green Vision” and the main outcome was a list of project candidates for further investigation and cost benefit analyses in the Assessment Phase. Proposed project candidates covered six main areas of interest, according to input from all TSO’s in the Regional Group Baltic Sea:

4. Reinforcing Northern Part – 7 new projects
5. North-South reinforcement in Scandinavia – 2 new projects
6. Sweden - Denmark West and Sweden – Norway (Projects are not included into TYNDP)
7. Increased capacity between Scandinavia and Continental Europe (and UK) – 7 new projects
8. Increased North-South capacity through Baltic States – 6 new projects
9. Power Flow control on Estonia/Latvia - Russia border
10. Baltics synchronization with Continental Europe

In total, 14 new projects were proposed during Exploratory Phase to be analysed by RG Baltic Sea within Assessment Phase. During the Assessment Phase, all projects from the Exploratory Phase and the previous TYNDP (2012); were assessed according to the four official ENTSO-E visions. The assessment has been done for each project candidate and the assessments are being approved by all TSOs of the Baltic Sea Regional Group.

Additionally some sensitivities derived from Visions were studied for regionally specific possible developments, which were not covered by Pan – European development Visions. Sensitivities are used to improve quality and robustness of results, delivered by RGBS. Sensitivities were studied for all assessed Visions, and were applied for reference case only. Three sensitivities were analysed. All sensitivities are estimated as a reference case only and the results are available in relation to each scenario, rather than individual projects. The sensitivity cases are as follows:

1. Reduced Nuclear production in Sweden, Finland and Poland
2. Delay of projects – if 30 % of projects are commissioning out of scope
3. Baltic Sea Green Vision (prepared based on Vision 3 input data but more realistic development plans have been used).

9 Monitoring of the Regional Investment Plan 2012

9.1 Portfolio

The project portfolio of Baltic Sea region includes the internal and interconnector projects of Pan European Significance and Regional interest from all regional member states - Nordics, Baltics, Germany and Poland.

Approximately 56% (123) of the investments are proceeding as planned compared to TYNDP 2012, together with the commissioned and cancelled investments they make a share of 64 % of the investment portfolio.

5% (11) of the projects have been cancelled, some have been cancelled due to the fact that the driver has vanished, or the evolution has not been like expected on the time the project was initially put into plan, sometimes it has not reached very mature state, and has only been in consideration phase. A couple of planned projects have been rendered unnecessary and have been replaced by a new concept (SVC's in Germany). Some of the projects has not been confirmed by the National development plan and have thus been cancelled from the TYNDP (several projects in Norway and Germany).

In total 47 new projects have been suggested compared to the TYNDP 2012.

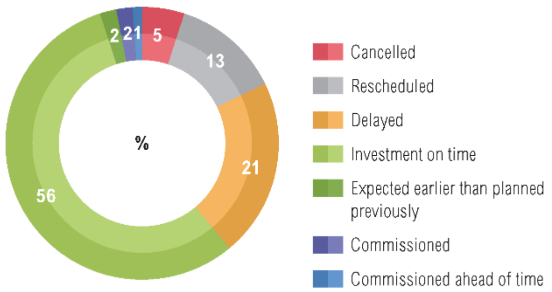

Figure 83 Evolution of the pan-EU significance projects of the BS region

9.2 Monitoring statistics

Around a half of the projects are being in time (51%) and about 4% of the projects are even expected earlier than in previous TYNDP 2012. Few projects have been also rescheduled (9%) and some of the projects have been cancelled (5%). A number of long term projects within BS region have been rescheduled while making coordination with National Development plan and some rescheduling has been done due to the change in the drivers for the projects.

Number of projects (19%) is reported as being delayed. The main reason for delays is permitting procedures and licencing or land acquisition. A Number of projects have been delayed due to changes in the drivers (generation development delayed, consumption development delayed). Some of the projects have been delayed for further investigation whether the project is the best technical solution. Also the new power lines by itself face huge public opposition therefore some projects have delays of many years if not more than a decade.

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7% of projects have been already commissioned. Among those projects a second HVDC link between Finland and Estonia, and several internal grid reinforcements in all Baltic Sea region countries. All commissioned grid reinforcements are increasing possibilities for RES interconnection, and increasing integration between different market areas in the region.

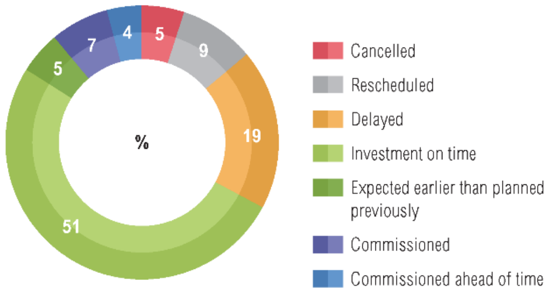

Figure 84 Evolution of the BS region investments portfolio (including pan-EU and regional significance investments)

9.2.1 Delayed investments

Major reason for delays is the authorization process, permitting granting and sometimes the land acquisition. Reasons have also been changes in evolution of generation and demand connection; consequently changes were applied to the TYNDP projects. Out of the 43 investments reported being delayed 22 report having delays due to these reasons. Most of these projects are internal grid reinforcements in Germany and Poland but there are projects also in other countries. The highest share of projects has delayed for 1 year at least (17) but also some projects have delayed more than 5 years (7).

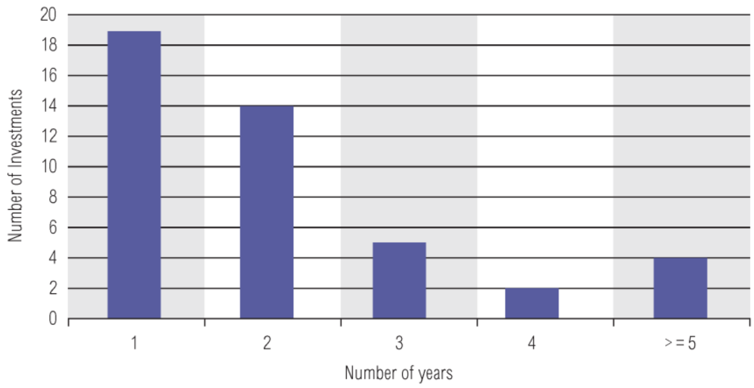

Figure 85 Number of Delayed investments and number of delayed years

9.2.2 Rescheduled investments

A new category “rescheduled” is introduced compared to TYNDP 2012 to highlight the uncertainty of long terms investment. In particular, investments which meet all the criteria below are displayed as rescheduled:

- To be commissioned after 2020 in the current report
- Still under consideration or planning
- Postponed

The objective is to give a more comprehensive picture of the investments ‘evolution in relation to their maturity. Indeed, the status “rescheduled” corresponds to long term, or conceptual investments, at the early stage of the planning process, on which further studies have allowed the provision of more accurate date of commissioning, based for instance on a better understanding of the technical challenges or of the socio-economic environment. In addition, investments postponed due to their external driver being delayed (e.g. connection of new RES postponed, etc.) are also reported into this category.

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10 Conclusion

10.1 The TYNDP 2014 confirms the conclusions of the TYNDP 2012

Looking further towards 2030, the TYNDP 2014 confirms the conclusions of the TYNDP 2012.

The generation portfolio will most likely experience a major shift by 2030, with the replacement of existing capacity by different ones, encompassing more intermittent power generation, located differently and in most cases farther from load centres. This renewal of the generation infrastructure is a major challenge for the transmission grid. As a result, ENTSO-E forecasts larger, more volatile power flows, over longer distances across Europe. In the event of significant cooperation between the European states distribution of RES will to a certain extent be based on where it has the best generation opportunities, as in Vision 4. The bulk power flows will be stretching from the south of Europe all the way to the north and back again depending on whether it is Wind in the North Sea or Solar in Spain and Italy which dominates at that point in time.

One of the main drivers in the Baltic Sea region is an expected Nordic surplus, largely due to the hydro generation in Norway and Sweden, but also due to increases in nuclear capacity, additional wind power and biomass generation. In visions with large shares of renewables (Vision 3 and 4), hydro reservoirs are exploited for balancing volatile renewable generation in the rest of Europe. In Vision 4, hydro reservoirs also serve as storage capacities to allow integration of even more RES in the rest of Europe. The Nordic surplus and integration of RES all over Europe makes interconnections to the Continental Europe highly beneficial, especially in visions with a high share of renewables.

Additional to the Nordic surplus, an important driver is the integration of energy peninsulas into the common European Electricity market. The results of the analysis show that further grid-interconnection of the Baltic States with the Continental and Nordic system is needed. In addition, Baltic synchronisation with Continental Europe has been analysed only in market modelling and that has only in vision 4 shown significant socio-economic benefits. The Feasibility study of "Interconnection Variants for the Integration of the Baltic States to the EU Internal Electricity Market" has proven that due to very high investments costs of grid reinforcement, synchronization in the Baltic States with Continental Europe is not profitable.

Analysis of the TYNDP 2014 in Baltic Sea region shows that project portfolio has a positive impact in targets: contributing to increased social welfare and supporting European climate and renewables targets. Analysis results of Vision 4 shows substantially higher benefits than other Visions. It is clear that further integration of renewables call for even higher investments in order to allow development of optimal supply-demand system.

A major challenge is that the grid development may not be completed in time for the EU-wide targets in 2030. Permit granting procedures are lengthy, and may cause commissioning delays. If energy and climate objectives have to be achieved, it is of the outmost importance to smooth the authorisation processes. It is also important to understand that delays in commissioning cause additional costs to the European society with Baltic Sea regional analyses emphasising this.

The bulk power flows in the studies are mainly directed from the North to South of the region towards Central Europe. However, depending on assumptions behind the visions, significant flows from East to West and from West to East are observed. A robust development plan needs assessment of different possible futures which is done in all 4 visions. Additionally, Regional Group Baltic Sea has analysed sensitivities on delays of projects and an entirely new vision where fuel and CO2 prices are selected to be similar to the "New Policies" scenario from the IEA with additional RES capacities in some countries in Baltic Sea region. The results show that there may even be further need for interconnection capacity, which needs to be assessed in the future. It is clear that assessed projects may not cover needs of all possible futures – extreme scenarios may need additional analyses beyond the TYNDP-2014 scenarios, i.e. refining exact locations of generation units and connections and investigating possible additional internal bottlenecks. It is also important to understand that despite the four Visions and several sensitivities analysed regionally, there are still some uncertainties in future developments such as location of new generation; future interaction with third countries; new demand types; future of industrial demand; evolution of nuclear capacity and competitiveness of generation investments.

11 Appendices

11.1 Appendix 1: technical description of projects

All detailed information about this assessment of projects is displayed in this Appendix. The organisation of Appendix 1 reflects the various roles and evolution of the TYNDP package since 2012:

- Section 11.1.1 displays the detailed assessment of Projects of Pan-European significance within the Baltic Sea region, i.e. transmission projects stemming from ENTSO-E analyses or submitted by third parties, and matching the criteria of pan-European significance, be they eventually PCIs or not;
- Section 11.1.2 displays the list of all projects and investments within the Baltic Sea region, including latest information on the evolution of each investment since TYNDP and RgIPs 2012.
- Section 11.1.3 displays the list of all commissioned investments within the Baltic Sea region.
- Section 11.1.4 displays the list of all cancelled investments within the Baltic Sea region.
- Section 11.1.5 displays the assessment of storage projects within the Baltic Sea region, complying with Reg 314/2013.

11.1.1 Transmission projects of pan-European significance

This section displays all assessments sheets for projects of pan-European significance within the Baltic Sea region. It gives a synthetic description of each project with some factual information as well as the expected projects impacts and commissioning information.

11.1.1.1 Transmission projects of pan-European significance

All projects (but one) presented in Section 11.1.1 are matching the criteria for projects of pan-European significance, set as of the TYNDP 2012.

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 least one of the following minimums:
    - At least 500 MW of additional NTC; or
    - Connecting or securing output of at least 1 GW/1000 km² of generation; or
    - Securing load growth for at least 10 years for an area representing consumption greater than 3 TWh/yr.

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NB: Regional Investment Plans and National Development Plans can complement the development perspective with respect to other projects than Projects of Pan-European Significance.

11.1.1.2 Corridors, Projects, and investment items

Complying with the CBA methodology, a **project** in the TYNDP 2014 package can cluster several **investment items**, matching the CBA clustering rules. Essentially, a project clusters all investment items that have to be realised in total to achieve a desired effect.

The CBA clustering rules proved however challenging for complex grid reinforcement strategies: the largest investment needs may require some 30 investments items, scheduled over more than five years but addressing the same concern. In this case, for the sake of transparency, they are formally presented in a series – a **corridor** – of smaller projects, each matching the clustering rules.

As far as possible, every project is assessed individually. However, the rationale behind the grid reinforcement strategy invited sometimes to assess some projects jointly (e.g. the two phases of Nordbalt, the transbalkan corridor, etc.), or even a whole corridor at once (e.g. German corridors from north to south of Germany).

One investment item may contribute to more than one project. It is then depicted in the investment table of each of the projects it belongs to.

11.1.1.3 Labelling

Labelling of investment items and projects started with the first TYNDP, in 2010. They got a reference number as soon as they were identified, regardless where (in Europe) and why (a promising prospect? a mere option among others to solve a specific problem?) they were proposed, and with what destination (pan-European significance or regional project?). Projects are also lively objects (with commissioning of investment items, evolution of consistency, etc.). Hence, now, there is simply no logic in the present labelling. It is a mere reference number to locate projects on maps and track their assessments.

Since the TYNDP 2010, the TYNDP contains

- projects with reference numbers between 1 to 227;
- investment items with individual reference numbers from 1 to about 1200. On maps, the reference numbers are Project_ref|Investment_Item_ref (e.g. 79|459 designates the investment item with the label 459, contributing to project 79).

Corridors have no reference number.

11.1.1.4 How to read every assessment sheet

Every project of pan-European significance is displayed in an **assessment sheet, i.e. 1-3 pages of standard information** structured in the following way:

- A short description of the consistency and rationale of the project;
- A table listing all constituting investment items, with their technical description, commissioning date, status, evolution and evolution drivers since last TYNDP, and its contribution to the Grid Transfer Capability of the project.
- The project’s CBA assessment, in two parts,
    - o on the one hand, the CBA indicators that are independent from the scenarios: GTC increase, resilience, flexibility, length across protected areas, length across urbanised areas, costs;

- on the other hand, the CBA Vision-dependent indicators: SoS, SEW, RES, Losses variation, CO2 emissions variations;
- Additional comments, especially regarding the computation of CBA indicators.

Remarks

- Uncertainties are attached to these forecasts, hence assessment figures are presented as ranges.
- In the same respect, a ‘0’ for losses or CO2 emissions variations means a neutral impact, sometimes positive or negative and not a strict absence of variation.
- Some projects of pan-European significance build on already commissioned investment that were mentioned in the TYNDP (as well as they all build on the existing grid assets), or other investments that are of regional importance. This is mentioned in the ‘additional comments’ as the case may be.

11.1.1.5 Assessment of projects of pan-European significance

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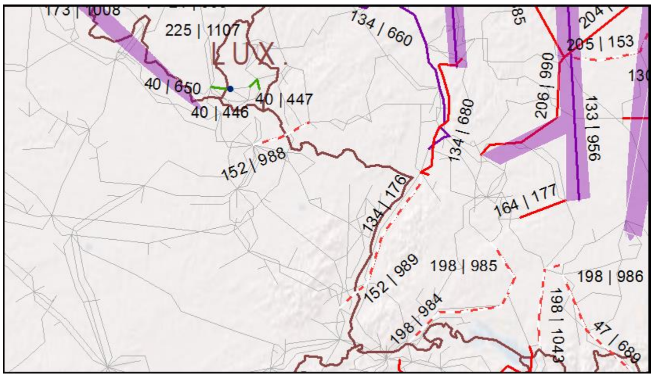
Project 152: France Germany Interconnection

Description of the project

The project aims at increasing the cross-border capacity between Germany and France by reinforcing the existing axes in Lorraine-Saar and Alsace-Baden areas. Studies in progress showed positive impact, with main benefits in terms of market and RES generation integration.

Detailed timeline is under discussion between RTE, Amprion and TransnetBW.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
988	Vigy	Ensdorf or further (tbd)	Upgrade of the existing transmission axis between Vigy and Ensdorf (Uchtelfangen) to increase its capacity.	1500	Under Consideration	2030	New Investment	Studies in progress showed positive impact on FR-DE exchange capacity (investment contribution to GTC highly dependent on the scenario and on generation/load pattern). Technical feasibility under investigation. Commissioning date depends on the scope of the investment.
989	Muhlbach	Eichstetten	Operation at 400 kV of the second circuit of a 400kV double circuit OHL currently operated at 225 kV; some restructuration of the existing grid may be necessary in the area.	300	Under Consideration	2026	New Investment	Studies in progress showed the feasibility of upgrading the existing asset in order to provide mutual support to increase exchange capacity between FR and DE.. The detailed timeline of the investment is under definition.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

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CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
FR=>DE: 1000-2000	DE=>FR: 1000-2000	1	4	NA	NA	100-140

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[18;22]	0	0	0
Scenario Vision 2 - 2030	-	[48;59]	0	0	[1200;1400]
Scenario Vision 3 - 2030	-	[140;170]	[130000;160000] MWh	0	[-860;-700]
Scenario Vision 4 - 2030	-	[220;270]	[200000;250000] MWh	0	[-1400;-1100]

Additional comments

Comment on the RES integration: avoided spillage concerns RES in Germany and France mostly.

Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES

Comment on the Losses indicator: basically, the project enables power exchanges over greater distances (increasing losses), and conversely reduce the overall resistance of the grid. Losses variation is hence symbolically 0, with depending on the point in times losses being lower or greater, with variation close to the model accuracy range.

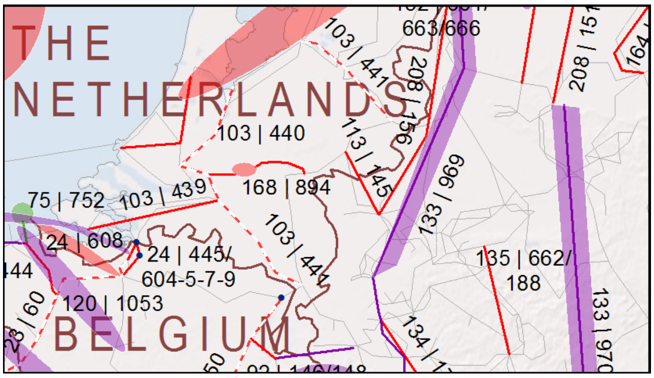
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Project 113: Doetinchem - Niederrhein

Description of the project

This new AC 400-kV double circuit overhead line will interconnect The Netherlands and Germany (Ruhr-Rhein area). Upon realization of the project, the border between The Netherlands and Germany will consist of four double circuit interconnections in total. The project will increase the cross border capacity and will facilitate the further integration of the European Energy market especially in Central West Europe.

PCI 2.12



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
145	Niederrhein (DE)	Doetinchem (NL)	New 400kV line double circuit DE-NL interconnection line. Length: 57km.	-	Design & Permitting	2016	Delayed	Permitting procedures take longer than expected

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
NL=>DE: 1400	DE=>NL: 1400	3	3	15-50km	25-50km	190-220

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[0;10]	[4500;5500] MWh	[-39000;-32000]	[-11;-9]
Scenario Vision 2 - 2030	-	[4;5]	0	[-39000;-32000]	[-27;-22]
Scenario Vision 3 - 2030	-	[15;65]	[100000;130000] MWh	[-180000;-150000]	[-770;-630]
Scenario Vision 4 - 2030	-	[40;60]	[63000;77000] MWh	[-180000;-150000]	[-1000;-1200]

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Additional comments

Comment on the security of supply: The new capacity will also contribute to the Security of Supply by providing new energy exchange channels which increases the system flexibility.

Comment on the RES integration: facilitate the further integration of RES in the Netherlands and Germany

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Project 92: ALEGrO

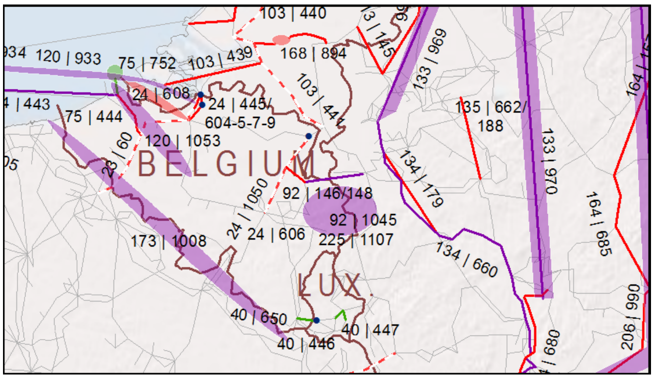
Description of the project

The ALEGrO (Aachen Liège Electricity Grid Overlay) project involves the realization of a HVDC link with a bidirectional rated power of approximately 1.000 MW capacity, as the first interconnection between Belgium and Germany.

First of all, it enhances the internal market integration by enabling direct power exchanges between these countries

Secondly, the new interconnection will play a major role for the transition to a generation mix which is undergoing structural changes in the region (high penetration of RES, nuclear phase-out, commissioning and decommissioning of conventional power plants etc.). Given these major changes in the production mix, the new interconnection also contributes to the security of supply in facing the arising challenges for secure system operation.

The project has been selected as PCI 2.2.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
146	Area of Oberzier - Aachen/Düren (DE)	Area of Lixhe - Liège (BE)	ALEGrO Connection between Germany and Belgium including new 100 km HVDC underground cable with convertor stations and extension of existing 380 kV substations. The assessment of the Final Investment Decision is planned in 2015.	1000	Design & Permitting	2019	Delayed	BE: Several months delay due to authorization procedure in Belgium longer than expected (modification of "Plan de secteur" in Wallonia). DE: Delay due to unclear permitting framework (legal framework for planning approval is presently under development
1045	Lixhe	Herderen	AC BE Reinforcements Internal reinforcements in AC network in Belgium have started in the context of securing infeed from the 380kV	1000	Design & Permitting	2017	Investment on time	This investment item is split off from the generic Alegro investment item which up to now included also

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			network into the Limburg & Liège area's. These reinforcements are also needed to facilitate the integration of ALEGrO into the Belgian grid. The reinforcements consist of - extension of an existing single 380 kV connection between Lixhe and Herderen by adding an additional circuit with high performance conductors (HTLS) - creation of 380kV substation in Lixhe, including a 380/150 transformator - creation of 380kV substation in Genk (André Dumont), including a 380/150 kV traformator					the internal reinforcements
1048	Lixhe	Herderen	Potentially additional AC BE Reinforcements Envisions the installation of a second 380 kV overhead line between Herderen to Lixhe. And the installation of a 2nd 380/150 transformator in Limburg area (probably substation André Dumont). These reinforcements are conditional to the evolution of production in the Limburg-Liège area and to the evolution of the physical (transit)flux towards 2020-2025.	900	Under Consideration	2020	New Investment	Evolution of generation in the Limburg-Liège must be accounted for in the perimeter of the Alegro project. This conditional project has a commissioning date set to 2020 as indication for further monitoring of the need.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
BE=>DE: 1000	DE=>BE: 1000	3	3	Negligible or less than 15km	Negligible or less than 15km	450-570

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[5;15]	[9000;11000] MWh	[150000;180000]	[140;170]
Scenario Vision 2 - 2030	-	[5;15]	[4500;5500] MWh	[150000;180000]	[-22;-18]
Scenario Vision 3 - 2030	-	[35;45]	[100000;130000] MWh	[120000;140000]	[-800;-650]
Scenario Vision 4 - 2030	-	[45;75]	[180000;210000] MWh	[120000;140000]	[-1100;-900]

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Additional comments

Comment on the security of supply: A new interconnector contributes to the security of supply of Belgium as a whole, due to the diversification it offers to the market players to import energy from countries where excess generation could be available. Given the changing production mix with ongoing nuclear phase out and decommissioning of old power plants, this benefit materializes itself as soon as the project is realized.

The internal reinforcements in the Belgian grid which are part of this project also contribute to the security of supply from a more local perspective, namely by securing in feed from 380kV to 220kV/150kV in Liège & Limburg.

Comment on the RES integration: avoided spillage concerns RES in Germany and Belgium mostly

Comment on the S1 and S2 indicators: Definitive route to be determined, but taking perspective of minimizing impact.

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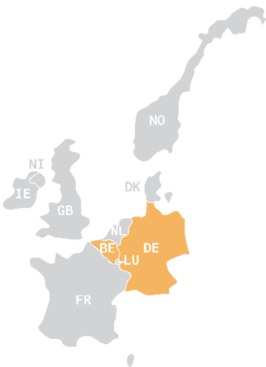
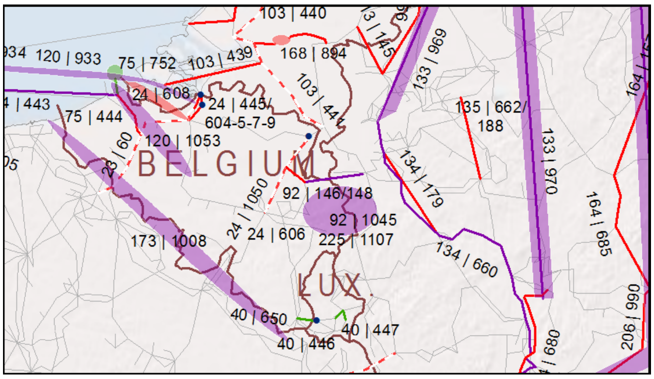
Project 225: 2nd Interconnector Belgium – Germany

Description of the project

This is a conceptual project that could be considered as an investment option, triggered by high RES scenario's. Preliminary analysis shows potential of justifying additional regional welfare & RES integration increase via the construction of an additional +- 1000MW interconnection between Germany and Belgium.
The determination of the optimal capacity, timing (2025-2030), location, technology, and potential needed internal grid reinforcements are subject of further studies.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1107	BE (TBD)	DE (TBD)	This investment item envisions the possibility of a second 1 GW interconnection between Belgium and Germany. Subject to further studies.	-	Under Consideration	2030	New Investment	Preliminary studies on high RES scenario's have indicated potential for further regional welfare & RES integration increase by further increasing the interconnection capacity between Belgium & Germany towards time horizon 2025-2030.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
BE=>DE: 1000	DE=>BE: 1000	2	1	NA	NA	400-600

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CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 4 - 2030	-	[45;55]	[150000;180000] MWh	[120000;140000]	[-850;-690]

Additional comments

Comment on the RES integration: avoided spillage concerns wind farms offshore Belgium mostly.

Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

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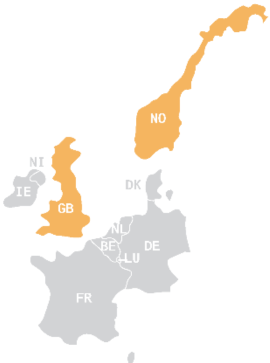
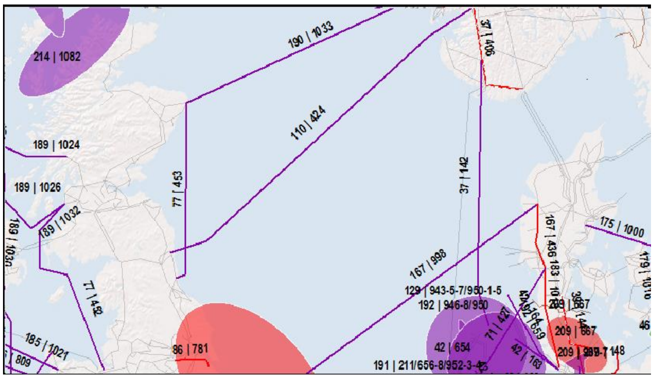
Project 110: Norway-Great Britain

Description of the project

A 720 km long subsea interconnector between Norway and England is planned to be realized in 2020. If realized it will be the world's longest. The main driver for the project is to integrate the hydro-based Norwegian system with the thermal/nuclear/wind-based British system. The interconnector will improve security of supply both in Norway in dry years and in Great Britain in periods with negative power balance (low wind, low solar, high demand etc.). Additional the interconnector will be positive both for the European market integration, for facilitating renewable energy and also for preparing for a power system with lower CO_2-emission. The interconnector is planned to be a 500 kV 1400 MW HVDC subsea interconnector between western Norway and eastern England.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
424	Kvilldal (NO)	Blythe (GB)	A 720 km long 500 kV 1400 MW HVDC subsea interconnector between western Norway and eastern England.	-	Design & Permitting	2020	Investment on time	Progress as planned.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	GTC direction 2 (MW)	B6 Technical Resilience	B7 Flexibility	S1 - protected areas	S2 - urban areas	C1 Estimated cost (Meuros)
GB=>NO: 1400	NO=>GB: 1400	2	4	Negligible or less than 15km	Negligible or less than 15km	1700

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[150;220]	[1000000;1200000] MWh	[760000;930000]	[-440;-360]
Scenario Vision 2 - 2030	-	[90;170]	[900000;1100000] MWh	[760000;930000]	[-240;-190]
Scenario Vision 3 - 2030	-	[280;360]	[2700000;3300000] MWh	[760000;930000]	[-2000;-1700]
Scenario Vision 4 - 2030	-	[280;300]	[2100000;2600000] MWh	[760000;930000]	[-1800;-1500]

Additional comments

Comment on the RES integration: Both the NSN and the NorthConnect-project are showing very high values regarding RES-integration. The reason for this is that the projects leads to both decreased spillage in Great Britain (when windy) and in the Nordic countries (when wet).

Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES (by bringing it to load centres or to and from storage facilities)

Comment on the Losses indicator: the load factor of the cable is similar in all Visions, leading to the same and very high additional losses.

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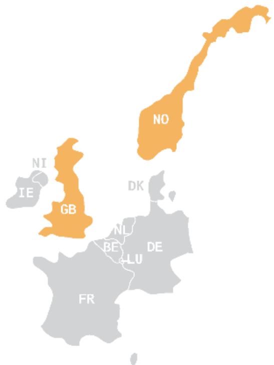
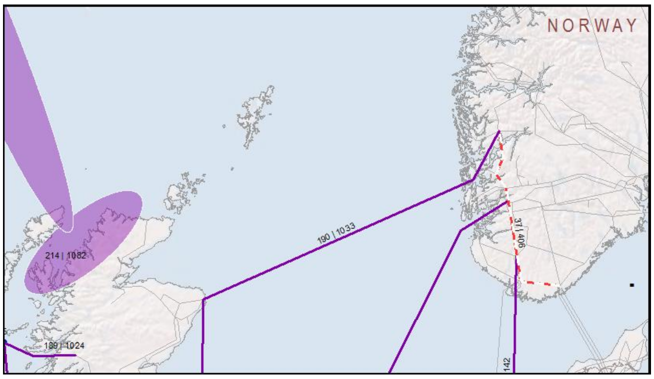
Project 190: Norway-Great Britain

Description of the project

A 650 km long subsea interconnector between Norway and Scotland is planned to be realized in 2021. The main driver for the project is to integrate the hydro-based Norwegian system with the thermal/nuclear/wind-based British system. The interconnector will improve security of supply both in Norway in dry years and in Great Britain in periods with negative power balance (low wind, low solar, high demand etc.). Additional the interconnector will be positive both for the European market integration, for facilitating renewable energy and also for preparing for a power system with lower CO_2-emission. The interconnector is planned to be a 500 kV 1400 MW HVDC subsea interconnector between western Norway and eastern Scotland.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1033	Sima	Peterhead	A 650 km long 500 kV 1400 MW HVDC subsea interconnector between western Norway and eastern Scotland.	-	Design & Permitting	2020	New Investment	Project application to TYNDP 2014.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
GB=>NO: 1400	NO=>GB: 1400	2	4	Negligible or less than 15km	Negligible or less than 15km	2200

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[150;220]	[1000000;1200000] MWh	[760000;930000]	[-440;-360]
Scenario Vision 2 - 2030	-	[90;170]	[900000;1100000] MWh	[760000;930000]	[-240;-190]
Scenario Vision 3 - 2030	-	[280;360]	[2700000;3300000] MWh	[760000;930000]	[-2000;-1700]
Scenario Vision 4 - 2030	-	[280;300]	[2100000;2600000] MWh	[760000;930000]	[-1800;-1500]

Additional comments

Comment on the SEW: the results for NorthConnect (Norway-Scotland) is the same as for project 110 NSN (Norway-England), this because Great Britain in the analysis is modelled as one node. If there are price-differences between England and Scotland, this would make the values different for the two projects. In addition, according to current plans, NorthConnect is expected to be commissioned after NSN.

Comment on the RES integration: both the NSN and the NorthConnect are showing very high values regarding RES-integration. The reason for this is that the projects leads to both decreased spillage in Great Britain (when windy) and in the Nordic countries (when wet).

Comment on the Losses indicator: the load factor of the cable is similar in all Visions, leading to the same and very high additional losses.

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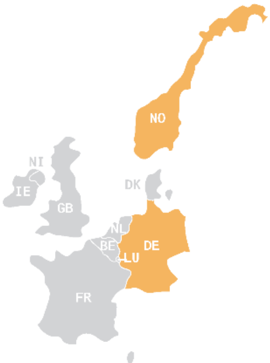
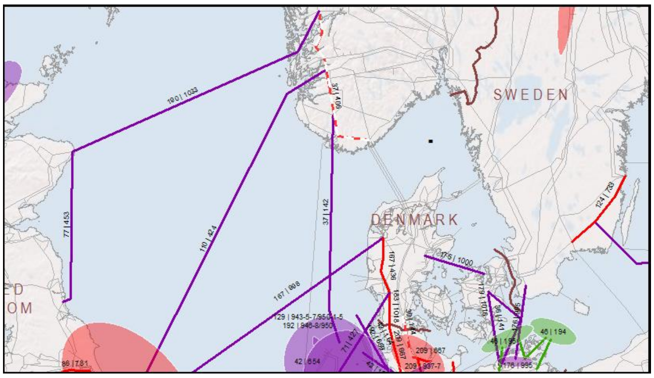
Project 37: Southern Norway - Germany

Description of the project

A 514 km long subsea interconnector between Norway and Germany is planned to be realized in 2018. The main driver for the project is to integrate the hydro-based Norwegian system with the thermal/wind/solar-based Continental system. The interconnector will improve security of supply both in Norway in dry years and in Germany in periods with negative power balance (low wind, low solar, high demand etc.). Additional the interconnector will be positive both for the European market integration, for facilitating renewable energy and also for preparing for a power system with lower CO2-emission. The interconnector is planned to be a 500 kV 1400 MW HVDC subsea interconnector between southern Norway and northern Germany.

PCI 1.8





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
142	Tonstad (NO)	Wilster (DE)	A 514 km 500 kV HVDC subsea interconnector between southern Norway and northern Germany.	1400	Design & Permitting	2018	Investment on time	Agreement between the two TSOs on commissioning date.
406	(Southern part of Norway) (NO)	(Southern part of Norway)(NO)	Voltage uprating of existing 300 kV line Sauda/Saurdal - Lyse - Ertsmyra - Feda - 1&2, Feda - Kristiansand; Sauda-Samnanger in long term. Voltage upgrading of existing single circuit 400kV OHL Tonstad-Solhom-Arendal. Reactive power devices in 400kV substations.	1000	Design & Permitting	2020	Delayed	Revised progress due to less flexible system operations in a running system (voltage upgrade of existing lines). Commissioning date expected 2019-2021.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1	GTC direction 2	B6 Technical	B7 Flexibility	S1 - protected areas	S2 - urban areas	C1 Estimated

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(MW)	(MW)	Resilience				cost (Meuros)
DE=>NO: 1400	NO=>DE: 1400	3	4	50-100 km	Negligible or less than 15km	2500

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[120;140]	[510000;620000] MWh	[910000;1100000]	[-930;-760]
Scenario Vision 2 - 2030	-	[65;110]	[950000;1200000] MWh	[910000;1100000]	[-670;-550]
Scenario Vision 3 - 2030	-	[210;280]	[1500000;1800000] MWh	[910000;1100000]	[-2200;-1800]
Scenario Vision 4 - 2030	-	[350;400]	[1700000;2100000] MWh	[910000;1100000]	[-3400;-2800]

Additional comments

Comment on the RES integration: avoided spillage concerns mainly RES in Germany and Norway.

Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES (by bringing it to load centres or to and from storage facilities)

Comment on the Losses indicator: the load factor of the cable is similar in all Visions, leading to the same and very high additional losses.

Comment on the cost of the project: the cost of investment 142 (Nord.Link) is estimated to 1600 MEuros while the cost of investment 406 is estimated to 900 MEuros.

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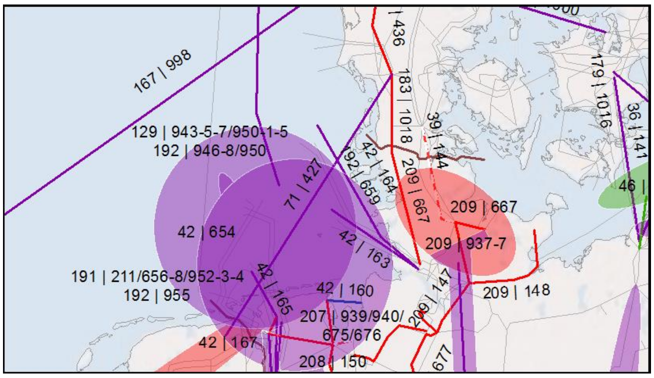
Project 71: COBRA cable

Description of the project

The project is an interconnection between Endrup (Denmark) and Eemshaven (The Netherlands). The purpose is to incorporate more renewable energy into both the Dutch and the Danish power systems and to improve the security of supply. Moreover, the cable will help to intensify competition on the northwest European electricity markets. The project consists of a 320 kV 700 MW DC subsea cable and related substations on both ends, 320-350 km apart, applying VSC DC technology. The project is supported by the European Energy Programme for Recovery (EEPR) and is labelled by the EC as project of common interest (PCI 1.5).



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
427	Endrup (DK)	Eemshaven (NL)	COBRA: New single circuit HVDC connection between Jutland and the Netherlands via 350km subsea cable; the DC voltage will be 320kV and the capacity 700MW.	-	Design & Permitting	2019	Delayed	Rescheduled to develop a solid regional business case (including additional project partners); and to account for the time needed for the acceptance by the authorities of a preferred route.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKW=>NL: 700	NL=>DKW: 700	3	3	15-50 km	Negligible or less than 15km	560-680

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[5;25]	[45000;55000] MWh	[44000;54000]	[-120;-94]
Scenario Vision 2 - 2030	-	[0;10]	[27000;33000] MWh	[44000;54000]	[-44;-36]
Scenario Vision 3 - 2030	-	[25;85]	[180000;220000] MWh	[110000;130000]	[-560;-460]
Scenario Vision 4 - 2030	-	[100;150]	[350000;420000] MWh	[110000;130000]	[-920;-760]

Additional comments

Comment on the security of supply: the project improves the SoS of Western Denmark and the Netherlands.

Comment on the RES integration: The significant increase of RES between Vision 1 and Vision 4 in both countries contributes to an increased number of hours with more volatile prices and thus higher flows in both directions. Additionally, the higher CO2 price in vision 4 causes a shift between coal and gas in the merit order, which increases the price spread between high and low RES hours. This explains the spread of the SEW indicator between these two extreme visions.

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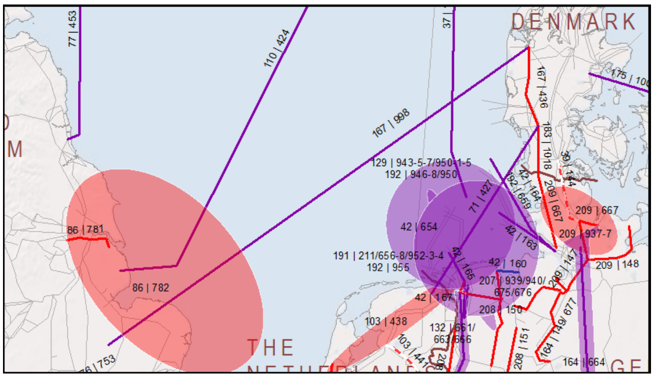
Project 167: Viking DKW-GB

Description of the project

This project, known as Viking Link and under development by National Grid Interconnector Holdings Limited and Energinet.dk, investigates a connection of up to 1400MW between Denmark West and Great Britain by two parallel up to 700 MW HVDC subsea cables and related substations on both ends. A final route is not designed yet - the investigated project is one out of several possible alternatives.

The project cluster includes in Denmark additionally the establishment of a 400 kV AC underground cable system between the 400 kV substation Idomlund and the existing 400 kV substation Endrup with needed compensation arrangements. The parts of national investments already known from TYNDP12 are included in this project cluster.
The project adds cross-border transmission capacity between both countries, thereby facilitating the incorporation of more RES, as the wind is not correlated between both markets.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
436	Idomlund (DK)	Endrup (DK)	New 74km single circuit 400kV line via cable with capacity of approx. 1200MW.	1360	Under Consideration	2030	Rescheduled	In national plan route is replaced by different project, upgrading an existing route from Tjele to Idomlund (72.898). The known route (Endrup-Idomlund) from the TYNDP12 would additionally be necessary as soon as the interconnection to GB is built.
998	Idomlund (DKW)	Stella West (GB)	2x700 MW HVDC subsea link across the North Seas.	1400	Under Consideration	2030	New Investment	New opportunity to integrate markets, new opportunity to exploit non correlated RES

CBA results

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The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKW=>GB: 1400	GB=>DKW: 1400	2	4	NA	NA	1700-1900

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[75;110]	[320000;400000] MWh	[200000;250000]	[570;690]
Scenario Vision 2 - 2030	-	[25;45]	[77000;94000] MWh	[240000;290000]	[380;460]
Scenario Vision 3 - 2030	-	[220;300]	[2300000;2900000] MWh	[360000;440000]	[-2000;-1600]
Scenario Vision 4 - 2030	-	[240;270]	[1800000;2200000] MWh	[350000;420000]	[-1800;-1400]

Additional comments

Comment on the CBA assessment: The significant increase of RES between Vision 1 and Vision 4 in both countries contributes to an increased number of hours with more volatile prices and thus higher flows in both directions. Additionally, the higher CO2 price in vision 4 causes a shift between coal and gas in the merit order, which increases the price spread between high and low RES hours. This explains the spread of the SEW indicator between these two extreme visions.

Comment on the security of supply: the project improves the SoS of Western Denmark and the Wash area in Great Britain.

Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES

Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Comment on GB and DK Connection: Since the time of the origi-nal project assessment for TYNDP, the project has received a connection offer from the GB national TSO for a grid connection at Bicker Fenn substation, with a capacity of 1000MW and a con-nection date in late 2020. In Denmark the connection point has been set to Revsing substation. The project proponents are now working to this timescale. The expected capex of a 1000MW link is in the range €1700-€1900 M€.

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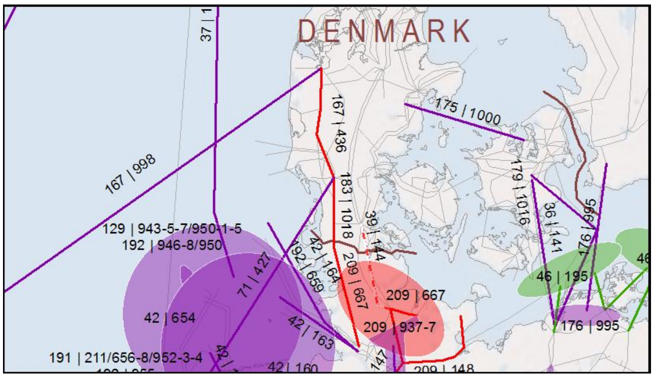
Project 183: DKW-DE, Westcoast

Description of the project

The project consists of a new 400 kV line from Endrup (Denmark) to Niebüll (Germany), adding another 500 MW at the West Coast between these countries. On the Danish side, this project includes the establishment a 400 kV AC underground cable system from the existing 400 kV substation Endrup, via Ribe and Bredebro to the border, from where the interconnector continues to Niebüll. The project helps to integrate RES and to strenghten the connection between the Scandinavian and Continental market. The project is labelled by the EC as project of common interest (PCI 1.3.1).



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1018	Niebüll (DE)	Endrup (DKW)	new 380 kV cross border line DK1-DE for integration of RES and increase of NTC	-	Planning	2022	Investment on time	in TYNDP12 this investment was part of 43.A90

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKW=>DE: 500	DE=>DKW: 500	2	3	Negligible or less than 15km	Negligible or less than 15km	170-210

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[0;10]	[14000;17000] MWh	[-11000;-9000]	[-88;-72]
Scenario Vision 2 - 2030	-	[4;5]	[14000;17000] MWh	[-11000;-9000]	[-22;-18]
Scenario Vision 3 - 2030	-	[20;60]	[120000;140000] MWh	[-12000;-9900]	[-440;-360]
Scenario Vision 4 - 2030	-	[80;100]	[260000;310000] MWh	[-12000;-9600]	[-830;-680]

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Additional comments

Comment on the security of supply: the project improves the SoS of Western Denmark and the area of Schleswig Holstein in Germany.

Comment on the RES integration: avoided spillage concerns RES in Germany and Denmark mostly.

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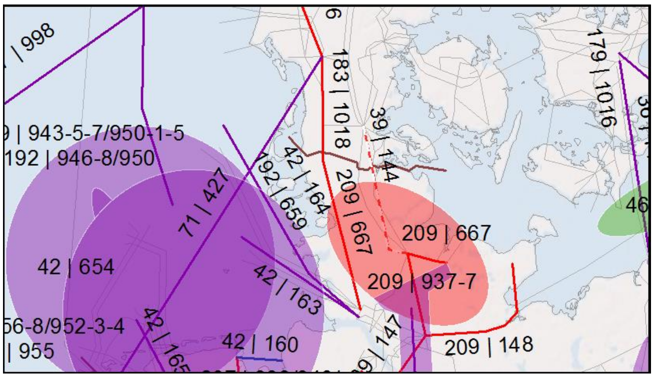
Project 39: DKW-DE, step 3

Description of the project

This project is the third phase in the Danish-German agreement to upgrade the transfer capacity between Denmark West and Germany. The investments of the second phase were included in the TYNDP 2012 edition and have been commissioned in the meantime, thus increasing the cross border capacity since then.
The third-phase project consists of a new 400 kV line from Kassoe (Denmark) to Audorf (Germany). It mainly follows the trace of an existing 220 kV line, which will be substituted by the higher voltage line. The project helps to integrate RES and to strenghten the connection between the Scandinavian and Continental market. The project is labelled by the EC as project of common interest (PCI 1.4.1).



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
144	Audorf (DE)	Kassö (DK)	Step 3 in the Danish-German agreement to upgrade the Jutland-DE transfer capacity. It consists of a new 400kV route in Denmark and In Germany new 400kV line mainly in the trace of an existing 220kV line.	-	Planning	2019	Delayed	Planning ongoing - minor delay due to coordination with project 183.1018

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKW=>DE: 720	DE=>DKW: 1000	3	3	15-50km	15-25km	220-270

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[10;30]	[54000;66000] MWh	[-46000;-38000]	[-120;-94]
Scenario Vision 2 - 2030	-	[0;10]	[110000;130000] MWh	[32000;39000]	[-38;-31]
Scenario Vision 3 - 2030	-	[35;95]	[190000;230000] MWh	[50000;62000]	[-680;-560]
Scenario Vision 4 - 2030	-	[120;150]	[370000;460000] MWh	[51000;62000]	[-1300;-1000]

Additional comments

Comment on the security of supply: the project improves the SoS of Western Denmark and the area of Schleswig Holstein in Germany.

Comment on the RES integration: The significant increase of RES between Vision 1 and Vision 4 in both countries contributes to an increased number of hours with more volatile prices and thus higher flows in both directions. Additionally, the higher CO2 price in vision 4 causes a shift between coal and gas in the merit order, which increases the price spread between high and low RES hours. This explains the spread of the SEW indicator between these two extreme visions.

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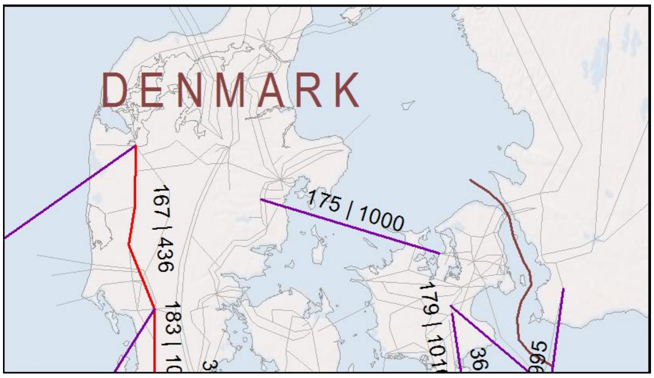
Project 175: Great Belt II

Description of the project

This project candidate includes a 1x 600 MW HVDC connector between Denmark-West (DKW) and Denmark-East (DKE). The connector is called Great Belt-2. It could among other variants be located between the 400 kV substation Malling in DKW and the reconstructed 400 kV substation Kyndby in DKE. The main purpose of this project is to incorporate more RES into the Danish system by sharing reserves between both systems and improve market integration.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1000	Malling (DKW)	Kyndby (DKE)	600 MW HVDC subsea link between both DK systems (2 synchr. areas, 2 market areas)	-	Under Consideration	2030	New Investment	In case of an expanded DKE-SE connection this link could be beneficial.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKW=>DKE: 600	DKE=>DKW: 600	3	3	NA	NA	390-480

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	0	0	[72000;87000]	[190;230]
Scenario Vision 2 - 2030	-	0	0	[72000;88000]	[65;80]
Scenario Vision 3 - 2030	-	[0;1]	[18000;22000] MWh	[62000;76000]	[-50;-41]
Scenario Vision 4 - 2030	-	[2;3]	[45000;55000] MWh	[62000;76000]	[-40;-33]

Additional comments

Comment on the security of supply: The price difference between both Danish market areas is marginal, thus the SEW indicator is very small. Anyhow, the project improves the SoS of both Danish synchronous systems by facilitating sharing reserves.

Comment on the RES integration: In Vision 1 there is only a relative small amount of RES in the region which can be absorbed by the system. Thus the curtailment value does not change due to the project - it stays at zero.

Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

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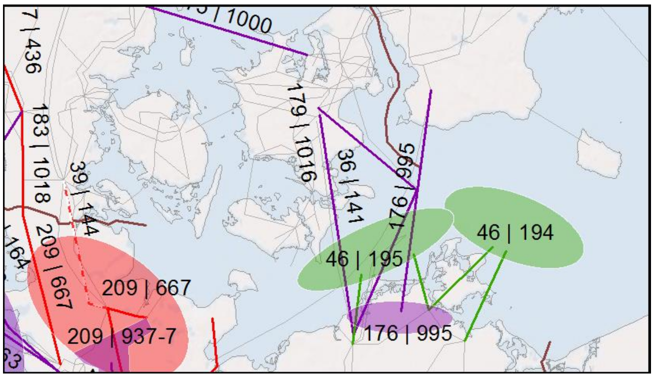
Project 179: DKE - DE

Description of the project

This project includes a 600 MW HVDC subsea interconnector between Denmark-East (DKE) and Germany (DE) and is called Kontek-2. A final grid-connection solution is not prepared yet; one of the possible alternatives could establish the Danish HVDC converter station in the area of Lolland-Falster. This alternative has been investigated for the TYNDP and comprises among other things an HVDC converter station being connected to the existing 400 kV substation Bjæverskov via 400 kV underground cables and/or 400 kV OHL. Some additional investments in eastern Danmark would be necessary, which are not described in detail in this document.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1016	Bjæverskov (DK2)	Bentwisch (DE)	new 600 MW HVDC subsea cable connecting DK2 and DE	-	Under Consideration	2030	New Investment	RGBS common investigations for TYNDP14

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKE=>DE: 600	DE=>DKE: 600	3	3	NA	NA	500-610

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[31;38]	[54000;66000] MWh	[17000;21000]	[82;100]
Scenario Vision 2 - 2030	-	[22;27]	[54000;66000] MWh	[-2200;-1800]	[73;90]
Scenario Vision 3 - 2030	-	[22;27]	[63000;77000] MWh	[120000;150000]	[-890;-720]
Scenario Vision 4 - 2030	-	[140;170]	[63000;77000] MWh	[120000;150000]	[-1900;-1600]

Additional comments

Comment on the CBA assessment: The significant increase of RES between Vision 1 and Vision 4 in both countries contributes to an increased number of hours with more volatile prices and thus higher flows in both directions. Additionally, the higher CO2 price in vision 4 causes a shift between coal and gas in the merit order, which increases the price spread between high and low RES hours. This explains the spread of the SEW indicator between these two extreme visions.

Comment on the security of supply: the project improves the SoS of Eastern Denmark and the Mecklenburg-Vorpommeranian area in Germany.

Comment on the RES integration: avoided spillage concerns RES in Germany and Denmark mostly.

Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

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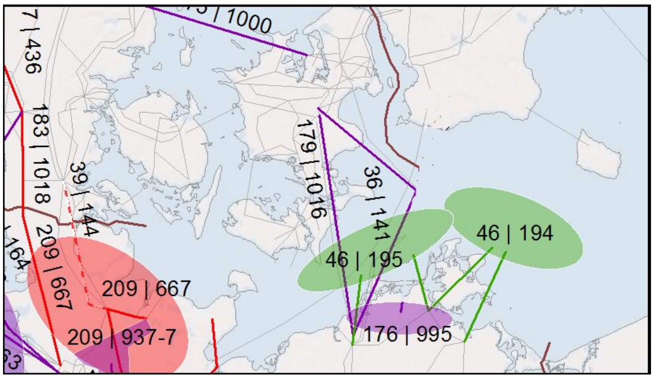
Project 36: Kriegers Flak CGS

Description of the project

The Kriegers Flak Combined Grid Solution (CGS) is a new DC offshore connection between Denmark and Germany. It had been designed and was simulated for this TYNDP as a combined grid connection of the offshore wind farms Kriegers Flak (Denmark), Baltic 1 and 2 (Germany) and a 400 MW interconnection between both countries connecting Ishøj/Bjæverskov (Denmark) and Bentwisch/Güstrow (Germany). The project facilitates RES connection and increased trade of electricity. The modelling results refer to the infrastructure part only, not to the benefit of the involved offshore wind farms, which would be an evaluation of the benefit of new generation, which is beyond the scope of the TYNDP. Thus also the cost reflect only the extra cost compared to the usual way of connecting the offshore wind farms to the two systems. The project is supported by the European Energy Programme for Recovery (EEPR) and labelled by the EC as project of common interest (PCI 4.1).



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
141	Ishøj / Bjæverskov (DK)	Bentwisch (DE)	Three offshore wind farms connected to shore combined with 400 MW interconnection between both countries	-	Design & Permitting	2018	Investment on time	Commissioning date must be achieved in order to ensure grid connection for further renewable energy.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKE=>DE: 400	DE=>DKE: 400	3	3	Negligible or less than 15km	Negligible or less than 15km	300

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[19;24]	[54000;66000] MWh	[-62000;-51000]	[-130;-110]
Scenario Vision 2 - 2030	-	[7;8]	[9000;11000] MWh	[-62000;-50000]	[-4;-3]
Scenario Vision 3 - 2030	-	[10;13]	[18000;22000] MWh	[4500;5500]	[-390;-320]
Scenario Vision 4 - 2030	-	[36;44]	[18000;22000] MWh	[4500;5500]	[-760;-620]

Additional comments

Comment on the security of supply: the project improves the SoS of Eastern Denmark and the Mecklenburg-Vorpommeranian area in Germany.

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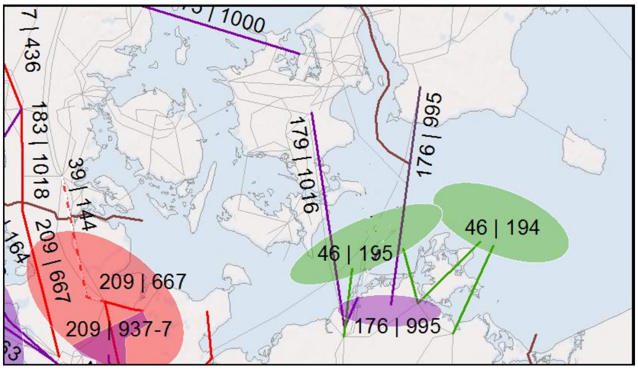
Project 176: Hansa PowerBridge

Description of the project

New interconnector between Sweden (SE4) and Germany (50 Hertz).
There has been joint studies with 4 options for this project. The other options were new interconnectors Latvia-Sweden, Lithuania-Sweden and Poland-Sweden. CBA indicators are based only on the SE4-DE interconnector.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
995	Station SE4	Station DE	New DC cable interconnector between Sweden and Germany.	-	Under Consideration	2025	New Investment	RGBS common investigations for TYNDP 2014

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DE=>SE: 600	SE=>DE: 600	3	3	NA	NA	200-400

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[72;88]	[36000;44000] MWh	[420000;520000]	[590;720]
Scenario Vision 2 - 2030	-	[15;18]	[36000;44000] MWh	[190000;230000]	[340;420]
Scenario Vision 3 - 2030	-	[28;35]	[90000;110000] MWh	[62000;75000]	[-710;-580]
Scenario Vision 4 - 2030	-	[220;270]	[90000;110000] MWh	[280000;350000]	[-2200;-1800]

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Additional comments

Comment on the RES integration: The project helps integrating wind power on both sides and improves power balancing.

Comment on the S1 and S2 indicators: The project will have a social and environmental impact. However, the project is in an early stage and there is not enough facts regarding the impact.

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NordBalt

Nordbalt is splitted into two projects (60, 124), representing its 2 phases spanning from now to 2023.
Nordbalt will connect the Baltic grid to the Nordic and integrate the Baltic countries with the Nordic electricity market and also increases security of supply.
It consists of a 700 MW DC interconnector between Sweden and Latvia and associated internal grid reinforcements. Before phase 2 is implemented, the Nordbalt cable can be fully utilized thanks to a temporary system protection scheme.
The assessment of project 124 is complementary to the one presented for project 60.

Project 60: NordBalt phase 1

Description of the project

NordBalt project - phase one: investments before 2020. DC interconnector between Lithuania and Sweden and internal investments in Lithuania, Latvia and Sweden. The project will connect the Baltic grid to the Nordic and integrate the Baltic countries with the Nordic electricity market and also increases security of supply.

PCI 4.4.1

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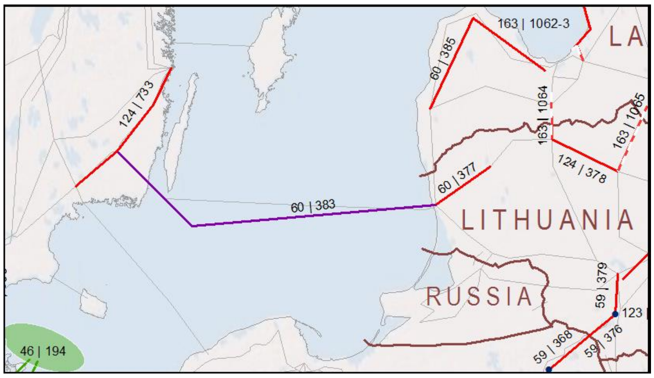

Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
377	Klaipeda (LT)	Telsiai (LT)	New single circuit 330kV OHL (943 MVA, 85km).	600	Under Construction	2014	Investment on time	Progress as planned.
383	Klaipeda (LT)	Nybro (SE)	(NordBalt) A new 300kV HVDC VSC partly subsea and partly underground cable between Lithuania and Sweden	700	Under Construction	2015	Investment on time	Progress as planned.
385	Grobina (LV)	Imanta (LV)	The reinforcement for Latvian grid project with the new 330kV OHL construction and connection to the Riga node. New 330kV OHL construction mainly instead of the existing 110kV double circuit line route, 110kV line will be renovated at the same time and both will be assembled on the same towers. Length 380km, Capacity 800MW	150	Under Construction	2018	Investment on time	The part of reinforcement for Kurzemes ring

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	GTC direction 2 (MW)	B6 Technical Resilience	B7 Flexibility	S1 - protected areas	S2 - urban areas	C1 Estimated cost (Meuros)
LT=>SE: 700	SE=>LT: 700	4	4	Negligible or less than 15km	Negligible or less than 15km	690-1200

CBA results	for each scenario				
Scenario	B1 SoS (MWh/year)	B2 SEW (MEuros/year)	B3 RES integration	B4 Losses (MWh)	B5 CO2 Emissions (kT/year)
Scenario Vision 1 - 2030	-	[16;19]	[18000;22000] MWh	[280000;340000]	[-90;-73]

Scenario Vision 2 - 2030	-	[35;42]	[18000;22000] MWh	[320000;390000]	[1100;1300]
Scenario Vision 3 - 2030	-	[9;12]	[110000;130000] MWh	[140000;170000]	[-650;-530]
Scenario Vision 4 - 2030	-	[180;220]	[110000;130000] MWh	[350000;430000]	[-1400;-1200]

Additional comments

Comment on the security of supply: The project is a key for the SoS of the Baltic states

Comment on the RES integration: The project helps integrating RES, especially in the Baltic states but also in the southern Sweden.

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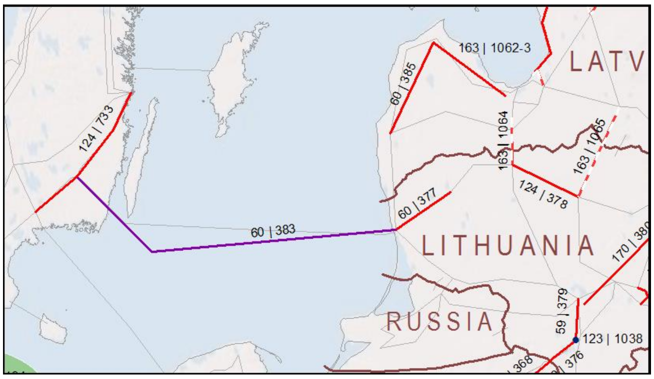
Project 124: NordBalt phase 2

Description of the project

NordBalt - phase two: internal investments after 2020 in Lithuania and Sweden to be able to fully utilize the interconnector between Lithuania and Sweden (project 60) that will connect the Baltic grid to the Nordic and integrate the Baltic countries with the Nordic electricity market.

PCI 4.4.2



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
378	Panevezys (LT)	Musa (LT)	New single circuit 330kV OHL (1080 MVA, 80km).	150	Planning	2022	Rescheduled	Investment 60 is postponed in the new national transmission grid development plan. Construction of new NPP, which has impact to the necessity of this investment is unclear, so priority was taken to the other internal investments needed.
733	Ekhyddan (SE)	Nybro/Hemsjö (SE)	New single circuit 400 kV OHL. A key investment to accomplish full utilization of the NordBalt cable between Lithuania and Sweden (project 60) at all times.	700	Planning	2021	Rescheduled	Thanks to postponement, other internal investments will be commissioned on time. Congestions due to the delay will be handled by investing in a temporary system protection scheme.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	GTC direction 2 (MW)	B6 Technical Resilience	B7 Flexibility	S1 - protected areas	S2 - urban areas	C1 Estimated cost (Meuros)

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LT=>SE: 700	SE=>LT: 700	4	3	NA	NA	170-270

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	0	0	[-23000;-19000]	0
Scenario Vision 2 - 2030	-	0	0	[61000;75000]	0
Scenario Vision 3 - 2030	-	0	0	[83000;100000]	0
Scenario Vision 4 - 2030	-	0	0	[11000;13000]	0

Additional comments

Comment on the GTC: The project will fully utilize the GTC increase of 700 for NordBalt HVDC interconnector and will replace the temporary system protection scheme. The total delta GTC for project 60 and 124 is then 700.

Comment on the security of supply: The project is a key for the SoS of the Baltic states.

Comment on the RES integration: The project helps integrating RES, especially in the Baltic states but also in the southern Sweden.

Comment on the S1 and S2 indicators: The project will have a social and environmental impact but the investments are in an early stage so it's not possible to give any facts regarding the impact

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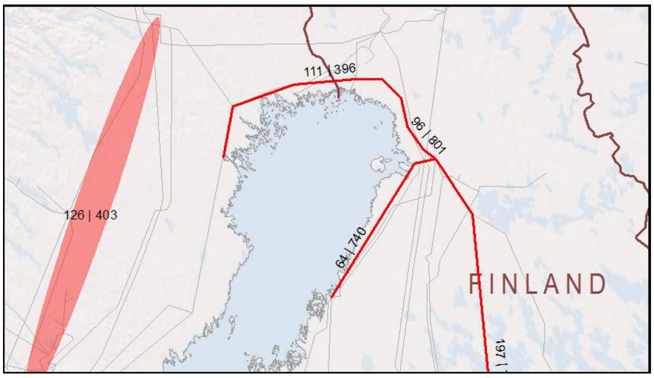
Project 111: 3rd AC Finland-Sweden north

Description of the project

Third AC 400 kV interconnector between Finland north and Sweden SE1. 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.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
396	Finland North (FI)	Sweden bidding area SE1/SE2	Third single circuit 400kV AC OHL between Sweden and Finland	-	Under Consideration	2025	Rescheduled	Rescheduled following a review of priorities and dependencies for all grid reinforcements in Sweden. Thanks to postponement of this investment, other internal investments will be commissioned on time

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
FI=>SE: 500	SE=>FI: 800	6	6	Negligible or less than 15km	Negligible or less than 15km	64-120

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CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[12;15]	[19000;23000] MWh	[230000;280000]	[230;280]
Scenario Vision 2 - 2030	-	[4;5]	[1800;2200] MWh	[210000;250000]	[440;530]
Scenario Vision 3 - 2030	-	[4;5]	[23000;28000] MWh	[110000;130000]	[-48;-39]
Scenario Vision 4 - 2030	-	[54;66]	[54000;66000] MWh	[170000;210000]	[-120;-96]

Additional comments

Comment on the security of supply: The project enhances system security of whole Finnish system, especially during outages on other interconnections between the countries.

Comment on the RES integration: The project helps integrating 500-800 MW wind power in Northern Sweden and Finland and improves the possibilities of balancing the system.

Project 62: Estonia-Latvia 3rd IC

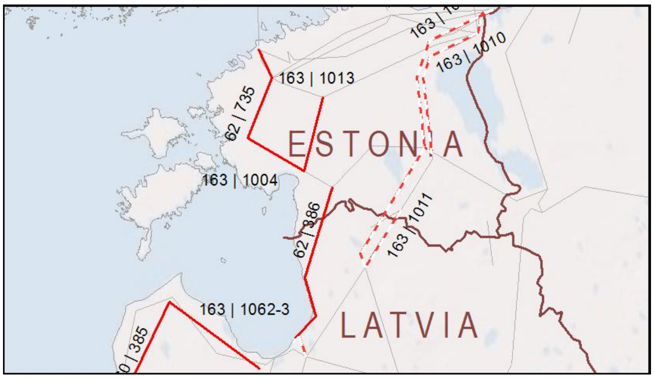
Description of the project

Project nr 62 is a planned third 330 kV interconnection between Estonia and Latvia. The project consists of 2 investments of which nr 386 is the main inter-area investment, AC 330 kV OHL between Kilingi-Nõmme substation in Estonia and TEC2 substation in Latvia. Estonia-Latvia third interconnection associated investment nr 735 AC 330 kV OHL Harku-Lihula-Sindi in Estonian. It increases the capacity between Estonia and Latvia by 600 MW.

The project also helps to improve SoS and contributes to RES increase in the Baltics western coastal areas. The project is also a precondition for construction of off-shore wind parks in Estonia and Latvia.

The Estonia-Latvia third interconnection is the significant project for all the Baltic region, because it will increase competition for electricity market in Baltic States and between Baltic States and Nordic countries. It will provide reliable transmission network corridor will improve interoperability between Baltic states. In addition after commissioning the projects forming the Baltic Energy Interconnection Plan 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.

PCI 4.2



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
386	Kilingi-Nomme (EE)	R-TEC2 (LV)	330 kV AC OHL between Kilingi-Nõmme substation in Estonia and R-TEC2 substation in Latvia. New 330 kV power transmission line is planned to take route along already existing 110 kV power transmission lines, by constructing both 110 kV and 330 kV lines on the same towers. Under the framework of the project it is planned to reconstruct the open-air switchyard of the 330/110 kV substation „TEC-2" by	500	Planning	2020	Investment on time	Progress as planned.

			constructing new open-air connection point for the 330 kV line „Kilingi Nomme-TEC-2”.					
735	Harku (EE)	Sindi (EE)	New double circuit OHL with 2 different voltages 330 kV and 110 kV and with capacity 1200 MVA/240 MVA and a length 140 km. Major part of new internal connection will be established on existing right of way on the western part of Estonian mainland.	250	Design & Permitting	2018	Investment on time	Progress as planned.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
EE=>LV: 450-600	LV=>EE: 450-600	4	4	More than 100km	Negligible or less than 15km	105-195

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[8;9]	[36000;44000] MWh	[53000;65000]	[90;110]
Scenario Vision 2 - 2030	-	[10;13]	[36000;44000] MWh	[91000;110000]	[7;8]
Scenario Vision 3 - 2030	-	[0;1]	[9000;11000] MWh	[-1100;-900]	[-9;-8]
Scenario Vision 4 - 2030	-	[8;9]	[11000;13000] MWh	[11000;13000]	[-31;-26]

Additional comments

Comment on the SEW: The outcome of study shows that the 3rd interconnector between LV-EE is not so beneficial in all four Visions because Visaginas NPP is in operation and caused opposite power flows as it is now. To refer on the last statements of government of Lithuania Visaginas NPP project is very uncertain now and further evolution depends on common decisions made by governments of Baltic States. SEW benefit for this project is strongly influenced by Vision assumptions related specifically to large scale RES integration into the concentrated area inside of Baltics power system and that assumption might not be fully realistic due to the limitation of district heat demand and biofuels availability. Another factor is the assumption of self-sufficient installed generation-consumption balance on country-level. The 3rd interconnector looks less beneficial comparing the indicators of other projects but in reality main bottleneck is on border EE-LV. Special sensitivity cases, especially Baltic Sea Green vision show potential for much higher benefit than highest benefit in studied visions. According to study prepared by RGBS 3rd interconnector improves the resilience and robustness and allows connect high amount of RES.

Due to congestion removal and transfer capacity increase the Project has an impact to socio-economic benefits increase in the whole Baltic Sea region and Central Europe.

Comment on the security of supply: although the CBA calculated value for SoS was 0, other studies show the project improves significantly Security of Supply internally in Estonia and Latvia. Especially on the west south of Estonia and in Latvia capital, Riga area.

Comment on the RES integration: the project enables indirectly to increase up to 1000 MW of RES capacity in the Baltics power system, especially in Estonia and Latvia western coastal areas. The project is also a precondition for construction of off-shore wind parks in Estonia and Latvia.

LitPol

"LitPol" consists of two projects (59, 123), representing its 2 phases spanning from now to 2020, and each adding a 500 MW interconnection capacity.
The LitPol Link Project is an HVDC interconnection between Poland and Lithuania. It removes an energy island by connecting the Baltic States to the Continental Europe and completes Baltic Sea ring.
The assessment of project 123 is complementary to the one presented for project 59.

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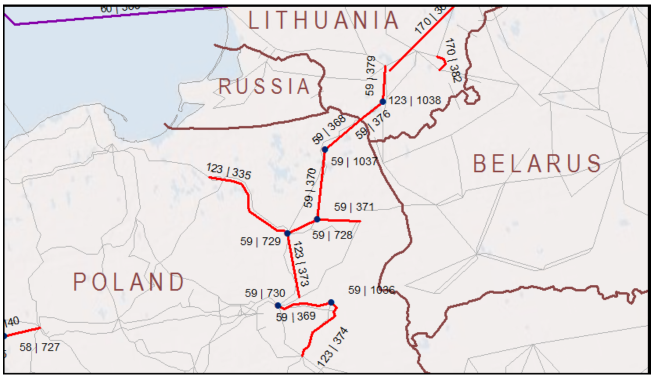
Project 59: LitPol Link Stage 1

Description of the project

The LitPol Link Project is an interconnection between Poland and Lithuania. The first stage of the LitPol Link interconnection project is realized by the construction of new double circuit 400 kV interconnector between Ełk and Alytus together with 500 MW back-to-back convertor station in substation Alytus and strengthening of the internal high voltage transmission grid in Poland and Lithuania in order to utilize the capacity of the interconnection. The capacity increase in first stage is 500 MW (on the direction from Lithuania to Poland; the capacity in opposite direction is curtailed by the limitations of the internal Polish transmission grid) and the expected commissioning date is 2015. The project removes an energy island by connecting the Baltic States to the Continental Europe and completes Baltic Sea ring.

PCI 4.5.1



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
368	Elk (PL)	PL-LT border	Construction of a new 400 kV interconnector line from Ełk to PL-LT border.	400	Under Construction	2015	Investment on time	Progress as planned.
369	Siedlce Ujrzanów (PL)	Milosna (PL)	Construction of new 400 kV line Siedlce Ujrzanów - Miłosna.	100	Under Construction	2015	Investment on time	The project is in the construction phase.
370	Elk (PL)	Lomza (PL)	Construction of new 400 kV line Ełk-Łomża.	400	Under Construction	2015	Investment on time	The project is under construction.
371	Ostroleka (PL)	Narew (PL)	Construction of new 400 kV line Ostrołęka-Łomża-Narew + extension of substation Narew.	400	Under Construction	2015	Investment on time	The project is under construction.
376	Alytus (LT)	PL-LT border	Construction of 500 MW Back-to-Back convertor station near Alytus 330kV substation. Construction of double circuit 400kV OHL between Alytus and PL-LT border (51 km).	500	Under Construction	2015	Investment on time	Progress as planned.
379	Kruonis (LT)	Alytus (LT)	New double circuit 330kV OHL Alytus–Kruonis (2x1080 MVA, 53km).	300	Design & Permitting	2016	Delayed	Several months delay due to difficulties with the acquisition of the land
728	Lomza (PL)		Construction of new substation Łomża to connect the line Ełk-Łomża.	400	Under Construction	2015	Investment on time	The project is under construction.

729	Ostroleka (PL)		A new 400 kV switchgear in existing substation Ostroleka (in two stages) with transformation 400/220kV 500 MVA and with transformation 400/110kV 400 MVA.	400	Under Construction		2015	Investment on time	The project is under construction.
730	Stanislawów (PL)		New substation 400kV Stanisławów will be connected by splitting and extending existing line Miłosna-Narew and Miłosna-Siedlce.	400	Under Construction		2015	Expected earlier than planned previously	In TYNDP 2012 the building of the substation Stanisławów was reported as part of a line Ostrołęka-Stanisławów. The commissioning time has been aligned with the construction of the line Miłosna-Siedlce Ujrzanów which is expected in 2015.
1036	Siedlce Ujrzanów		New Substation Siedlce Ujrzanów will be connected by new line Miłosna-Siedlce Ujrzanów and later by new line Kozienice-Siedlce Ujrzanów	100	Under Construction		2015	Investment on time	The investment was previously included in the investment no. 369 as "new 400 kV switchgear in existing Substation Siedlce". The concept has changed and there is a new substation in a different location.
1037	Elk Bis		New 400/110 kV Substation Ełk Bis connected by two double 400 kV lines Łomża-Ełk and Ełk-Alytus creating an interconnector Poland-Lithuania.	400	Under Construction		2015	Investment on time	The inv. was part of inv. no 370 in TYNDP2012 as "new 400kV switchgear in existing Substation Ełk". The concept has changed, it is not possible to extend the existing substation and there is a new substation in a different location, expected in 2015.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
PL=>LT: 0-0	LT=>PL: 0-500	3	5	50-100km	25-50km	510

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[40;49]	[54000;66000] MWh	[170000;200000]	[-280;-230]
Scenario Vision 2 - 2030	-	[52;63]	[9000;11000] MWh	[200000;240000]	[750;920]
Scenario Vision 3 - 2030	-	[23;28]	[9000;11000] MWh	[-1100000;-890000]	[-2000;-1700]
Scenario Vision 4 - 2030	-	[160;200]	[9000;11000] MWh	[-1100000;-900000]	[-2500;-2000]

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Additional comments

Comment on the RES integration:
The analysis shows that the project helps integrating RES – avoided spillage (equivalent to installed capacity of 5-30 MW, assuming capacity factor of 2000 h/a) in the region of Baltic States and Poland.

Comment on the flexibility indicator: the project appears useful in all visions, depends on a key-investment and interconnects two synchronous areas.

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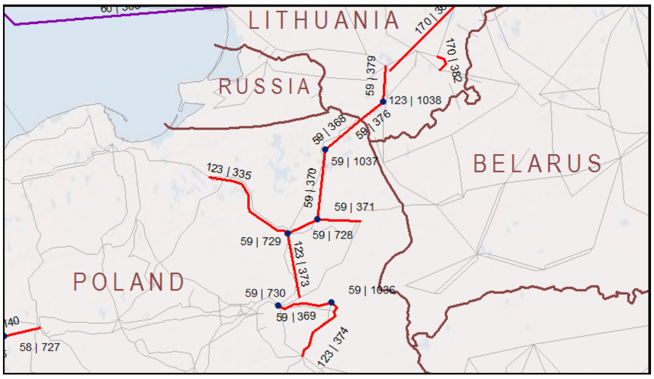
Project 123: LitPol Link Stage 2

Description of the project

The LitPol Link Stage 2 is a continuation of building of the interconnection between Poland and Lithuania in order to achieve the planned transmission capacity of 1000 MW in both directions. Building of additional internal investments in Poland and Lithuania are necessary. In Poland three additional lines will be erected (Ostrołeka-Olsztyn Mątki, Ostrołęka-Stanisławów and Kozienice-Siedlce Ujrzanów). In Lithuania a second 500 MW back-to-back converter station will be built in substation Alytus.

The project improves connection the Baltic States to the Continental Europe and Baltic Sea ring.

PCI 4.5.2 and 4.5.3



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
335	Ostroleka (PL)	Olsztyn Matki (PL)	Construction of new 400 kV line Ostrołęka - Olsztyn Mątki after dismantling of 220kV line Ostrołęka - Olsztyn with one circuit from Ostrołęka to Olsztyn temporarily on 220 kV.	500	Design & Permitting	2017	Investment on time	The investment in on time.
373	Ostroleka (PL)	Stanislawów (PL)	Construction of new 400 kV line Ostrołęka-Stanisławów.	500	Design & Permitting	2020	Investment on time	The project is at the design stage.
374	Kozienice (PL)	Siedlce Ujrzanów (PL)	Construction of new 400 kV line Kozienice-Siedlce Ujrzanów.	300	Design & Permitting	2019	Expected earlier than planned previously	The commissioning date has been adjusted compared to the previous national plan and TYNDP.
1038	Alytus		Construction of the second 500 MW back-to-Back converter station in Alytus	500	Planning	2020	New Investment	This investment was missing not explicitly mentioned in TYNDP 2012, but was already foreseen.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
PL=>LT: 0-1000	LT=>PL: 0-1000	1	5	15-50km	25-50km	310

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[36;45]	[18000;22000] MWh	[190000;230000]	[-350;-290]
Scenario Vision 2 - 2030	-	[32;39]	[18000;22000] MWh	[170000;210000]	[290;360]
Scenario Vision 3 - 2030	-	[36;44]	[27000;33000] MWh	[-670000;-550000]	[-1900;-1600]
Scenario Vision 4 - 2030	-	[150;180]	[27000;33000] MWh	[-290000;-240000]	[-2200;-1800]

Additional comments

Comment on the RES integration:
The analysis shows that the project helps integrating RES – avoided spillage (equivalent to installed capacity of 10-15 MW, assuming capacity factor of 2000 h/a) in the region of Baltic States and Poland.

Comment on the flexibility indicator: LitPol appears useful in all visions, depends on a key-investment and interconnects two synchronous areas.

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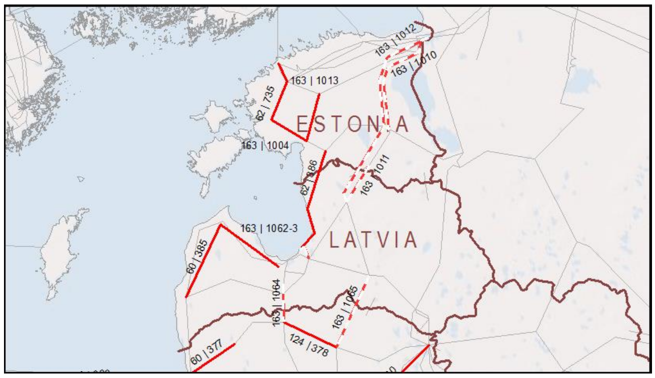
Project 163: BalticCorridor

Description of the project

Baltic corridor project includes several investments to enable the increase of 600MW though the Baltic States starting from North Estonia until Lithuania - Poland border in the south of Baltics. The project is strongly related to Baltic market integration to common European market and enables great new possibilities for large scale RES integration up to 1200MW. Additionally, this project can be considered as an alternative possibility to transfer electricity from North Scandinavia to continental Europe. The investments in this project are also seen as relevant preconditions for synchronous operation of Baltic States with the Continental Europe. So it means the project serves also as a backbone for project Baltics Synchronization with CE (project nr 170).
The project includes reinforcement of existing 330 kV lines internally and on the borders of Baltic States. The new standards of line construction enable significant increase of the line capacity, up to 50%.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1004	Sindi	Paide	Reinforcement of existing 330 kV OHL between Paide and Sindi 330 kV substations in Estonia. Old line will be replaced with new towers and wires of 3x400 mm2 in phase. The thermal capacity of the line is planned 1143 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	200	Planning	2030	New Investment	-
1010	Tartu	Valmiera	Reinforcement of existing 330 kV OHL with new towers and wires of 3x300 mm2 in phase. The thermal capacity of the line is planned 1000 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	200	Under Consideration	2030	New Investment	-
1011	Tsirguliina	Valmiera	Reinforcement of existing 330 kV OHL with new towers and wires of 3x300 mm2 in phase. The thermal capacity of the line	200	Under Consideration	2030	New Investment	-

			is planned 1000 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).					
1012	Balti	Tartu	Reinforcement of existing 330 kV OHL between Balti and Tartu 330 kV substations in Estonia. Old line will be replaced with new towers and wires of 3x400 mm2 in phase. The thermal capacity of the line is planned 1143 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	200	Under Consideration	2030	New Investment	-
1013	Eesti	Tsirguliina	Reinforcement of existing 330 kV OHL between Eesti and Tsirguliina 330 kV substations in Estonia. Old line will be replaced with new towers and wires of 3x400 mm2 in phase. The thermal capacity of the line is planned 1143 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	200	Under Consideration	2030	New Investment	-
1062	TEC2	Salaspils	Internal reinforcement for Baltic Corridor 600 MW	600	Under Consideration	2030	New Investment	-
1063	TEC1	TEC2	Investment is necessary to strengthening internal grid in Latvia due to get transmission capacity of 600 MW via Latvia	600	Under Consideration	2030	New Investment	-
1064	Viskali (LV)	Musa (LT)	To get 600 MW of capacity via Baltic States additionally.	600	Under Consideration	2030	New Investment	-
1065	Aizkraukle (LV)	Panevežys (LT)	To increase transmission capacity by 600 MW via Baltic States	600	Under Consideration	2030	New Investment	-

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 600	South=>North: 600	2	1	More than 100km	More than 50km	120-140

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	0	[36000;44000] MWh	[-59000;-49000]	[60;73]
Scenario Vision 2 - 2030	-	[1;2]	[36000;44000] MWh	[38000;46000]	[-22;-18]
Scenario Vision 3 - 2030	-	[2;3]	0	[18000;22000]	[-69;-56]
Scenario Vision 4 - 2030	-	[3;4]	[54000;66000] MWh	[83000;100000]	[-17;-14]

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Additional comments

Comment on the RES integration: Even the spillage reduction calculations shows relevantly low values the project enables indirectly to increase technical possibilities to connect RES capacity to the Baltics power system around 1200 MW.

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Project 170: Baltics synchro with CE

Description of the project

The PCI project 4.3 Estonia/Latvia/Lithuania synchronous interconnection with the Continental European networks is aimed at infrastructure development for deeper market integration and synchronous operation of the power systems of the Baltic States with the Continental European networks.

Two different landing points and two differently routed interconnections are required to achieve physical separation of the two redundant interconnections in order to establish a reliable synchronous connection between the transmission systems of Baltic States and Continental Europe networks. The first Lithuania – Poland connection (LitPol Link) is already decided and it will be the first connection. The second connection is still under investigation.

The projects consists mainly of the 330-400 kV cross-border lines and internal lines in order to reinforce internal grids to handle the situation.

Baltics synchronization with EU is unique project as main driver for it is not to increase GTC but to disconnect from Russia system and connect with Continental European networks synchronously.

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
380	Visaginas (LT)	Kruonis (LT)	New single circuit 330kV OHL (1080 MVA, 200km) for the internal grid reinforcement.	150	Under Consideration	2022	Rescheduled	Investment depending on Visaginas NPP construction time.
382	Vilnius (LT)	Neris (LT)	New single circuit 330kV OHL (943 MVA, 50km).	150	Planning	2022	Rescheduled	Investment 61 is postponed in the new national transmission grid development plan. Construction of new NPPP is unclear, so priority was taken to the other internal investments needed.
1034	Substation in Lithuania	State border	400 kV interconnection line for synchronous interconnection of Baltics	600	Under Consideration	2023	New Investment	-

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 600	South=>North: 600	2	4	NA	NA	96-100

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[26;31]	0	0	[-340;-280]
Scenario Vision 2 - 2030	-	[12;15]	0	0	[86;110]
Scenario Vision 3 - 2030	-	[34;41]	0	0	[-2600;-2100]
Scenario Vision 4 - 2030	-	[120;140]	[54000;66000] MWh	0	[-2000;-1700]

Additional comments

Comment on the CBA assessment: During 2012-2013, Lithuanian, Latvian and Estonian TSOs carried out the Feasibility study “Interconnection Variants for the Integration of the Baltic States to the EU Internal Electricity Market“ to evaluate the possible technical and economic consequences and benefits of synchronizing power systems of Baltics within synchronous area of Continental Europe. The study was prepared by Gothia Power Company.

The list of investments is not final and is very preliminary including just a few of probable necessary investments.

Only SEW was analysed via simplified capacity increase approach and no grid studies were performed in this stage as the exact route and investments are not decided yet.

Comment on the RES integration: avoided spillage in Vision 4 concerns RES in the whole Baltic area.

Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

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Project 58: GerPol Power Bridge

Description of the project

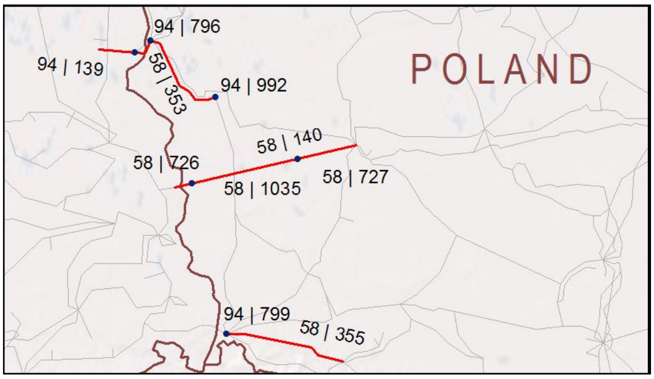
The construction of a new (third) interconnection between Polish and German power systems includes the construction of the interconnector between Eisenhuetenstadt and Plewiska as well as two internal lines (Mikułowa-Świebodzice and Krajnik -Baczyna) and substations Plewiska BIS, Gubin and Zielona Góra to connect the new line in the Polish transmission system and contributes to the following:

• increase of market integration between member states - additional NTC of 1500 import and 500 MW export on PL-DE/SK/CZ synchronous profile;

• integration of additional Renewable Energy Sources on the area of western and north-western Poland as well as eastern part of Germany;

• improving network security - project contributes to increase of security of supply and flexibility of the transmission network (security of supply of Poznań agglomeration area).

PCI 3.14



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
140	Eisenhüttenstadt (DE)	Plewiska (PL)	Construction of new 400 kV double circuit line Plewiska (PL)-Eisenhüttenstadt (DE) creating an interconnector between Poland and Germany.	800	Planning	2030	Rescheduled	Change of the commissioning date – see comment in the next page
353	Krajnik (PL)	Baczyna (PL)	Construction of new 400 kV double circuit line Krajnik – Baczyna.	400	Planning	2020	Investment on time	Investment is in the tendering procedure.
355	Mikulowa (PL)	Swiebodzice (PL)	Construction of new 400 kV double circuit line Mikułowa-Świebodzice in place of existing 220 kV line.	400	Planning	2020	Investment on time	Investment on time.
726	Gubin (PL)		New 400 kV substation Gubin located near the PL-DE border. The substation will be connected by the new line Plewiska (PL)-	800	Planning	2030	Rescheduled	Change of the commissioning date as the investment is correlated with the investment 140

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			Eisenhüttenstadt (DE).					
727	Plewiska (PL)		Construction of new substation Plewiska Bis (PL) to connect the new line Plewiska (PL)-Eisenhüttenstadt (DE).	800	Planning	2020	Investment on time	The project is at the planning stage.
1035	Baczyna		Construction of new 400/220 kV Substation Baczyna to connect the new line Krajnik-Baczyna.	400	Planning	2018	Investment on time	The investment was part of n°58.353 in TYNDP 2012 and is now presented stand alone. It is in the tendering procedure (design and build scheme).

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
PL=>DE: 0-500	DE=>PL: 0-1500	1	4	15-50km	Negligible or less than 15km	390-400

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[69;84]	0	[-170000;-140000]	[760;930]
Scenario Vision 2 - 2030	-	[67;82]	0	[-160000;-130000]	[1000;1200]
Scenario Vision 3 - 2030	-	[99;120]	[300000;370000] MWh	[-770000;-630000]	[-81;-66]
Scenario Vision 4 - 2030	-	[98;120]	[650000;800000] MWh	[-910000;-740000]	[87;110]

Additional comments

Comment on the RES integration:
The project, depending on the vision, helps integrating RES in the region of north-west Poland as well as eastern part of Germany.

The analysis evaluating the effectiveness of the construction of the third interconnection with German power system was performed, which took into account the assessment of the technical conditions of the existing highest voltage lines, system conditions as well as domestic needs in the area of transmission network expansion and the need to increase the import capacity.
The analysis was performed using current internal forecasts in terms of demand for power and energy in the Polish Power System, including the assessment of the ability to balance the demand for power by generation sources (conventional and RES) located in the north-western part of the country.
The assessment took into account the intention to improve conditions of the cross-border power exchange over synchronous cross-section considering the installation of phase shifting transformers (PSTs) on the Mikułowa-Hagenwerder and Krajnik-Vierraden interconnection lines, and the planned

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upgrade of Krajnik-Vierraden line to 400 kV.
The results of PSE's analysis show that it is possible to achieve the increase of cross border capacity to 1800-2000 MW with a different approach.
The reinforcements in the internal Polish transmission network, which prove necessary despite the cross border capacity increase needs, yield comparable results with significantly lower costs.
The proposed reinforcements include:

- 2x400 kV line Krajnik-Baczyna (planned currently)
- 2x400 kV line Mikułowa-Świebodzice (planned currently)
- Rebuilding of existing single 400 kV line Mikułowa-Pasikurowice to 2x400 kV (internal replacement)
- 2x400 kV line Baczyna-Plewiska (instead of Eisenhüttenstadt-Plewiska)

Based on the above described conditions PSE and 50Hertz intend to concentrate in a first step on the proposed reinforcements and to consider the construction of the third interconnection line between Poland and Germany in a second step, in 2030 as the earliest date.
The decision on the construction of the third interconnection will be taken after the internal infrastructure development has been completed and after the evaluation of the needs for further development has been performed.

When the project was assessed with the CBA during the TYNDP 2014 assessment phase, the CBA clustering rules were respected. This was reflected in the draft TYNDP 2014 for consultation published in July 2014. Given the changes above-mentioned the project now does not fulfil anymore the CBA clustering rules.

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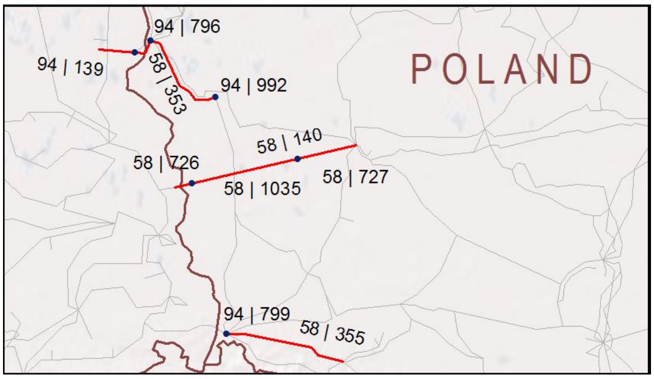
Project 94: GerPol Improvements

Description of the project

Upgrade of the existing 220 kV double interconnection line between Krajnik and Vierraden to 400 kV double line in the same direction together with installation of Phase Shifting Transformers on two existing interconnection lines (Krajnik-Vierraden by 50Hertz Transmission GmbH in Vierraden and Mikułowa-Hagenverder by PSE S.A. in Mikułowa) on the PL/DE border including an upgrade of substations Vierraden, Krajnik and Mikułowa contribute to the following:

• decreasing of unscheduled flow from Germany to Poland, Poland to Czech Republic and Poland to Slovakia by increasing of controllability on entire synchronous profile;
• enhancement of market capacity on Polish synchronous profile - PL/DE as well as PL-CZ/SK border in case of both import and export. The project provides additional capacity (NTC – Net Transfer Capability) of 500 MW in terms of import and 1500 MW export; greater level of safety and reliability of operation of the transmission network in Poland due to enhanced control of power flow.

PCI 3.15



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
139	Vierraden (DE)	Krajnik (PL)	Upgrade of existing 220 kV line Vierraden-Krajnik to double circuit 400 kV OHL.	1500	Design & Permitting	2017	Investment on time	A delay in the permit process for the line Neuenhagen-Bertikow-Vierraden (DE) as a prerequisite caused an adaptation in the time schedule for the line between Vierraden and Krajnik from to 2017.
796	Krajnik (PL)		Upgrade of 400/220 kV switchgear in substation Krajnik (new 400/220 kV switchyard).	1500	Design & Permitting	2017	Delayed	The commissioning time of the investment has been aligned with the schedule for the investment 139.
799	Mikulowa (PL)		Installation of new Phase Shift Transformer in substation Mikułowa and the upgrade of substation Mikułowa for the purpose of PST installation.	1500	Design & Permitting	2015	Delayed	Investment postponed because of prolongation of the tendering process. Due to complexity of the technical solutions more time is needed for the tendering procedure.

992	Vierraden		Installation of new PSTs in Vierraden	1500	Planning	2016	New Investment	Based on a common agreement between PSE and 50Hertz the investment was specified in more detail in close cooperation between PSE and 50Hertz. The common solution consists of PST in Vierraden (DE) and PST in Mikułowa (PL) Investment 799.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
PL=>DE: 0-1500	DE=>PL: 0-500	2	3	Negligible or less than 15km	Negligible or less than 15km	150

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[250;300]	[110000;130000] MWh	[-60000;-49000]	[2000;2400]
Scenario Vision 2 - 2030	-	[240;300]	[41000;50000] MWh	[-49000;-40000]	[2800;3400]
Scenario Vision 3 - 2030	-	[75;92]	[130000;160000] MWh	[-140000;-110000]	[1300;1600]
Scenario Vision 4 - 2030	-	[270;330]	[800000;970000] MWh	[-190000;-150000]	[50;61]

Additional comments

Comment on the security of supply:
By improving the control over the unscheduled flows, which in certain conditions cause severe overload of the system elements, the project has a positive impact on Security of Supply in the region of north-west and south-west Poland as well as eastern part of Germany.

Comment on the RES integration:
The project, depending on the vision, helps integrating RES in the region of north-west Poland as well as eastern part of Germany.

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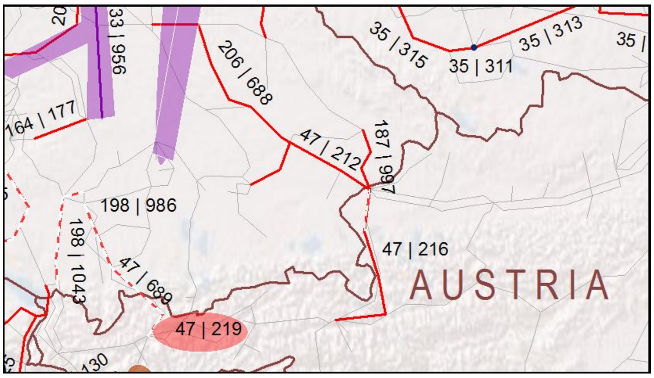
Project 47: AT - DE

Description of the project

This project reinforces the interconnection capacity between Austria and Germany. The national investments comprised are a precondition to achieve the full benefit of the cross border investments and are vital for the Austrian security of supply (e.g. part of the Austrian 380-kV-Security Ring). It supports the interaction of RES in Northern Europe (mainly in Germany) and in the eastern part of Austria with the pump storages in the Austrian Alps and therewith facilitates their utilisation.

PCI 2.1, 3.1.1 and 3.1.2



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
212	Isar (DE)	St. Peter (AT)	New 400kV double circuit OHL Isar - St. Peter including new 400kV switchgears Altheim, Pirach, Simbach and St. Peter. Also including 4. circuit on line Ottenhofen - Isar.	2320	Design & Permitting	2018	Delayed	delayed due to long permitting process
216	St. Peter (AT)	Tauern (AT)	Completion of the 380kV-line St. Peter - Tauern. This contains an upgrade of the existing 380kV-line St. Peter - Salzburg from 220kV-operation to 380kV-operation and the erection of a new internal double circuit 380kV-line connecting the substations Salzburg and Tauern (replacement of existing 220kV-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.	1740	Design & Permitting	2020	Investment on time	In Sept. 2012 the application for granting the permission (EIA) was submitted to the relevant authorities. According to the experience of similar projects the commissioning is expected for 2020.
219	Westtirol (AT)	Zell-Ziller (AT)	Upgrade of the existing 220kV-line Westtirol - Zell-Ziller and erection of an additional 220/380kV-Transformer. Line length: 105km.	470	Planning	2021	Investment on time	The upgrade of the line and substation Westtirol is currently in the planning process.
689	Vöhringen (DE)	Westtirol (AT)	Upgrade of an existing overhead line to 380 kV, extension of existing and	585	Planning	2020	Investment on time	Progress as planned.

			erecting of new 380-kV-substations including 380/110-kV-transformers. Transmission route Vöhringen (DE) - Westtirol (AT). This project will increase the current power exchange capacity between the DE, AT.					

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DE=>AT: 2900	AT=>DE: 2900	1	4	15-50km	15-25km	830-1400

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[53;64]	0	[-450000;-370000]	[530;650]
Scenario Vision 2 - 2030	-	[110;140]	0	[-420000;-340000]	[390;480]
Scenario Vision 3 - 2030	-	[310;380]	[300000;360000] MWh	[-330000;-270000]	[-1500;-1300]
Scenario Vision 4 - 2030	-	[470;490]	[690000;850000] MWh	[-300000;-330000]	[-1300;-1500]

Additional comments

Comment on the security of supply:
The security of supply (SoS) indicator is to be understood in the way it is defined within the Cost Benefit Analysis methodology which focuses merely on the connection of partly isolated grid areas. In general in rather meshed parts of the transmission grids other aspects are more significant for the security of supply (e.g. n-1-margin, cascade effects, etc.) and therefore the project benefit indicator on SoS according to the CBA methodology underestimates the real value of the project. The considered project is vital for the Austrian SoS. It comprise an important part of the Austrian 380-kV-Security Ring, enforces the east-west connection in Tyrol and improves the connection to distribution grids.

Comment on the RES integration:
The project supports the interaction of RES in Northern Europe (mainly in Germany) and in the eastern part of Austria with the pump storages in the Austrian Alps and therewith facilitates their utilisation.

Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES (by bringing it to load centres or to and from storage facilities)

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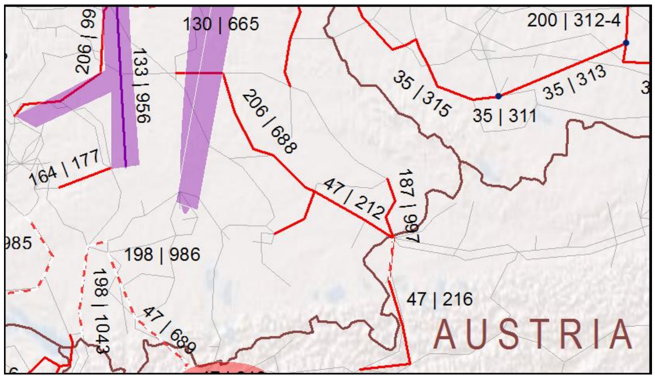
Project 187: St. Peter - Pleinting

Description of the project

Increase of the cross border transmission capacity by erecting a new 380kV line between St. Peter (Austria) and Pleinting (Germany). This leads to an improved connection of the very high amount of RES in Germany and the pump storages in the Austrian Alps.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
997	Pleinting (DE)	St. Peter (AT)	new 380-kV-line Pleinting (DE) - St. Peter (AT) on existing OHL corridor	-	Under Consideration	2022	New Investment	new investment

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
AT=>DE: 1500	DE=>AT: 1500	1	3	Negligible or less than 15km	Negligible or less than 15km	130-190

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[13;16]	0	[-79000;-65000]	[140;170]
Scenario Vision 2 - 2030	-	[15;18]	[4400;5400] MWh	[-83000;-68000]	[560;680]
Scenario Vision 3 - 2030	-	[100;130]	[140000;170000] MWh	[-88000;-72000]	[-520;-420]
Scenario Vision 4 - 2030	-	[190;230]	[220000;260000] MWh	[-110000;-90000]	[-720;-590]

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Additional comments

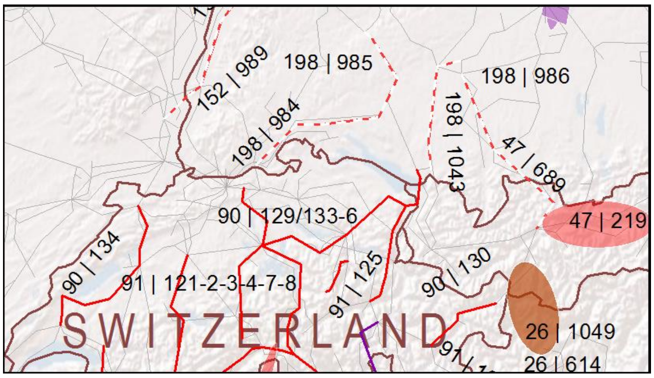
Comment on the RES integration:
The project supports the interaction of RES in Northern Europe (mainly in Germany) and in the eastern part of Austria with the pump storages in the Austrian Alps and therewith facilitates their utilisation.

Project 198: Area of Lake Constance

Description of the project

The transmission capacity of the 380-kV-grid in this grid area and especially the cross-border lines between Germany and Austria are extended significantly by this project. Capacity overloads with existing lines are eliminated and therefore connection between the German and the Austrian transportation grid is strengthened.

PCI 2.11.2



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
136	Border area (DE-AT)	Rüthi (CH)	380 kV Rüthi – Meiningen and 380 kV Meiningen - Border Area AT-DE	1200	Planning	2022	Investment on time	Investment 136 now comprises the cross-border part of former investment 136, and investment 1099 is the Swiss part of former investment 136.
984	Herbertingen	Tiengen	Herbertingen – Tiengen: Between the two substations Herbertingen and Tiengen a new line will be constructed in an existing corridor. Enhancement of the grid, which will increase transmission capacity noticeably, is needed at the substation Herbertingen.	400	Planning	2020	Investment on time	Progress as planned. This project is a concretion of TYNDP12 project 44.A77. Due to the ongoing planning stage, this section was developed and an own investment item was created.
985	point Rommelsbach	Herbertingen	Rommelsbach – Herbertingen: Between point Rommelsbach and substation Herbertingen a new line will be constructed in an existing corridor. This will significantly increase transmission capacity (grid enhancement).	400	Planning	2018	Investment on time	Progress as planned. This project is a concretion of TYNDP12 project 44.A77. Due to the ongoing planning stage, this section was developed and an own investment item was created.
986	point Wullenstetten (DE)	point Niederwangen (DE)	Point Wullenstetten – Point Niederwangen Between point Wullenstetten and point Niederwangen an upgrade of an	2000	Planning	2020	Investment on time	This project is a concretion of TYNDP 2012 project 44.A77. Due to the ongoing

			existing 380-kV-line is necessary (grid enhancement). Thereby, a significantly higher transmission capacity is realized. The 380 kV substation station Dellmensingen is due to be extended (grid enhancement).					planning stage, this section was developed and an own investment item was created.
1043	Neuravensburg	border area (AT)	Point Neuravensburg – Point Austrian National border (AT) Between switching point Neuravensburg and Austrian National border (AT) a new line with a significantly higher transmission capacity will be constructed in an existing corridor (grid enhancement).	2000	Planning	2023	Investment on time	This project is a concretion of TYNDP 2012 project 44.A77. This investment is caused by the investment 136 "Bodensee Studie". Due to the ongoing planning stage, this section was developed and an own investment item was created.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DE=>CH: 3400	CH=>DE: 1400	1	4	50-100km	Negligible or less than 15km	390-530

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[90;110]	0	[-99000;-81000]	[820;1000]
Scenario Vision 2 - 2030	-	[140;170]	0	[-140000;-110000]	[1900;2400]
Scenario Vision 3 - 2030	-	[310;380]	[450000;550000] MWh	[-91000;-75000]	[-1200;-950]
Scenario Vision 4 - 2030	-	[480;580]	[900000;1100000] MWh	[-180000;-150000]	[-2100;-1700]

Additional comments

Comment on the clustering: the project also takes advantage of investment items n°1100, depicted in the Regional investment plan.

Comment on the RES integration: avoided spillage concerns RES in Germany mostly.

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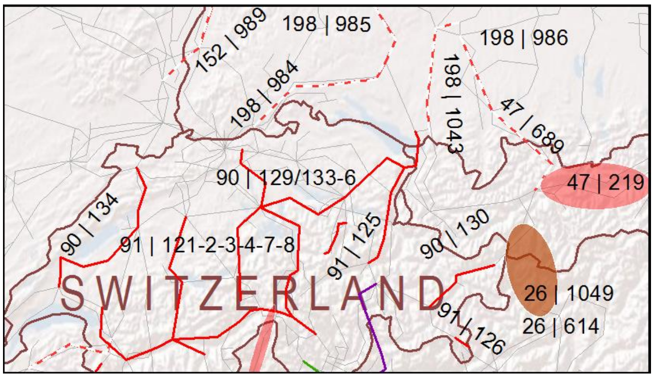
Project 90: Swiss Roof

Description of the project

This project increases the capacity between CH and its neighbours DE and AT. This enables to connect large renewable generation in Northern Europe to pump storage devices in the Alps, thus noticeably increasing the mutual balancing between both regions. Project 90 is completed by Project 198.

PCI 2.11.1



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
129	Beznau (CH)	Mettlen (CH)	Upgrade of the existing 65km double circuit 220kV OHL to 400kV.	800	Design & Permitting	2020	Delayed	Long permitting procedure (comprising several phases). In this case, Federal Court decision for partial cabling.
130	La Punt (CH)	Pradella / Ova Spin (CH)	Installation of the second circuit on existing towers of a double-circuit 400kV OHL (50km).	650	Planning	2017	Investment on time	Progress as planned.
133	Bonaduz (CH)	Mettlen (CH)	Upgrade of the existing 180km double circuit 220kV OHL into 400kV.	340	Under Consideration	2020	Investment on time	Progress as planned.
134	Bassecourt (CH)	Romanel (CH)	Construction of different new 400kV line sections and voltage upgrade of existing 225kV lines into 400kV lines; total length: 140km. Construction of a new 400/220 kV substation in Mühleberg (= former investment 132 'Mühleberg Substation')	660	Design & Permitting	2020	Delayed	lines: long permitting procedure (comprising several phases)- Mühleberg substation: under construction
136	Border area (DE-AT)	Rüthi (CH)	380 kV Rüthi – Meiningen and 380 kV Meiningen - Border Area AT-DE	1200	Planning	2022	Investment on time	Investment 136 now comprises the cross-border part of former investment 136, and investment 1099 is the Swiss part of former investment 136.

1099	Rüthi	Bonaduz - Grynau	Rüthi - Grynau 2 x 380 kV Rüthi - Bonaduz 1 x 380 kV	1200	Planning	2022	Investment on time	Investment 136 now comprises the cross-border part of former investment 136, and investment 1099 is the Swiss part of former investment 136.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
upstream=>upstream: 0	upstream=>upstream: 0	1	4	Negligible or less than 15km	Negligible or less than 15km	490

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[90;110]	0	[-200000;-160000]	[820;1000]
Scenario Vision 2 - 2030	-	[140;170]	0	[-270000;-220000]	[1900;2400]
Scenario Vision 3 - 2030	-	[310;380]	[450000;550000] MWh	[-180000;-150000]	[-1200;-950]
Scenario Vision 4 - 2030	-	[480;580]	[900000;1100000] MWh	[-360000;-300000]	[-2100;-1700]

Additional comments

Comment on the GTC:
GTC increases, Vision 1, 2, 3 and 4 2030

DE>CH: 3400 MW
AT>CH: 1000 MW
CH>DE: 1400 MW
CH>AT: 1000 MW

Comment on the RES integration: avoided spillage concerns RES in Germany mostly

Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES (by bringing it to load centres or to and from storage facilities)

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German Offshore wind parks connection

This section presents alongside the 5 projects (42, 191, 192, 129, 46) foreseen for direct connection of offshore wind park, the first four in the North Sea, the fifth in the Baltic Sea.
Each project has been independently assessed.

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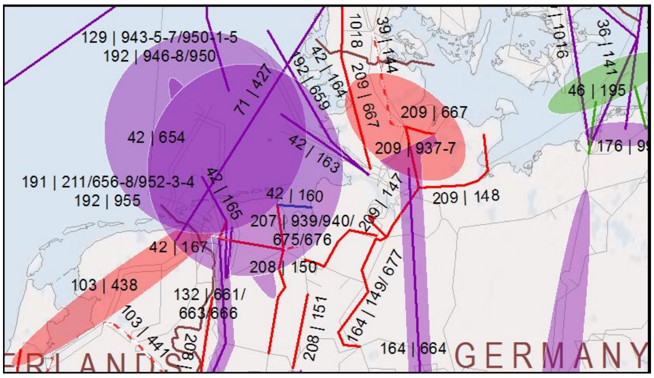
Project 42: OWP TenneT Northsea part 1

Description of the project

Germany is planning to build a big amount of offshore wind power plants in the Northsea. The OWP will help to reach the European goal of CO2 reduction and RES integration. This project is for the connection of the OWP with the German grid.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
160	Offshore-Wind park Nordergründe (DE)	Inhausen (DE)	New AC-cable connection with a total length of 32km.	111	Under Construction	2016	Delayed	Delay due delay of wind farms
163	Cluster HelWin1 (DE)	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 133km. Line capacity: aprox. 576 MW.	576	Under Construction	2014	Investment on time	Progress as planned.
164	Cluster SylWin1 (DE)	Büttel (DE)	New line consisting of underground +subsea cable with a total length of 206 km. Line capacity: aprox.864MW.	864	Under Construction	2015	Delayed	
165	Cluster DolWin1 (DE)	Dörpen/West (DE)	New line consisting of underground +subsea cable with a total length of 167 km. Line capacity: 800MW.	800	Under Construction	2014	Delayed	
167	Cluster BorWin2 (DE)	Diele (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205km. Line capacity: 800MW.	800	Under Construction	2015	Delayed	
654	Cluster DolWin2 (DE)	Dörpen/West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 138 km. Line capacity: 900 MW	900	Under Construction	2015	Investment on time	Progress as planned.
655	Cluster DolWin3 (DE)	Dörpen/West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 162 km. Line capacity: 900 MW	900	Under Construction	2017	Investment on time	Progress as planned.

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657	Cluster HelWin2	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 133 km. Line capacity: 690 MW	690	Under Construction	2015	Investment on time	Progress as planned.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 5750	South=>North: 5750	2	3	More than 100km	Negligible or less than 15km	6000-8000

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[1300;1600]	4033 MW	0	[-13000;-11000]
Scenario Vision 2 - 2030	-	[620;760]	4033 MW	0	[-8500;-7000]
Scenario Vision 3 - 2030	-	[1900;2300]	5748 MW	0	[-10000;-8400]
Scenario Vision 4 - 2030	-	[1600;2000]	5748 MW	0	[-8900;-7300]

Additional comments

Comment on the clustering: for the sake of consistency, and by exception to the rule, the project has been assessed including two investment items connecting wind farms for 111 MW and 108 MW, the latter being commissioned, hence not matching the clustering rule requiring each investment to contribute to more than 20% of the major investment of the project

Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

Comment on the Losses indicator: the losses variation for this direct connection project have not been valued.

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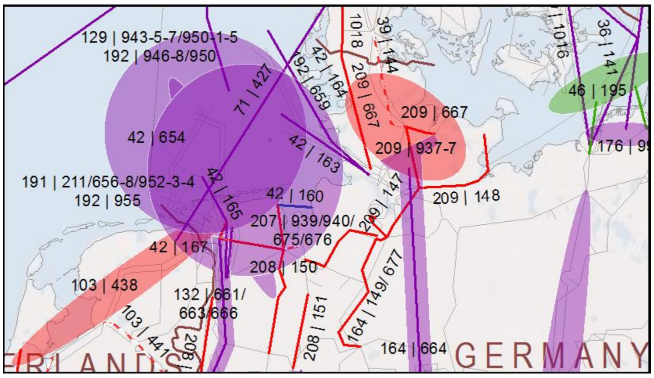
Project 191: OWP TenneT Northsea Part 2

Description of the project

Germany is planning to build a big amount of wind offshore power plants in the Northsea. The OWP will help to reach the European goal of CO2 reduction and RES integration. This project is for the connection of the OWP with the German grid.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
211	Cluster DolWin 4 (NOR 3-2)	Unterweser	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 190km. Line capacity: 900 MW	900	Under Consideration	2020	Investment on time	Progress as planned.
656	Cluster BorWin3	Emden/Ost (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 160 km. Line capacity: 900 MW	900	Design & Permitting	2018	Investment on time	Progress as planned.
658	Cluster BorWin4 (DE)	Emden/Ost (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 172 km. Line capacity: 900 MW	900	Design & Permitting	2019	Investment on time	Progress as planned.
952	Cluster DolWin 5 (NOR-1-1)	Halbemond	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 250 km. Line capacity: 900 MW	900	Under Consideration	2021	New Investment	new investment
953	Cluster DolWin 6 (NOR-3-3)	Halbemond	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 60km. Line capacity: 900 MW	900	Under Consideration	2021	New Investment	new investment
954	Cluster BorWin 5 (NOR-7-1)	Halbemond	Connecton of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 260km. Line capacity: 900 MW	900	Under Consideration	2022	New Investment	new investment

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CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
inside=>DE: 5400	DE=>inside: 5400	4	3	More than 100km	Negligible or less than 15km	8000-10000

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[520;640]	3788 MW	0	[-6200;-5100]
Scenario Vision 2 - 2030	-	[330;400]	3788 MW	0	[-5600;-4500]
Scenario Vision 3 - 2030	-	[1700;2100]	5401 MW	0	[-9400;-7700]
Scenario Vision 4 - 2030	-	[1500;1900]	[5300;5500] MW	0	[-8700;-7100]

Additional comments

Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

Comment on the Losses indicator: the losses variation for this direct connection project have not been valued

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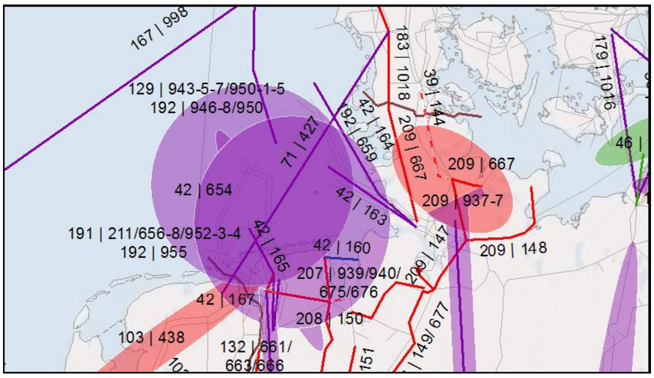
Project 192: OWP Northsea TenneT Part 3

Description of the project

Germany is planning to build a big amount of wind offshore power plants in the Northsea. The OWP will help to reach the European goal of CO2 reduction and RES integration. This project is for the connection of the OWP with the German grid. This project becomes necessary in case of further long-term strong increase in OWP generation like in Vision 3 and 4. The project is not in focus of Vision 1 and 2.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
659	Cluster SylWin2 (DE)	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205 km. Line capacity: 900 MW	900	Under Consideration	2023	Investment on time	Progress as planned.
946	NOR-11-1	Elsfleth/West	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 230km. Line capacity: 900 MW	900	Under Consideration	2026	New Investment	new investment
948	NOR-12-1	Wilhelmshafen	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 230km. Line capacity: 900 MW	900	Under Consideration	2027	New Investment	new investment
950	NOR-13-1	Kreis Segeberg	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 330km. Line capacity: 900 MW	900	Under Consideration	2025	New Investment	new investment
955	Cluster BorWin6 (NOR-7-2)	Unterweser	Connection of new offshore wind parks.New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 180km. Line capacity: 900 MW	900	Under Consideration	2023	New Investment	new investment

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CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
inside=>DE: 4500	DE=>inside: 4500	4	3	More than 100km	Negligible or less than 15km	5500-9500

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 3 - 2030	-	[1400;1700]	4499 MW	0	[-7400;-6000]
Scenario Vision 4 - 2030	-	[1100;1400]	[4400;4600] MW	0	[-6100;-5000]

Additional comments

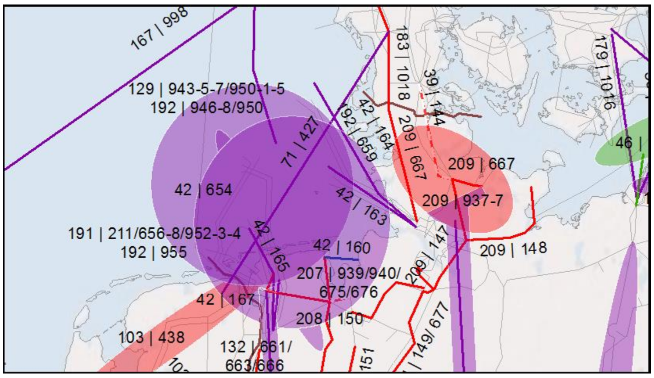
Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

Comment on the S1 and S2 indicators: „Detailed values for most lines are not available due to the early state in the planning process“

Project 129: OWP Northsea TenneT Part 4

Description of the project

Germany is planning to build a big amount of wind offshore power plants in the Northsea. The OWP will help to reach the European goal of CO2 reduction and RES integration. This project is for the connection of the OWP with the German grid. This project becomes necessary in case of further long-term strong increase in OWP generation like in Vision 3 and 4. The project is not in focus of Vision 1 and 2.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
943	NOR-9-1	Cloppenburg	Connection of new offshore wind park. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 255 km. Line capacity: 900 MW	900	Under Consideration	2028	New Investment	new investment
945	NOR-10-1	Cloppenburg	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 260km. Line capacity: 900 MW	900	Under Consideration	2029	New Investment	new investment
947	NOR-11-2	Wilhelmshafen	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 270km. Line capacity: 900 MW	900	Under Consideration	2031	New Investment	new investment
951	NOR-13-2	Kreis Segeberg	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 330km. Line capacity: 900 MW	900	Under Consideration	2030	New Investment	new investment

CBA results

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The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
inside=>DE: 3600	DE=>inside: 3600	2	3	More than 100km	Negligible or less than 15km	4000-8000

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 3 - 2030	-	[900;1100]	3074 MW	0	[-4900;-4000]
Scenario Vision 4 - 2030	-	[770;940]	3074 MW	0	[-4300;-3500]

Additional comments

Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

Comment on the Losses indicator: the losses variation for this direct connection project have not been valuated.

Comment on the S1 and S2 indicators: Detailed values for most lines are not available due to the early state in the planning process

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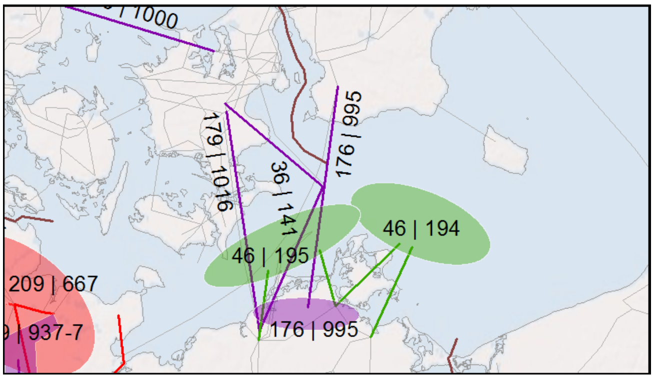
Project 46: Offshore Wind Baltic Sea

Description of the project

Grid connections of offshore wind farms (using AC-technology), connecting offshore wind farms in the Baltic Sea to the German transmission grid in Bentwisch, Lüdershagen and Lubmin. According to German law, the grid connection has to be constructed and operated by the TSO (50Hertz Transmission).



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
194	OWF Cluster Baltic Sea East (DE)	Lüdershagen/Lubmin (DE)	Grid Connection of offshore wind farms (using AC-technology). According to German law, the grid connection has to be constructed and operated by the TSO (50Hertz Transmission).	3000	Design & Permitting	2031	Investment on time	The investment is split into different stages with different commissioning dates (starting in 2017) depending on the predicted installed capacity of offshore wind. For further informations see the national "Offshore Grid Development Plan"
195	wind farm cluster Baltic Sea West (DE)	Bentwisch/Lüdershagen (DE)	Grid Connection of offshore wind farms (using AC-technology). According to German law, the grid connection has to be constructed and operated by the TSO (50Hertz Transmission).	1500	Design & Permitting	2032	Investment on time	The investment is split into different stages with different commissioning dates (starting in 2026) depending on the predicted installed capacity of offshore wind. For further informations see the national "Offshore Grid Development Plan"

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 4500	South=>North: 4500	0	3	NA	NA	1700-4500

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[300;360]	1568 MW	0	[-3300;-2700]
Scenario Vision 2 - 2030	-	[210;250]	1568 MW	0	[-3000;-2400]
Scenario Vision 3 - 2030	-	[1300;1600]	4342 MW	0	[-7300;-6000]
Scenario Vision 4 - 2030	-	[1100;1400]	4342 MW	0	[-6400;-5200]

Additional comments

Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

Comment on the Losses indicator: the losses variation for this direct connection project have not been valuated.

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North South Eastern German Corridor

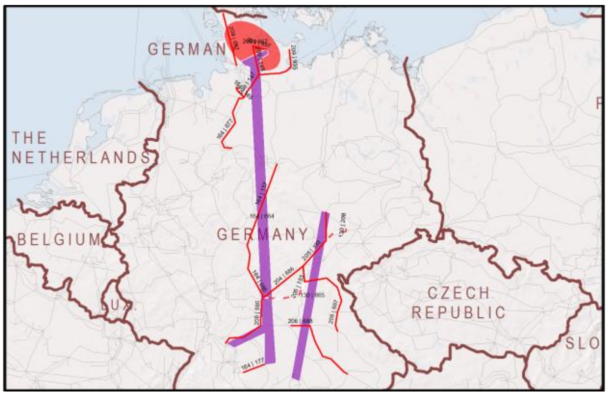
Description of the corridor

This corridor is necessary, due to the strong increase in RES generation, meeting the goals of the European and especially German energy policy. It connects 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. This 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).The corridor ends 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). Thus, the corridor is an essential element for the integration of renewable energy sources into the German power system and the provision of additional transmission capacities in order to meet the increasing demand of the European electricity market and to avoid unscheduled transit flows to neighboring countries. Moreover, due to the nuclear phase out in Germany, the amount of reliable available capacity in southern Germany decreases and the security of supply of this area require additional transmission capacity to areas with conventional generation units.

The corridor consists of 6 projects:

- project 209 groups all investments needed to collect wind in-feed north east of Germany;
- project 130 and 164 represents the 2 sections of new HVDC lines aiming at transporting this power to the south of the country;
- project 206 groups all investments needed to secure the supply south of Germany in this corridor;
- projects 205 (resp. 204) group all supporting measures on existing assets in the short (resp; longer) term.

Working together, the six projects have been assessed as a whole and share the same common assessment.



Investment index	Substation 1	Substation 2	Description	GTC contri	Present status	Expected date of	Evolution since	Evolution driver

				bution (MW)		commissioning	TYNDP 2012	
Project 209								
147	Dollern (DE)	Hamburg/Nord (DE)	New 380kV double circuit OHL Dollern - Hamburg/Nord. Length: 43km. First circuit 2015, second circuit 2017	2008	Under Construction	2017	Delayed	Delay due to long permitting process
148	Audorf (DE)	Hamburg/Nord (DE)	New 380kV double circuit OHL Audorf - Hamburg/Nord including two new 380/220kV transformers in substation Audorf and new 380 kV Switchgear in Kummerfeld. Length: 65km.	2410	Design & Permitting	2017	Delayed	delay due to long permitting process
667	Brunsbüttel (DE)	Niebüll	About 135 km new 380-kV-lines and around 10 new transformers for integration of onshore Wind in Schleswig-Holstein and increase of NTC between DE and DK	2014	Planning	2018	Delayed	The old investment 43.A90 is now divided in several parts.
935	Kreis Segeberg	Göhl	New 380-kV-lineKreis Segeberg - Lübeck - Siems - Göhl, including five new transformers	4482	Under Consideration	2021	Rescheduled	Investment was part of investment 43.A90 in TYNDP 2012. Now separately
937	Audorf	Kiel	New 380-kV-line in existing OHL corridor including 4 new transformers and new 380-kV-switchgears in Kiel/West and Kiel/Süd	2299	Under Consideration	2021	Rescheduled	In TYNDP 2012 this investment was part of investment 43.A90
Project 130								
208	Pulgar (DE)	Vieselbach (DE)	Construction of new 380kV 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.	2063	Planning	2024	Investment on time	The project is part of the results of the national grid development plan and included in the list of national interest (Bundesbedarfsplan). Within this process the commissioning dates of the included projects have been aligned with the current situation.
665	Lauchstädt (DE)	Meitingen (DE)	New DC- lines to integrate new wind generation from control area 50Hertz especially Mecklenburg-Vorpommern, Brandenburg and Sachsen-Anhalt towards Central/south Europe for consumption and storage.	3583	Planning	2022	Investment on time	Result from National Grid Development Plan
Project 164								
149	Dollern (DE)	Stade (DE)	New 380kV double circuit OHL Dollern - Stade including new 380kV switchgear in Stade. Length: 14km.	3749	Design & Permitting	2022	Delayed	The investment is delayed because of changes in the investment driver
157	Wahle (DE)	Mecklar (DE)	New 380kV double circuit OHL Wahle - Mecklar	2264	Design & Permitting	2018	Delayed	delay due to long permitting process

			including two new substations. Length: 210km.					
177	Goldshöfe (DE)	Bünzwangen (DE)	AC-extension of the "C corridor" at one ending point in Southern Germany towards the consumption areas allowing the existing grid to deal with the additional flows from DC-link	2070	Design & Permitting	2020	Investment on time	Anticipation of design and permitting phase due to foreseen difficulties (protected area in the Swabian Alps)
664	Brunsbüttel, Wilster, Kreis Segeberg	Großgartach, Goldshöfe, Grafenrheinfeld	New DC-lines to integrate new wind generation from Northern Germany towards Southern Germany and Southern Europe for consumption and storage.	3575	Planning	2022	Investment on time	The expected commissioning date is 2017 - 2022
677	Dollern (DE)	Landesbergen (DE)	New 380 kV line in existing OHL corridor Dollern-Sottrum-Wechold-Landesbergen (130 km)	3749	Planning	2022	Investment on time	Progress as planned.
685	Mecklar (DE)	Grafenrheinfeld (DE)	New double circuit OHL 400-kV-line (130 km)	2387	Planning	2022	Investment on time	Progress as planned.
Project 206								
682	Großgartach (DE)	Endersbach (DE)	AC-extension of the "C corridor" at one ending point in Southern Germany towards the consumption areas allowing the existing grid to deal with the additional flows from DC-link	1340	Planning	2019	Investment on time	Standard processing 2018-2019
687	Redwitz (DE)	Schwandorf (DE)	New double circuit OHL 380 kV line in existing OHL corridor Redwitz-Mechlenreuth-Etzenricht-Schwandorf (185 km)	1218	Planning	2020	Investment on time	Progress as planned.
688	Raitersaich (DE)	Isar (DE)	New 380 kV line in existing OHL corridor Raitersaich - Ludersheim - Sittling - Isar or Altheim (160 km)	1902	Under Consideration	2024	Rescheduled	Delay due to missing confirmation by the regulator
990	Grafenrheinfeld (DE)	Großgartach (DE)	AC-extension of the "C corridor" between two of its ending points in Southern Germany allowing the existing grid to deal with the additional flows from DC-link	4310	Planning	2019	New Investment	Standard processing
Project 205								
153	Redwitz (DE)	Grafenrheinfeld (DE)	Upgrade of 220kV connection Redwitz - Grafenrheinfeld to 380kV, including new 380kV switchgear Eltmann. Line length: 97km.	2473	Design & Permitting	2015	Delayed	Delayed due to delayed of related investment 45.193 and unexpected long permitting process of the investment itself
193	Vieselbach (DE)	Redwitz (DE)	New 380kV double-circuit OHL between the substations Vieselbach-Altenfeld-Redwitz with 215km length combined with upgrade between Redwitz and Grafenrheinfeld (see	3583	Design & Permitting	2015	Delayed	Previously "mid-term" is now updated to specific date. Partly under construction (section Vieselbach – Altenfeld). 3rd section (Altenfeld – Redwitz) in permitting process, long

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			investment 153). The Section Lauchstädt-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 Eastern and Western Germany and is right downstream in the main load flow direction. The project will help to avoid loop flows through neighbouring grids.					permitting process with strong public resistance.
Project 204								
686	Schalkau / area of Altenfeld (DE)	area of Grafenrheinfeld (DE)	New double circuit OHL 380-kV-line (130 km)	-	Under Consideration	2024	Rescheduled	Delay due to missing confirmation by the regulator

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 11800	South=>North: 11800	5	5	More than 100km	More than 50km	6200-8600

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[340;420]	[3100000;3700000] MWh	[-4200000;-3400000]	[-1500;-1200]
Scenario Vision 2 - 2030	-	[310;380]	[3000000;3600000] MWh	[-4300000;-3500000]	[110;130]
Scenario Vision 3 - 2030	-	[1300;1600]	[8700000;11000000] MWh	[-5200000;-4200000]	[-7300;-6000]
Scenario Vision 4 - 2030	-	[2000;2400]	[14000000;17000000] MWh	[-6400000;-5200000]	[-12000;-9700]

Additional comments

Comment on the CBA assessment: As the existing tools are not designed to assess single internal projects within a price zone, the above-mentioned projects are assessed together as one corridor. Additionally the main goal of the corridor is to integrate new RES in Northern and North East Germany and can only be reached with all projects in.

Comment on the security of supply: Market simulations are not able to take internal bottlenecks inside one bidding area into account in a comprehensive way. Therefore, to evaluate the SOS-indicator for internal projects a more detailed and specialized survey is indispensable. In Germany the quick decommissioning of nuclear power plants has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (see also : http://www.bundesnetzagentur.de/)

Comment on the CO2 indicator: the very high scores reflect that the project connects RES sources to load centres

Comment on the Losses indicator: without the project the grid would be overloaded; so the amount of lower losses with compared to without the project is theoretical.

Comment on the S1 and S2 indicators: Detailed values for most lines are not available due to the early state in the planning process

Comment on the technical resilience indicator: The corridor is necessary to enable switch-off of assets for maintenance. The corridor includes VSC-DC-Links, which are necessary for (n-1)-security, voltage control and system stability.

Comment on the flexibility indicator: the project appears useful in all visions, consists of various investments complementing each other, and integrates two control zones

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North South Western German Corridor

Description of the corridor

This corridor is necessary, due to the strong increase in RES generation, meeting the goals of the European and especially German energy policy. It connects 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. This corridor begins in the North of Germany, an area with high RES generation (planned and existing), conventional generation and connections with Scandinavia (planned and existing).The corridor ends 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). Thus, the corridor is an essential element for the integration of renewable energy sources into the German power system and the provision of additional transmission capacities in order to meet the increasing demand of the European electricity market and to avoid unscheduled transit flow to neighboring countries. Moreover, due to the nuclear phase out in Germany, the amount of reliable available capacity in southern Germany decreases and the security of supply of this area requires additional transmission capacity to areas with conventional generation units.

The Corridor consist of 5 projects:

- project 207 groups all investments needed to collect wind in-feed north west of Germany;
- project 132 and 208 represents the 2 sections of new HVDC lines aiming at transporting this power to the south of the country;
- project 134 groups all investments needed to secure the supply south of Germany in this corridor;
- project 135 group all supporting measures on existing assets.

Working together, the five projects have been assessed as a whole and share the same common assessment.

Investment index	Substation 1	Substation 2	Description	GTC contribution	Present status	Expected date of commissioning	Evolution since TYNDP	Evolution driver

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				(MW)			2012	
Project 208								
150	Conneforde (DE)	Fedderwarden (DE)	New 380kV double circuit (OHL, partly underground) Conneforde - Wilhelmshaven (Fedderwarden, former Maade) including new 400kV switchgear Fedderwarden. Length: 35 km.	3668	Design & Permitting	2018	Investment on time	Progress as planned.
151	Wehrendorf (DE)	Ganderkesee (DE)	New line (length: ca. 95km), extension of existing and erection of substations, erection of 380/110kV-transformers.	3538	Design & Permitting	2017	Delayed	delay due to long permitting process
156	Niederrhein (DE)	Dörpen/West (DE)	New 380 kV double circuit overhead line Dörpen - Niederrhein including extension of existing substations.	988	Design & Permitting	2018	Delayed	The project is delayed due to delays in public-law and civil-law licensing procedures.
Project 132								
661	Emden East (DE)	Osterath (DE)	New HVDC-lines from Emden to Osterath to integrate new wind generation especially from North Sea towards Central Germany for consumption.	3049	Planning	2022	Investment on time	Progress as planned.
663	Cloppenburg East (DE)	Merzen (DE)	New 380-kV double circuit over-head-line Cloppenburg East - Merzen with a total length of ca. 55 km. New erecting of a 380-kV substation Merzen.	3386	Planning	2022	Investment on time	Progress as planned.
666	Conneforde (DE)	Cloppenburg (DE)	New 380-kV-line in existing OHL corridor for integration of on- and offshore Wind generation. Incl. new 380-kV-switchgear in Cloppenburg and new transformers in Cloppenburg	3386	Planning	2022	Investment on time	TYDNP 2012 investment 43.A89 is divided in serveral parts
Project 135								
188	Kruckel (DE)	Dauersberg (DE)	New 380 kV overhead lines in existing rout. Extension of existing and erection of several 380/110kV-substations.	774	Design & Permitting	2020	Investment on time	Progress as planned.
662	Wehrendorf (DE)	Urberach (DE)	New lines in HVDC technology from Wehrendorf to Urberach to integrate new wind generation especially from North Sea towards Central-South Europe for consumption and storage.	2856	Under Consideration	2022	Rescheduled	The need for this long-term investment was not confirmed by the regulatory authority within the national grid development plan 2012. Therefore further studies on this project are ongoing.
680	Urberach (DE)	Daxlanden (DE)	New line and extension of existing line to 380 kV double circuit overhead line Urberach - Weinheim - Daxlanden. Extension of existing substations are included.	1833	Planning	2021	Investment on time	Progress as planned.
Project 134								

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176	Daxlanden (DE)	Eichstetten (DE)	This AC project is necessary in order to evacuate the energy arriving from HVDC corridors towards southern Germany and reinforce the interconnection capacity with Switzerland	754	Under Consideration	2020	Investment on time	Progress as planned.
179	Rommerskirchen (DE)	Weißenthurm (DE)	New380 kV overhead line in existing route. Extension and erection of substations incl. erection of 380/110kV-transformers.	900	Under Construction	2017	Delayed	The section Rommerskrichen to Sechtem is delayed because the permitting procedures take longer than planned. The 36 km section from Sechtem to Weißenturm is already commissioned.
660	Osterath (DE)	Philippsburg (DE)	New HVDC-lines from Osterath to Philippsburg to integrate new wind generation especially from North Sea towards Central-South Germany for consumption and storage.	3049	Design & Permitting	2019	Investment on time	Progress as planned.
680	Urberach (DE)	Daxlanden (DE)	New line and extension of existing line to 380 kV double circuit overhead line Urberach - Weinheim - Daxlanden. Extension of existing substations are included.	1833	Planning	2021	Investment on time	Progress as planned.
Project 207								
675	Conneforde (DE)	Unterweser (DE)	Upgrade of 220-kV-circuit Unterweser-Conneforde to 380kV , Line length: 32 km.	4068	Under Consideration	2024	Rescheduled	Delay due to missing confirmation by the regulator
676	Dollern (DE)	Elsfleht/West (DE)	New 380 kV line in existing OHL corridor Dollern - Elsfleht/West Length:100 km	2849	Under Consideration	2024	Rescheduled	Delay due to missing confirmation by the regulator
939	Conneforde	Emden/Ost	New 380-kV-line in existing OHL corridor for integration of RES	3336	Planning	2019	Delayed	In TYNDP 2012 part of investment 43.A89
940	Emden/Ost	Halbemond	New 380-kV-line Emden - Halbemond for RES integration incl. new transformers in Halbemond	3336	Under Consideration	2021	Rescheduled	In TYNDP 2012 part of investment 43.A89

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 5500	South=>North: 5500	5	4	More than 100km	More than 50km	4900-6600

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**

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Scenario Vision 1 - 2030	-	[410;500]	[6000000;7300000] MWh	[-2500000;-2100000]	[-4600;-3800]
Scenario Vision 2 - 2030	-	[290;350]	[5400000;6600000] MWh	[-1200000;-1000000]	[-3600;-2900]
Scenario Vision 3 - 2030	-	[1400;1700]	[14000000;17000000] MWh	[-6200000;-5000000]	[-6700;-5500]
Scenario Vision 4 - 2030	-	[1300;1600]	[15000000;18000000] MWh	[-5100000;-4100000]	[-6500;-5300]

Additional comments

Comment on the CBA assessment:
As the existing tools are not designed to assess single internal projects within a price zone, the above-mentioned projects are assessed together as one corridor. Additionally the main goal of the corridor is to integrate new RES in Northern and North East Germany and can only be reached with all projects in.

Comment on the security of supply:
Market simulations are not able to take internal bottlenecks inside one bidding area into account in a comprehensive way. Therefore, to evaluate the SOS-indicator for internal projects, a more detailed and specialized survey is indispensable. In Germany, the quick decommissioning of nuclear power plants has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realised, especially for the reliably power supply of Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (see also : http://www.bundesnetzagentur.de/) The necessary reserve capacity is in the range of some GW.

Comment on the CO2 indicator:
the very high scores reflect that the project connects RES sources to load centres

Comment on the Losses indicator: without the project the grid would be overloaded; so the amount of lower losses with compared to without the project is theoretical.
Comment on the S1 and S2 indicators:
Detailed values for most lines are not available due to the early state in the planning process.

Comment on the technical resilience indicator:
The project is necessary to enable switch-off of assets for maintenance. The project includes VSC-DC-Links, which are necessary for (n-1)-security, voltage control and system stability.

Comment on the flexibility indicator: the project appears useful in all visions, consists of various investments complementing each other, and integrates two control zones

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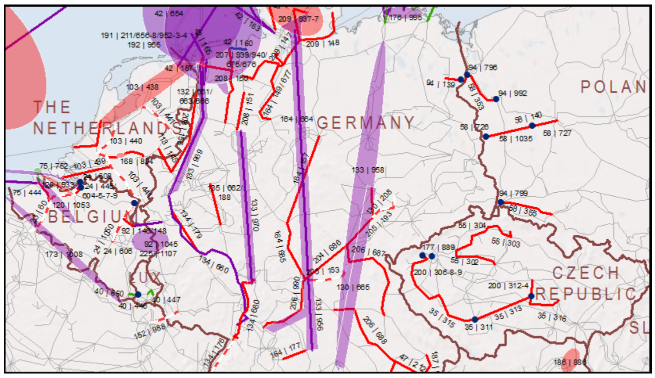
Project 133: Longterm German RES

Description of the project

This project becomes necessary in case of further long-term strong increase in RES generation like in Vision 3 and 4. The project is not in Vision 1 and 2. It connects 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. This project begins in the North and North-East of Germany, areas with high RES generation (planned and existing) and connections with Scandinavia (planed and existing).The project ends 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).



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
956	Schleswig-Hostein	Baden-Würtemberg / Bavaria	New DC- line in HVDC technology to integrate new wind generation from northern Germany toward southern Germany and southern Europe for consumption and storage. Connections points north: Brunsbüttel, Wilster, Kreis Segeberg, Stade, and Alfsted. South: Großgartach, Goldshöfe, Raitersaich, Vöhringen	8000	Under Consideration	2030	New Investment	new investment
958	Güstrow (DE)	Meitingen (DE)	New DC- lines to integrate new wind generation from Baltic Sea and control area 50Hertz especially Mecklenburg-Vorpommern towards Central/south Europe for consumption and storage.	2000	Under Consideration	2034	New Investment	New Investment
969	lower saxony	NRW	New HVDC line to integrate new wind generation especially from North Sea towards Central Germany for consumption and storage. Connections points north: Emden, Conneforde. South: Oberzier, Rommerskirchen	4000	Under Consideration	2030	New Investment	new investment

970	lower saxony	Hessen/Baden-Würtemberg	New HVDC line to integrate new wind generation especially from North Sea towards South Germany for consumption and storage. Connections points north: Cloppenburg, Elsfelth/West. South: Bürstadt, Philipsburg	4000	Under Consideration	2030	New Investment	new investment

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 18000	South=>North: 18000	5	4	NA	NA	5100-6800

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 3 - 2030	-	[57;140]	[860000;1000000] MWh	[-3300000;-2700000]	[-380;-310]
Scenario Vision 4 - 2030	-	[180;260]	[1600000;2000000] MWh	[-4000000;-3200000]	[-1200;-960]

Additional comments

Comment on the CO2 indicator: the very high scores reflect that the project connects RES sources to load centres

Comment on the Losses indicator: without the project the grid would be overloaded; so the amount of lower losses with compared to without the project is theoretical.

Comment on the S1 and S2 indicators:
Values for this project are not available due to the early state in the planning process

Comment on the technical resilience indicator:
The project is necessary to enable switch-off of assets for maintenance. The project includes VSC-DC-Links, which are necessary for (n-1)-security, voltage control and system stability.

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Project 96: Keminmaa-Pyhänselkä

Description of the project

The project is 400 kV overhead line in North Finland. Integration of new generation at Bothnian bay and increased transmission capacity demand. Will help utilizing the Swedish/Finnish cross border capacity.

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
801	Keminmaa (FI)	Pyhänselkä (FI)	Integration of new generation + increased transmission capacity demand.	-	Under Consideration	2024	Rescheduled	Investment progresses as planned, rescheduled slightly since last TYNDP due to expected development on the drivers behind the investment.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 500-1000	South=>North: 500-1000	2	4	Negligible or less than 15km	Negligible or less than 15km	41-48

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[0;14]	1050 MW	[-30000;-60000]	[0;240]
Scenario Vision 2 - 2030	-	0	[800;1200] MW	[-30000;-60000]	[0;500]
Scenario Vision 3 - 2030	-	[0;6]	1000 MW	[-35000;-65000]	[0;-40]
Scenario Vision 4 - 2030	-	[0;68]	[1300;1800] MW	[-20000;-80000]	[0;-100]

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Additional comments

Comment on the RES integration:
The project help integrating 1000-1800 MW of RES in Coastline of Bothnian bay in Finland

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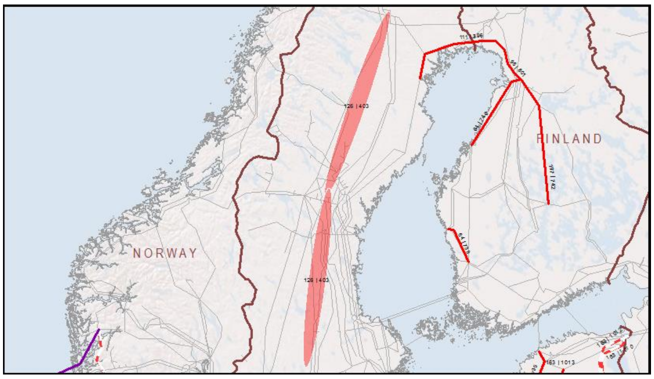
Project 126: SE North-south reinforcements

Description of the project

Reinforcements, both lines and stations, in and between bidding area SE1, SE2 and SE3 will accomplish RES integration in northern Sweden.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
403	Sweden bidding area SE1	Sweden bidding area SE3	Based on a joint Statnett & Svenska Kraftnät study for North-South reinforcements, this contains reinforcements in cut 1 and 2 in Sweden	-	Under Consideration	2025	Investment on time	The investment now combine new investments and the previous 399, 786, 787, 788 and 806. All of the old investments appear only in the list of cancelled investments in the regional plan

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	GTC direction 2 (MW)	B6 Technical Resilience	B7 Flexibility	S1 - protected areas	S2 - urban areas	C1 Estimated cost (Meuros)
North=>South: 700	South=>North: 700	2	4	NA	NA	800-1400

CBA results	for each scenario				
Scenario	B1 SoS (MWh/year)	B2 SEW (MEuros/year)	B3 RES integration	B4 Losses (MWh)	B5 CO2 Emissions (kT/year)
Scenario Vision 1 - 2030	-	[69;84]	[70000;86000] MWh	[110000;130000]	[9;12]
Scenario Vision 2 - 2030	-	[39;48]	[15000;19000] MWh	[120000;150000]	[36;44]
Scenario Vision 3 - 2030	-	[44;53]	[28000;34000] MWh	[110000;130000]	[18;22]
Scenario Vision 4 - 2030	-	[32;39]	[380000;460000] MWh	[230000;280000]	[-52;-43]

Additional comments

Comment on the RES integration: the project will help integrating 700-800 MW of RES in northern Sweden and Norway.

Comment on the S1 and S2 indicators: the project will have a social and environmental impact but the investments are in early stages so there are no facts regarding the impact.

The project will increase the GTC with 700MW between Sweden Bidding areas 1 and 2, and 800 MW between Sweden Bidding areas 2 and 3.

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Project 64: N-S Finland (P1) stage 1

Description of the project

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 exiting 220 kV lines. The commissioning of the lines is scheduled to take place in segments both in mid and long term.
Project changed in TYNDP 2014, stage 1 includes the investments up until 2016.

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
392	Yllikkälä (FI)	Huutokoski (FI)	New 155km single circuit 400kV OHL and renovation of 400kV substations in Yllikkälä and Huutokoski. Expected capacity: 1850 MVA.	-	Commissioned	2013	Commissioned	Investment progressing as planned, has been commissioned May/2013
393	Seinäjoki (FI)	Tuovila (FI)	First line part of the four new single circuit 400kV OHL are part of project in upgrading Ostrobothnian 220kV system into 400kV, and strengthening the 400 kV grid in Northern Finland. Total length of lines: 520 km. Total Expected capacity: 1850 MVA.	-	Commissioned	2011	Commissioned	Investment is commissioned
739	Ulvila (FI)	Kristinestad (FI)	Second line part of the four new single circuit 400kV OHL are part of project in upgrading Ostrobothnian 220kV system into 400kV, and strengthening the 400 kV grid in Northern Finland. Total length of lines: 520 km. Total Expected capacity: 1850 MVA.	700	Under Construction	2014	Investment on time	Investment progress as planned
740	Hirvisuo (FI)	Pyhänselkä (FI)	Third line part of the four new single circuit 400kV OHL are part of	700	Design & Permitting	2016	Expected earlier than planned	Station name updated from Ventusneva to

			project in upgrading Ostrobothnian 220kV system into 400kV, and strengthening the 400 kV grid in Northern Finland. Total length of lines: 520 km. Total Expected capacity: 1850 MVA.				previously	Hirvisuo. Investment decision has been made and schedule has been updated.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North => South: 700-1400	South=> North: 700-1400	2	4	NA	NA	190-260

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	[30;300]	[30;100]	[500;1500] MW	[0;-3000]	[500;1000]

Additional comments

Project 197: N-S Finland P1 stage 2

Description of the project

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 exiting 220 kV lines. The commissioning of the lines is scheduled to take place in segments both in mid and long term. Change in TYNDP 2014, taken the latest investment as its own project. This project is 400 kV overhead line from connecting North Finland to South.

Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
742	Pyhänselkä (FI)	Petäjävesi (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. Will replace existing 220 kV lines.	-	Design & Permitting	2023	Delayed	Rescheduled due to timing of system changes that trigger the investment. End station name updated.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 1000	South=>North: 1000	2	4	NA	NA	86-98

CBA results	for each scenario

Scenario	B1 SoS (MWh/year)	B2 SEW (MEuros/year)	B3 RES integration	B4 Losses (MWh)	B5 CO2 Emissions (kT/year)
S1 EU202020 - 2020	[30;300]	[30;100]	[500;1500] MW	[0;-3000]	[500;1000]

Additional comments

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11.1.2 List of projects and investments within the region

The table below depicts all projects and investments of pan-European and Regional significance within the Baltic Sea region. The evolution of each investment is monitored since the TYNDP and RgIPs 2012 with updated commissioning dates, status and description of the evolution.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
36	Kriegers Flak CGS								
		141	Ishøj / Bjæverskov (DK)	Bentwisch (DE)	Three offshore windfarms connected to shore combined with 400 MW interconnection between both countries	2018	Design & Permitting	Investment on time	Commisioning date must be achieved in order to ensure grid connection for further renewable energy.
37	Southern Norway - Germany								
		142	Tonstad (NO)	Wilster (DE)	A 514 km 500 kV HVDC subsea interconnector between southern Norway and northern Germany.	2018	Design & Permitting	Investment on time	Agreement between the two TSOs on commissioning date.
		406	(Southern part of Norway) (NO)	(Southern part of Norway)(NO)	Voltage uprating of existing 300 kV line Sauda/Saurdal - Lyse - Ertsmyra - Feda - 1&2, Feda - Kristiansand; Sauda-Samnanger in long term. Voltage upgrading of existing single circuit 400kV OHL Tonstad-Solhom-Arendal. Reactive power devices in 400kV substations.	2020	Design & Permitting	Delayed	Revised progress due to less flexible system operations in a running system (voltage upgrade of existing lines). Commissioning date expected 2019-2021.
39	DKW-DE, step 3								
		144	Audorf (DE)	Kassö (DK)	Step 3 in the Danish-German agreement to upgrade the Jutland-DE transfer capacity. It consists of a new 400kV route in Denmark and In Germany new 400kV line mainly in the trace of a existing 220kV line.	2019	Planning	Delayed	Planning ongoing - minor delay due to coordination with project 183.1018
40	Luxembourg-Belgium Interco								
		446	Schifflange (LU)		BELUX INTERIM As a first interim step a PST will be integrated in Schifflange, and connected to an existing OH-line to control the transit flows from Germany to Belgium as from end 2015.	2015	Planning	Investment on time	Studies for interim step are finalized; Investment decision has been taken mid-2014 and PST is planned to be operational end 2015.
		447	Heisdorf (LU)	Berchem (LU)	Erection of a new 20km 225kV double-circuit mixed (cable+OHL)line with 1000 MVA capacity in order to create a loop around Luxembourg city including substations for in feed in lower voltage levels.	2017	Design & Permitting	Investment on time	Substation Blooren is authorized and under construction, Authorization for line section is still pending

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		650	Bascharage (LU)	Aubange (BE)	BELUX LT In a second step: new 220 kV interconnection with neighbour(s) between Creos grid in LU and ELIA grid in BE via a 16km double circuit 225kV underground cable with a capacity of 1000 MVA.	2020	Under Consideration	Investment on time	An ongoing network study investigates the robustness of the planned 220kV connection between LU and BE.
42	**OWP TenneT Northsea part 1**								
		160	Offshore- Wind park Nordergründe (DE)	Inhausen (DE)	New AC-cable connection with a total length of 32km.	2016	Under Construction	Delayed	Delay due delay of windfarms
		163	Cluster HelWin1 (DE)	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 133km. Line capacity: aprox. 576 MW.	2014	Under Construction	Investment on time	
		164	Cluster SylWin1 (DE)	Büttel (DE)	New line consisting of underground +subsea cable with a total length of 206 km. Line capacity: aprox.864MW.	2015	Under Construction	Delayed	
		165	Cluster DolWin1 (DE)	Dörpen/West (DE)	New line consisting of underground +subsea cable with a total length of 167 km. Line capacity: 800MW.	2014	Under Construction	Delayed	
		167	Cluster BorWin2 (DE)	Diele (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205km. Line capacity: 800MW.	2015	Under Construction	Delayed	
		654	Cluster DolWin2 (DE)	Dörpen/West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 138 km. Line capacity: 900 MW	2015	Under Construction	Investment on time	
		655	Cluster DolWin3 (DE)	Dörpen/West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 162 km. Line capacity: 900 MW	2017	Under Construction	Investment on time	

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		657	Cluster HelWin2	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 133 km. Line capacity: 690 MW	2015	Under Construction	Investment on time	
46	Offshore Wind Baltic Sea								
		194	OWF Cluster Baltic Sea East (DE)	Lüdershagen/Lubmin (DE)	Grid Connection of offshore wind farms (using AC-technology). According to german law, the grid connection has to be constructed and operated by the TSO (50Hertz Transmission).	2031	Design & Permitting	Investment on time	The investment is split into different stages with different commissioning dates (starting in 2017) depending on the predicted installed capacity of offshore wind. For further informations see the national "Offshore Grid Development Plan"
		195	wind farm cluster Baltic Sea West (DE)	Bentwisch/Lüdershagen (DE)	Grid Connection of offshore wind farms (using AC-technology). According to german law, the grid connection has to be constructed and operated by the TSO (50Hertz Transmission).	2032	Design & Permitting	Investment on time	The investment is split into different stages with different commissioning dates (starting in 2026) depending on the predicted installed capacity of offshore wind. For further informations see the national "Offshore Grid Development Plan"
47	AT - DE								
		216	St. Peter (AT)	Tauern (AT)	Completion of the 380kV-line St. Peter - Tauern. This contains an upgrade of the existing 380kV-line St. Peter - Salzburg from 220kV-operation to 380kV-operation and the erection of a new internal double circuit 380kV-line connecting the substations Salzburg and Tauern (replacement of existing 220kV-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.	2020	Design & Permitting	Investment on time	In Sept. 2012 the application for granting the permission (EIA) was submitted to the relevant authorities. According to the experience of similar projects the commissioning is expected for 2020.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		212	Isar (DE)	St. Peter (AT)	New 400kV double circuit OHL Isar - St. Peter including new 400kV switchgears Altheim, Pirach, Simbach and St. Peter. Also including 4. circuit on line Ottenhofen - Isar.	2018	Design & Permitting	Delayed	delaye due to long permitting process
		219	Westtirol (AT)	Zell-Ziller (AT)	Upgrade of the existing 220kV-line Westtirol - Zell-Ziller and erection of an additional 220/380kV-Transformer. Line length: 105km.	2021	Planning	Investment on time	The upgrade of the line and substation Westtirol is currently in the planning process.
		689	Vöhringen (DE)	Westtirol (AT)	Upgrade of an existing over head line to 380 kV, extension of existing and errection of new 380-kV-substations including 380/110-kV-transformers. Transmission route Vöhringen (DE) -Westtirol (AT). This project will increase the current power exchange capacity between the DE, AT.	2020	Planning	Investment on time	Progess as planned.
57	PolBaltic Integration								
		326	Pelplin (PL)		Construction of new 400/110kV substation Pelplin between existing substation Grudziądz and planned substation Gdańsk Przyjaźń.	2019	Planning	Expected earlier than planned previously	The change in commissioning date stems from the recent update of National Development Plan and the schedule of planned generation connection.
		805	Grudziadz (PL)	Gdansk Przyjazn (PL)	Construction of new 400 kV line Grudziądz Węgrowo - Pelplin - Gdańsk Przyjaźń for planned generation connection.	2019	Planning	Expected earlier than planned previously	Investment on time.
		334	Patnów (PL)	Grudziadz (PL)	New 174 km 400 kV 2x1870 MVA double circuit OHL line Pątnów - Grudziądz after dismantling of 220kV line Pątnów - Jasiniec (two parallel lines) and Jasiniec - Grudziądz with extension of existing substations Patnów and Jasiniec. One circuit from Pątnów to Grudziądz via Jasiniec temporarily on 220kV.	2020	Planning	Investment on time	The project is in the planning phase.

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Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		804	Gdansk Blonia (PL)		Extension and upgrade of an existing 400/110 kV substation Gdańsk Błonia for connection of planned 900 MW power plant.	2020	Planning	Investment on time	The project is in the planning phase.
		328	Pila Krzewina (PL)	Bydgoszcz Zachód (PL)	New 400 kV double circuit line Piła Krzewina - Bydgoszcz Zachód temporarily on 220kV.	2019	Design & Permitting	Delayed	The commissioning date of the investment has been adopted to meet the schedule of generation connection in the region of northern Poland. The project is in the process of obtaining permits.
		329	Zydowo Kierzkowo (PL)	Slupsk (PL)	New 70km 400kV 2x1870 MVA OHL double circuit line Żydowo - Słupsk	2019	Planning	Expected earlier than planned previously	The change in the comissioning date due to rescheduling introduced in the latest investment plan. Investment is in the planning phase.
		724	Zydowo Kierzkowo (PL)		Construction of new AC 400/110kV substation Żydowo Kierzkowo next to existing 220/110kV substation in Northern Poland with transformation 400/110kV 450 MVA.	2019	Planning	Expected earlier than planned previously	The expected date of commissioning change to meet the schedule of generation connection.
		330	Zydowo Kierzkowo(PL)	Gdansk Przyjazn (PL)	New 150 km 400 kV 2x1870 MVA double circuit OHL line Żydowo Kierzkowo - Gdańsk Przyjaźń with one circuit from Żydowo to Gdańsk temporarily on 220 kV.	2019	Planning	Expected earlier than planned previously	Investment is in the planning phase.
		725	Gdansk Przyjazn		New 150 km 400 kV 2x1870 MVA double circuit OHL line Żydowo Kierzkowo - Gdańsk Przyjaźń with one circuit from Żydowo to Gdańsk temporarily on 220 kV.	2019	Planning	Expected earlier than planned previously	Investment on time.
		352	Dunowo (PL)	Plewiska (PL)	Construction of a new double circuit 400kV OHL Dunowo - Żydowo (2x1870 MVA) partly using existing 220 kV line + Construction of a new 400kV OHL Plewiska - Piła Krzewina - Żydowo (2x1870 MVA); single circuit temporarily working as a 220kV + A new AC 400kV switchgear in existing substation Piła Krzewina + upgrade of	2020	Planning	Investment on time	Investment is in the planning phase.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
					substation Dunowo				
58	**GerPol Power Bridge**								
		1035	Baczyna		Construction of new 400/220 kV Substation Baczyna to connect the new line Krajnik-Baczyna.	2018	Planning	Investment on time	The investment was part of n°58.353 in TYNDP 2012 and is now presented stand alone. It is in the tendering procedure (design and build scheme).
		140	Eisenhüttenstadt (DE)	Plewiska (PL)	Construction of new 400 kV double circuit line Plewiska (PL)-Eisenhüttenstadt (DE) creating an interconnector between Poland and Germany.	2022	Planning	Rescheduled	The investment in planning phase. Expected problems with the routing cause adoption of commissioning date.
		727	Plewiska (PL)		Construction of new substation Plewiska Bis (PL) to connect the new line Plewiska (PL)-Eisenhüttenstadt (DE).	2020	Planning	Investment on time	The project is at the planning stage.
		353	Krajnik (PL)	Baczyna (PL)	Construction of new 400 kV double circuit line Krajnik – Baczyna.	2020	Planning	Investment on time	Investment is in the tendering procedure.
		355	Mikulowa (PL)	Swiebodzice (PL)	Construction of new 400 kV double circuit line Mikułowa-Świebodzice in place of existing 220 kV line.	2020	Planning	Investment on time	Investment on time.
		726	Gubin (PL)		New 400 kV substation Gubin located near the PL-DE border. The substation will be conntected by the new line Plewiska (PL)-Eisenhüttenstadt (DE).	2020	Planning	Investment on time	The project is at the planning stage.
59	**LitPol Link Stage 1**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1036	Siedlce Ujrzanów		New Substation Siedlce Ujrzanów will be connected by new line Miłosna-Siedlce Ujrzanów and later by new line Kozienice-Siedlce Ujrzanów	2015	Under Construction	Investment on time	The investment was previously included in the investment no. 369 as "new 400 kV switchgear in existing Substation Siedlce". The concept has changed and there is a new substation in a different location.
		1037	Elk Bis		New 400/110 kV Substation Ełk Bis connected by two double 400 kV lines Łomża-Ełk and Ełk-Alytus creating an interconnector Poland-Lithuania.	2015	Under Construction	Investment on time	The inv. was part of inv. no 370 in TYNDP2012 as "new 400kV switchgear in existing Substation Ełk". The concept has changed, it is not possible to extend the existing substation and there is a new substation in a different location, expected in 2015.
		368	Elk (PL)	PL-LT border	Construction of a new 400 kV interconnector line from Ełk to PL-LT border.	2015	Under Construction	Investment on time	Investment is under construction.
		369	Siedlce Ujrzanów (PL)	Milosna (PL)	Construction of new 400 kV line Siedlce Ujrzanów - Miłosna.	2015	Under Construction	Investment on time	The project is in the construction phase.
		370	Elk (PL)	Lomza (PL)	Construction of new 400 kV line Ełk-Łomża.	2015	Under Construction	Investment on time	The project is under construction.
		728	Lomza (PL)		Construction of new substation Łomża to connect the line Ełk-Łomża.	2015	Under Construction	Investment on time	The project is under construction.
		371	Ostroleka (PL)	Narew (PL)	Construction of new 400 kV line Ostrołęka-Łomża-Narew + extension of substation Narew.	2015	Under Construction	Investment on time	The project is under construction.
		729	Ostroleka (PL)		A new 400 kV switchgear in existing substation Ostroleka (in two stages) with transformation 400/220kV 500 MVA and with transformation 400/110kV 400 MVA.	2015	Under Construction	Investment on time	The project is under construction.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		730	Stanislawów (PL)		New substation 400kV Stanisławów will be connected by splitting and extending existing line Miłosna-Narew and Miłosna-Siedlce.	2015	Under Construction	Expected earlier than planned previously	In TYNDP 2012 the building of the substation Stanisławów was reported as part of a line Ostrołęka-Stanisławów. The commissioning time has been aligned with the construction of the line Miłosna-Siedlce Ujrzanów which is expected in 2015.
		376	Alytus (LT)	PL-LT border	Construction of 500 MW Back-to-Back convertor station near Alytus 330kV substation. Construction of double circuit 400kV OHL between Alytus and PL-LT border (51 km).	2015	Under Construction	Investment on time	As planned.
		379	Kruonis (LT)	Alytus (LT)	New double circuit 330kV OHL Alytus–Kruonis(2x1080 MVA, 53km).	2016	Design & Permitting	Delayed	Several months delay due to difficulties with the acquisition of the land
60	**NordBalt phase 1**								
		377	Klaipeda (LT)	Telsiai (LT)	New single circuit 330kV OHL (943 MVA, 85km).	2014	Under Construction	Investment on time	-
		383	Klaipeda (LT)	Nybro (SE)	(NordBalt) A new 300kV HVDC VSC partly subsea and partly underground cable between Lithuania and Sweden	2015	Under Construction	Investment on time	
		385	Grobina (LV)	Imanta (LV)	The reinforcement for Latvian grid project with the new 330kV OHL construction and connection to the Riga node. New 330kV OHL construction mainly instead of the existing 110kV double circuit line route, 110kV line will be renovated at the same time and both will be assembled on the same towers. Length 380km, Capacity 800MW	2018	Under Construction	Investment on time	The part of reinforcement for Kurzemes ring
62	**Estonia-Latvia 3rd IC**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		386	Kilingi-Nomme (EE)	R-TEC2 (LV)	330 kV AC OHL between Kilingi-Nõmme substation in Estonia and R-TEC2 substation in Latvia. New 330 kV power transmission line is planned to take route along already existing 110 kV power transmission lines, by constructing both 110 kV and 330 kV lines on the same towers. Under the framework of the project it is planned to reconstruct the open-air switchyard of the 330/110 kV substation „TEC-2" by constructing new open-air connection point for the 330 kV line „Kilingi Nomme-TEC-2".	2020	Planning	Investment on time	Progress as planned.
		735	Harku (EE)	Sindi (EE)	New double circuit OHL with 2 different voltages 330 kV and 110 kV and with capacity 1200 MVA/240 MVA and a length 140 km. Major part of new internal connection will be established on existing right of way on the western part of Estonian mainland.	2018	Design & Permitting	Investment on time	Progress as planned.
64	**N-S Finland (P1) stage 1**								
		739	Ulvila (FI)	Kristinestad (FI)	Second line part of the four new single circuit 400kV OHL are part of project in upgrading Ostrobothnian 220kV system into 400kV, and strengthening the 400 kV grid in Northern Finland. total length of lines: 520 km. Total Expected capacity: 1850 MVA.	2014	Under Construction	Investment on time	Investment progresse as planned
		740	Hirvisuo (FI)	Pyhänselkä (FI)	Third line part of the four new single circuit 400kV OHL are part of project in upgrading Ostrobothnian 220kV system into 400kV, and strengthening the 400 kV grid in Northern Finland. total length of lines: 520 km. Total Expected capacity: 1850 MVA.	2016	Design & Permitting	Expected earlier than planned previously	Station name updated from Ventusneva to Hirvisuo. Invesment decision has been made and schedule has been updated.
65	**65 South-West in Finland**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		394	Hikiä (FI)	Forssa (FI)	New 80km single circuit 400kV OHL.	2015	Design & Permitting	Investment on time	Investment is progressing as planned
		743	Forssa (FI)		Building of 400 kV substation in Forssa.	2015	Design & Permitting	Investment on time	Investment progresses as planned.
		744	Forssa (FI)	Lieto (FI)	New 67km single circuit 400 kV OHL.	2017	Design & Permitting	Investment on time	Investment progresses as planned
66	**Gotland HVDC**								
		400	Ekhyddan (SE)	Barkeryd (SE)	New single circuit 400kV OHL	2019	Design & Permitting	Delayed	Delayed due to process for environmental policy act
		401	Misterhult (SE)	Stenkumla (SE)	New DC subsea cable connection ±300kV (500MW with an option for additional 500MW)	2019	Design & Permitting	Investment on time	As previous 2017-2021
67	**SouthWest Link**								
		402	Hallsberg (SE)	Barkeryd (SE)	"South West link" consisting of three main parts: 1) New 400kV line between Hallsberg and Barkeryd (SE) - The investments related also include new substations in the connection points line.	2014	Under Construction	Investment on time	
		745	Barkeryd (SE)	Hurva (SE)	"South West link" consisting of three main parts: 2) New double HVDC VSC underground cable and OHL between Barkeryd and Hurva (SE) - The investments related also include new substations and converter stations in the connection points line.	2015	Under Construction	Investment on time	
		411	Rød (NO)	Sylling (NO)	Voltage upgrading of existing single circuit 300kV OHL Rød-Tveiten-Flesaker-Sylling in connection with the new HVDC line to Sweden, the Syd Vest link.	3000	Design & Permitting	Cancelled	Investment is rescheduled to long term horizon in order to reconsider the benefits of the investment
		412	Rød (NO) - Sylling (NO) - Flesaker (NO	Hasle (NO)Tegneby (NO)Tegneby (NO)	Reinvestment and capacity increase Oslofjord 400kV subsea cables. Three cables: Filtvedt - Brenntangen, Solberg - Brenntangen, and Teigen - Evje.	2016	Design & Permitting	Delayed	Technical difficulties cable delivery.
68	**Northern part of Norway**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		421	Ofoten (NO)	Balsfjord (NO)	New 160km single circuit 400kV OHL.	2017	Design & Permitting	Investment on time	On time
		422	Balsfjord (NO)	Hammerfest (NO)	New 360 km single circuit 400kV OHL.	2022	Design & Permitting	Delayed	Demand driver Melkøya gas terminal postponed. Longer construction time expected.
70	**Integration Norway - Denmark**								
		405	Kristiansand (NO)	Rød (NO)	Voltage upgrading of an existing single circuit 300kV OHL.	2014	Under Construction	Investment on time	On time
		426	Kristiansand (NO)	Tjele (DK)	The interconnector is planned to be a 500 kV 700 MW HVDC subsea interconnector between southern Norway and northern Denmark.	2014	Under Construction	Investment on time	On time
71	**COBRA cable**								
		427	Endrup (DK)	Eemshaven (NL)	COBRA: New single circuit HVDC connection between Jutland and the Netherlands via 350km subsea cable; the DC voltage will be 320kV and the capacity 700MW.	2019	Design & Permitting	Delayed	Rescheduled to develop a solid regional business case (including additional project partners); and to account for the time needed for the acceptance by the authorities of a preferred route.
87	**Östra Svealand**								
		783	Forsmark (SE)	Råsten (SE)	New 50km single circuit 400kV OHL	2020	Under Consideration	Delayed	Under investigation if the investment is the best technical and cost efficient solution
		784	Råsten (SE)	Östfora (SE)	New 75km single circuit 400kV OHL	2020	Under Consideration	Delayed	Under investigation if the investment is the best technical and cost efficient solution
		785	Forsmark (SE)	Stackbo (SE)	New 75 km single circuit 400kV OHL	2020	Under Consideration	Delayed	Under investigation if the investment is the best technical and cost efficient solution
90	**Swiss Roof**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1099	Rüthi	Bonaduz - Grynau	Rüthi - Grynau 2 x 380 kV Rüthi - Bonaduz 1 x 380 kV	2022	Planning	Investment on time	Investment 136 now comprises the cross-border part of former investment 136, and investment 1099 is the Swiss part of former investment 136.
		129	Beznau (CH)	Mettlen (CH)	Upgrade of the existing 65km double circuit 220kV OHL to 400kV.	2020	Design & Permitting	Delayed	long permitting procedure (comprising several phases). In this case, Federal Court decision for partial cabling.
		130	La Punt (CH)	Pradella / Ova Spin (CH)	Installation of the second circuit on existing towers of a double-circuit 400kV OHL (50km).	2017	Planning	Investment on time	none
		133	Bonaduz (CH)	Mettlen (CH)	Upgrade of the existing 180km double circuit 220kV OHL into 400kV.	2020	Under Consideration	Investment on time	none
		134	Bassecourt (CH)	Romanel (CH)	Construction of different new 400kV line sections and voltage upgrade of existing 225kV lines into 400kV lines; total length: 140km. Construction of a new 400/220 kV substation in Mühleberg (= former investment 132 'Mühleberg Substation')	2020	Design & Permitting	Delayed	lines: long permitting procedure (comprising several phases)- Mühleberg substation: under construction
		136	Border area (DE-AT)	Rüthi (CH)	380 kV Rüthi – Meiningen and 380 kV Meiningen - Border Area AT-DE	2022	Planning	Investment on time	investment 136 now comprises the cross-border part of former investment 136, and investment 1099 is the Swiss part of former investment 136.
92	**ALEGrO**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1045	Lixhe	Herderen	AC BE Reinforcements Internal reinforcements in AC network in Belgium have started in the context of securing infeed from the 380kV network into the Limburg & Liège area's. These reinforcements are also needed to facilitate the integration of ALEGrO into the Belgian grid. The reinforcements consist of - extension of an existing single 380 kV connection between Lixhe and Herderen by adding an additional circuit with high performance conductors (HTLS) - creation of 380kV substation in Lixhe, including a 380/150 transformator - creation of 380kV substation in Genk (André Dumont), including a 380/150 kV traformator	2017	Design & Permitting	Investment on time	This investment item is split off from the generic Alegro investment item which up to now included also the internal reinforcements
		1048	Lixhe	Herderen	Potentially additional AC BE Reinforcements Envisions the installation of a second 380 kV overhead line between Herderen to Lixhe. And the installation of a 2nd 380/150 transformator in Limburg area (probably substation André Dumont). These reinforcements are conditional to the evolution of production in the Limburg-Liège area and to the evolution of the physical (transit)flux towards 2020-2025.	2020	Under Consideration	New Investment	Evolution of generation in the Limburg-Liège must be accounted for in the perimeter of the Alegro project. This conditional project has a commissioning date set to 2020 as indication for further monitoring of the need.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		146	Area of Oberzier - Aachen/Düren (DE)	Area of Lixhe - Liège (BE)	ALEGrO Connection between Germany and Belgium including new 100 km HVDC underground cable with convertor stations and extension of existing 380 kV substations. The assessment of the Final Investment Decision is planned in 2015.	2019	Design & Permitting	Delayed	BE: Several months delay due to authorisation procedure in Belgium longer than expected (modification of "Plan de secteur" in Wallonia). DE: Delay due to unclear permitting framework (legal framework for planning approval is presently under development
93	**RES/SoS Norway/Sweden phase 1**								
		895	Sweden bidding area SE2+SE3		Shunt compensation in several existing stations for increased capacity in cut 2 between SE2 and SE3 in Sweden	2019	Planning	Delayed	Delay due to changed implementation, the installation will be done during several years. Commissioning dates expected to be between 2016 and 2020
		413	Ørskog (NO)	Sogndal (NO)	New 285 km single circuit 400kV OHL.	2016	Under Construction	Delayed	Delayed due to delayed permits in certain areas
		414	Fardal (NO)	Sogndal (NO)	Voltage upgrading of existing single circuit 300kV OHL Sogndal-Aurland Extension of 413 - Ørskog - Fardal.	2018	Planning	Expected earlier than planned previously	On time
94	**GerPol Improvements**								
		992	Vierraden		Installation of new PSTs in Vierraden	2017	Planning	New Investment	Based on a common agreement between PSE and 50Hertz the investment was specified in more detail in close cooperation between PSE and 50Hertz. The common solution consists of PST in Vierraden (DE) and PST in Mikułowa (PL) Investment 799.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		139	Vierraden (DE)	Krajnik (PL)	Upgrade of existing 220 kV line Vierraden-Krajnik to double circuit 400 kV OHL.	2017	Design & Permitting	Investment on time	A delay in the permit process for the line Neuenhagen-Bertikow-Vierraden (DE) as a prerequisite caused an adaptation in the time schedule for the line between Vierraden and Krajnik from to 2017.
		796	Krajnik (PL)		Upgrade of 400/220 kV switchgear in substation Krajnik (new 400/220 kV switchyard).	2017	Design & Permitting	Delayed	The comissioning time of the investment has been aligned with the schedule for the investment 139.
		799	Mikulowa (PL)		Installation of new Phase Shift Transformer in substation Mikułowa and the upgrade of substation Mikułowa for the purpose of PST installation.	2015	Design & Permitting	Delayed	Investment postponed because of prolongation of the tendering process. Due to complexity of the technical solutions more time is needed for the tendering procedure.
96	**Keminmaa-Pyhänselkä**								
		801	Keminmaa (FI)	Pyhänselkä (FI)	Integration of new generation + increased transmission capacity demand.	2024	Under Consideration	Rescheduled	Investment progresses as planned, rescheduled slightly since last TYNDP due to expected development on the drivers behind the investment.
97	**97 FV connections**								
		802	Valkeus (FI)	Lumimetsä (FI)	New double circuit 400 kV OHLs required to connect Fennovoimas new 1 250-1 700 MW nuclear power plant that will be built in Pyhäjoki	2024	Under Consideration	Rescheduled	Investment progresses as planned, Ending station names have been updated. The investor has stated that the plant will produce energy by 2024, expected commissioning of the lines by 2024.
98	**98 OL4 connection**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		803	Rauma (FI)	Forssa (FI)Lieto (FI)Ulvila (FI)	New single circuit 400 kV OHLs required to connect TVO's new 1 000-1 800 MW nuclear power plant that will be built in Olkiluoto	2020	Under Consideration	Investment on time	Investment progresses as planned. Expected commissioning of the lines according to the plans of the investor by the later part of 2020's.
104	**RES Mid Norway/Sweden north**								
		1006	Namsos	Storheia	120 km, 420 kV, overhead line for RES-integration	2019	Planning	New Investment	RES-integration
		1007	Storheia	Snillfjord	70 km new AC line for RES-integration, incl. 8km subsea cable	2022	Planning	New Investment	RES
		398	Under consideration (SE)		New series compensation of OHL in Cut 1	2018	Under Consideration	Delayed	Rescheduled following a review of priorities and dependencies for all grid reinforcements. Thanks to postponment of this investment, other internal investments will be commissioned on time
		415	Namsos (NO)	Klæbu (NO)	New line and voltage upgrade of 286km single circuit 400kV OHL	2017	Design & Permitting	Delayed	Other projects in Statnetts portfolio evaluated as more critical
		418	Nedre Røssåga (NO)	Namsos (NO)	Upgrade of 70km single circuit 400kV OHL	2019	Design & Permitting	Investment on time	On time
		420	Snillfjord (NO)	Trollheim (NO)	New 60 km single circuit 400kV OHL	2019	Design & Permitting	Investment on time	Investment dependent on confirmed investment decisions wind power.
		416	Klæbu (NO)	Aura/ Viklandet (NO)	Voltage upgrading of existing single circuit 300kV OHL Klæbu-Aura.	2020	Design & Permitting	Investment on time	On time
105	**Edsäter-Stenkullen**								
		808	Edsäter (SE)	Stenkullen (SE)	New 80km single circuit 400kV OHL	2020	Planning	Delayed	Rescheduled following a review of priorities and dependencies for all grid reinforcements. Thanks to postponment of this investment, other internal investments will be commissioned on time
110	**Norway-Great Britain**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		424	Kvilldal (NO)	Blythe (GB)	A 720 km long 500 kV 1400 MW HVDC subsea interconnector between western Norway and eastern England.	2020	Design & Permitting	Investment on time	On time
111	**3rd AC Finland-Sweden north**								
		396	Finland North (FI)	Sweden bidding area SE1/SE2	Third single circuit 400kV AC OHL between Sweden and Finland	2025	Under Consideration	Rescheduled	Rescheduled following a review of priorities and dependencies for all grid reinforcements in Sweden. Thanks to postponment of this investment, other internal investments will be commissioned on time
113	**Doetinchem - Niederrhein**								
		145	Niederrhein (DE)	Doetinchem (NL)	New 400kV line double circuit DE-NL interconnection line. Length:57km.	2016	Design & Permitting	Delayed	Permitting procedures take longer than expected
116	**LUXEMBOURG 400 KV**								
		446	Schifflange (LU)		As a first interim step a PST is commissioned in 2016 in Schifflange and connected to an existing OH-line with an additional 3.5km cable between Biff(CREOS-LU) and Substation Bascharage (CREOS-LU).	2016	Planning	Investment on time	Studies for interim step are finalized, Investment decision expected by mid of 2014
		447	Heisdorf (LU)	Berchem (LU)	Erection of a new 20km 225kV double-circuit mixed (cable+OHL)line with 1000 MVA capacity in order to create a loop around Luxembourg city including substations for in feed in lower voltage levels.	2017	Design & Permitting	Investment on time	Substation Blooren is authorized and under construction, Authorization for line section is still pending
		651	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 220kV lines and partial new construction of lines; With power transformer station in LU	2032	Under Consideration	Rescheduled	Further market studies after 2018 needed
123	**LitPol Link Stage 2**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1038	Alytus		Construction of the second 500 MW back-to-Back converter station in Alytus	2020	Planning	New Investment	This investment was missing not explicitly mentioned in TYNDP 2012,but was already foreseen.
		335	Ostroleka (PL)	Olsztyn Matki (PL)	Construction of new 400 kV line Ostrołęka - Olsztyn Mątki after dismantling of 220kV line Ostrołęka - Olsztyn with one circuit from Ostrołęka to Olsztyn temporarily on 220 kV.	2017	Design & Permitting	Investment on time	The investment in on time.
		373	Ostroleka (PL)	Stanislawów (PL)	Construction of new 400 kV line Ostrołęka-Stanisławów.	2020	Design & Permitting	Investment on time	The project is at the design stage.
		374	Kozienice (PL)	Siedlce Ujrzanów (PL)	Construction of new 400 kV line Kozienice-Siedlce Ujrzanów.	2019	Design & Permitting	Expected earlier than planned previously	The commissioning date has been adjusted compared to the previous national plan and TYNDP.
124	**NordBalt phase 2**								
		378	Panevezys (LT)	Musa (LT)	New single circuit 330kV OHL (1080 MVA, 80km).	2022	Planning	Rescheduled	Investment 60 is postponed in the new national transmission grid development plan. Construction of new NPP, which has impact to the necessity of this investment is unclear, so priority was taken to the other internal investments needed.
		733	Ekhyddan (SE)	Nybro/Hemsjö (SE)	New single circuit 400 kV OHL. A key investment to accomplish full utilization of the NordBalt cable between Lithuania and Sweden (project 60) at all times.	2021	Planning	Rescheduled	Thanks to postponement, other internal investments will be commissioned on time. Congestions due to the delay will be handled by investing in a temporary system protection scheme.
126	**SE North-south reinforcements**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		806	Råbäcken (SE)	Trolltjärn (SE)	New 55 km single circuit 400kV OHL	2030	Under Consideration	Cancelled	Slower RES increase than planned in the area. The investment is now included in investment 403.
		399	Dingtuna (SE)	Karlslund (SE)	Upgrade of existing single circuit 220kV lines to 400kV. The investment is a part of investment 403	2021	Under Consideration	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
		786	Ängsberg (SE)	Horndal (SE)	New 85 km single circuit 400kV OHL. The investment is a part of investment 403	2021	Under Consideration	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
		787	Horndal (SE)	Dingtuna (SE)	New 90 km single circuit 400kV OHL	2021	Under Consideration	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
		788	Hamra (SE)	Dingtuna (SE)	New 50km single circuit 400kV OHL	2023	Under Consideration	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
		403	Sweden bidding area SE1	Sweden bidding area SE3	Based on a joint Statnett & Svenska Kraftnät study for North-South reinforcements, this contains reinforcements in cut 1 and 2 in Sweden	2025	Under Consideration	Investment on time	The investment now combine new investments and the previous 399, 786, 787, 788 and 806. All of the old investments appear only in the list of cancelled investments in the regional plan
129	**OWP Northsea TenneT Part 4**								
		943	NOR-9-1	Cloppenburg	Connection of new offshore wind park. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 255 km. Line capacity: 900 MW	2028	Under Consideration	New Investment	new investment
		945	NOR-10-1	Cloppenburg	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 260km. Line	2029	Under Consideration	New Investment	new investment

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
					capacity: 900 MW				
		947	NOR-11-2	Wilhelmshafen	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 270km. Line capacity: 900 MW	2031	Under Consideration	New Investment	new investment
		951	NOR-13-2	Kreis Segeberg	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 330km. Line capacity: 900 MW	2030	Under Consideration	New Investment	new investment
130	**N-S Eastern DE_section East**								
		665	Lauchstädt (DE)	Meitingen (DE)	New DC- lines to integrate new wind generation from control area 50Hertz especially Mecklenburg-Vorpommern, Brandenburg and Sachsen-Anhalt towards Central/south Europe for consumption and storage.	2022	Planning	Investment on time	Result from National Grid Development Plan
		208	Pulgar (DE)	Vieselbach (DE)	Construction of new 380kV 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.	2024	Planning	Investment on time	The project is part of the results of the national grid development plan and included in the list of national interest (Bundesbedarfsplan). With in this process the commissioning dates of the included projects have been aligned with the current situation.
132	**N-S Western DE_section North_2**								
		661	Emden East (DE)	Osterath (DE)	New HVDC-lines from Emden to Osterath to integrate new wind generation especially from North Sea towards Central Germany for consumption.	2022	Planning	Investment on time	Progess as planned.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		663	Cloppenburg East (DE)	Merzen (DE)	New 380-kV double circuit over-head-line Cloppenburg East - Merzen with a total length of ca. 55 km. New errection of a 380-kV substation Merzen.	2022	Planning	Investment on time	Progess as planned.
		666	Conneforde (DE)	Cloppenburg (DE)	New 380-kV-line in existing OHL corridor for integration of on- and offshore Wind generation. Incl. new 380-kV-switchgear in Cloppenburg and new transformers in Cloppenburg	2022	Planning	Investment on time	TYDNP 2012 investment 43.A89 is divided in serveral parts
133	**Longterm German RES**								
		956	Schleswig-Hostein	Baden-Würtemberg / Bavaria	new DC- line in HVDC technology to integrate new wind generation from northern Germany toward soutern Germany and southern Europe for consumption and storage. Connections points north: Brunsbüttel, Wilster, Kreis Segeberg, Stade, Alfsted. South: Großgartach, Goldshöfe, Raitersaich, Vöhringen	2030	Under Consideration	New Investment	new investment
		969	lower saxony	NRW	New HVDC line to integrate new wind gerneration especially from North Sea towards Central Germany for consumption and storage. connections points north: Emden, Conneforde. South: Oberzier, Rommerskirchen	2030	Under Consideration	New Investment	new investment
		970	lower saxony	Hessen/Baden-Würtemberg	New HVDC line to integrate new wind gerneration especially from North Sea towards South Germany for consumption and storage. Connectionspoints north: Cloppenburg, Elsfelth/West. South: Bürstadt, Philipsburg	2030	Under Consideration	New Investment	new investment
		958	Güstrow (DE)	Meitingen (DE)	New DC- lines to integrate new wind generation from Baltic Sea and control area 50Hertz especially Mecklenburg-Vorpommern towards Central/south Europe for consumption and storage.	2034	Under Consideration	New Investment	New Investment

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
134	N-S Western DE_section South								
		660	Osterath (DE)	Philippsburg (DE)	New HVDC-lines from Osterath to Philippsburg to integrate new wind generation especially from North Sea towards Central-South Germany for consumption and storage.	2019	Design & Permitting	Investment on time	Progess as planned.
		179	Rommerskirchen (DE)	Weißenthurm (DE)	New380 kV overhead line in existing route. Extension and erection of substations incl. erection of 380/110kV-transformers.	2017	Under Construction	Delayed	The section Rommerskrichen to Sechtem is delayed because the permitting procedures take longer than planned. The 36 km section from Sechtem to Weißenturm is already commissioned.
		680	Urberach (DE)	Daxlanden (DE)	New line and extension of existing line to 380 kV double circuit overhead line Urberach - Weinheim - Daxlanden. Extension of existing substations are included.	2021	Planning	Investment on time	Progess as planned.
		176	Daxlanden (DE)	Eichstetten (DE)	This AC project is necessary in order to evacuate the energy arriving from HVDC corridors towards southern Germany and reinforce the interconnection capacity with Switzerland	2020	Under Consideration	Investment on time	No significant change
135	N-S Western DE_parallel lines								
		662	Wehrendorf (DE)	Urberach (DE)	New lines in HVDC technology from Wehrendorf to Urberach to integrate new wind generation especially from North Sea towards Central-South Europe for consumption and storage.	2022	Under Consideration	Rescheduled	The need for this long-term investment was not confirmed by the regulatory authority within the national grid development plan 2012. Therefore further studies on this project are ongoing.
		188	Kruckel (DE)	Dauersberg (DE)	New 380 kV over head lines in existing rout. Extension of existing and erection of several 380/110kV-substations.	2020	Design & Permitting	Investment on time	Progress as planned.

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		680	Urberach (DE)	Daxlanden (DE)	New line and extension of existing line to 380 kV double circuit overhead line Urberach - Weinheim - Daxlanden. Extension of existing substations are included.	2021	Planning	Investment on time	Progess as planned.
152	France Germany Interconnection								
		988	Vigy	Ensdorf or further (tbd)	Upgrade of the existing Vigy Ensdorf (Uchtelfangen) 400 kV double circuit OHL to increase its capacity.	2030	Under Consideration	New Investment	Commissioning date will result from the on-going technical feasibility under investigation.
		989	Muhlbach	Eichstetten	Operation at 400 kV of the second circuit of a 400kV double circuit OHL currently operated at 225 kV ; some restructuration of the existing grid may be necessary in the area.	2026	Under Consideration	New Investment	Studies in progress showed the feasibility of upgrading the existing asset in order to provide mutual support to Alsace and Baden and some exchange capacity increase between France and Germany. The detailed timeline of the investment is under definition.
162	Finland Norway								
		397	Varangerbotn (NO)	Pirttikoski or Petäjäskoski (FI)	New single circuit 380 - 400kV OHL (500km). Alternative to smaller capacity increase of parallel and series compensation	2030	Under Consideration	Investment on time	Fingrid and Statnett have decided to study increasing capacity of the existing 220kV line instead of a new 400 kV line, thus the expected capacity increase is less than 500 MW, and the project is moved to Regional plan
163	BalticCorridor								
		1004	Sindi	Paide	Reinforcement of existing 330 kV OHL between Paide and Sindi 330 kV substations in Estonia. Old line will be replaced with new towers and wires of 3x400 mm2 in phase. The thermal capacity of the line is planned 1143 MVA. The investment	2030	Planning	New Investment	-

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
					is also a backbone for Baltics Synchronization with CE (project nr 170).				
		1010	Tartu	Valmiera	Reinforcement of existing 330 kV OHL with new towers and wires of 3x300 mm2 in phase. The thermal capacity of the line is planned 1000 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	2030	Under Consideration	New Investment	-
		1011	Tsirguliina	Valmiera	Reinforcement of existing 330 kV OHL with new towers and wires of 3x300 mm2 in phase. The thermal capacity of the line is planned 1000 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	2030	Under Consideration	New Investment	-
		1012	Balti	Tartu	Reinforcement of existing 330 kV OHL between Balti and Tartu 330 kV substations in Estonia. Old line will be replaced with new towers and wires of 3x400 mm2 in phase. The thermal capacity of the line is planned 1143 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	2030	Under Consideration	New Investment	-
		1013	Eesti	Tsirguliina	Reinforcement of existing 330 kV OHL between Eesti and Tsirguliina 330 kV substations in Estonia. Old line will be replaced with new towers and wires of 3x400 mm2 in phase. The thermal capacity of the line is planned 1143 MVA. The investment is also a backbone for Baltics Synchronization with CE (project nr 170).	2030	Under Consideration	New Investment	-

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1062	TEC2	Salaspils	Internal reinforcement for Baltic Corridor 600 MW	2030	Under Consideration	New Investment	-
		1063	TEC1	TEC2	Investment is necessary to strenghtening internal grid in Latvia due to get transmission capacity of 600 MW via Latvia	2030	Under Consideration	New Investment	-
		1064	Viskali (LV)	Musa (LT)	To get 600 MW of capacity via Baltic States additionally.	2030	Under Consideration	New Investment	-
		1065	Aizkraukle (LV)	Panevežys (LT)	To increase transmission capacity by 600 MW via Baltic States	2030	Under Consideration	New Investment	-
164	**N-S Eastern DE_central section**								
		149	Dollern (DE)	Stade (DE)	New 380kV double circuit OHL Dollern - Stade including new 380kV switchgear in Stade. Length:14km.	2022	Design & Permitting	Delayed	The investment is delayed because of changes in the investment driver
		664	Brunsbüttel, Wilster, Kreis Segeberg	Großgartach, Goldshöfe, Grafenrheinfeld	New DC-lines to integrate new wind generation from Northern Germany towards Southern Germany and Southern Europe for consumption and storage.	2022	Planning	Investment on time	The expected commissioning date is 2017 - 2022
		157	Wahle (DE)	Mecklar (DE)	New 380kV double circuit OHL Wahle - Mecklar including two new substations. Length: 210km.	2018	Design & Permitting	Delayed	delay due to long permitting process
		677	Dollern (DE)	Landesbergen (DE)	New 380 kV line in existing OHL corridor Dollern-Sottrum-Wechold-Landesbergen (130 km)	2022	Planning	Investment on time	
		177	Goldshöfe (DE)	Bünzwangen (DE)	AC-extension of the "C corridor" at one ending point in Southern Germany towards the consumption areas allowing the existing grid to deal with the additionnal flows from DC-link	2020	Design & Permitting	Investment on time	Anticipation of design and permitting phase due to foreseen difficulties (protected area in the Swabian Alps)
		685	Mecklar (DE)	Grafenrheinfeld (DE)	New double circuit OHL 400-kV-line (130 km)	2022	Planning	Investment on time	
166	**DKE-PL interconnection**								
		994	Bjæverskov	Dunowo	This project candidate investigates the possibility of establishing an interconnector between Bjæverskov (Denmark) and Dunowo (Poland). This very first conceptual study looks at a 500 kV 600 MW HVDC	2030	Under Consideration	New Investment	This is a conceptual project. In case the assessment is promising, it might be taken to a next step, in case it is not, it will be cancelled.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
					subsea connection, testing the idea of connecting these markets.				
167	DKW-GB								
		998	Idomlund (DKW)	Stella West (GB)	2x700 MW HVDC subsea link across the North Seas.	2030	Under Consideration	New Investment	New opportunity to integrate markets, new opportunity to exploit non correlated RES
		436	Idomlund (DK)	Endrup (DK)	New 74km single circuit 400kV line via cable with capacity of approx. 1200MW.	2030	Under Consideration	Rescheduled	In national plan route is replaced by different project, upgrading an existing route from Tjele to Idomlund (72.898). The known route (Endrup-Idomlund) from the TYNDP12 would additionally be necessary as soon as the interconnection to GB is built.
170	Baltics synchro with CE								
		1034	Substation in Lithuania	State border	400 kV interconnection line for synchronous interconnection of Baltics	2023	Under Consideration	New Investment	-
		380	Visaginas (LT)	Kruonis (LT)	New single circuit 330kV OHL (1080 MVA, 200km) for the internal grid reinforcement.	2022	Under Consideration	Rescheduled	Investment depending on Visaginas NPP construction time.
		382	Vilnius (LT)	Neris (LT)	New single circuit 330kV OHL (943 MVA, 50km).	2022	Planning	Rescheduled	Investment 61 is postponed in the new national transmission grid development plan. Construction of new NPPP is unclear, so priority was taken to the other internal investments needed.
175	Great Belt II								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1000	Malling (DKW)	Kyndby (DKE)	600 MW HVDC subsea link between both DK systems (2 synchr. areas, 2 market areas)	2030	Under Consideration	New Investment	in case of n expanded DKE-SE connection this link could be beneficial.
176	**Hansa PowerBridge**								
		995	Station SE4	Station DE	New DC cable interconnector between Sweden and Germany.	2025	Under Consideration	New Investment	RGBS common investigations for TYNDP 2014
178	**DKW - SE3**								
		1015	Vester Hassing (DK1)	Station SE3	new 700 MW HVDC subsea cable between DK1 and SE3	2030	Under Consideration	New Investment	RGBS common investigations for TYNDP14
		429	Ferslev (DK)	Vester Hassing (DK)	New 20km single circuit 400kV line via a cable with a capacity of approx. 800 MW.	2030	Under Consideration	Rescheduled	cancelled in National Plan due to changed plan. But would be necessary in case Kontiscan III to Sweden would be built.
		431	Tjele (DK)	Trige (DK)	New 46km single circuit 400kV line via cable with capacity of approx. 1200 MW.	2030	Under Consideration	Rescheduled	cancelled due to changed national plan. But necessary if Kontiscan 3 would be implemented
179	**DKE - DE**								
		1016	Bjæverskov (DK2)	Bentwisch (DE)	new 600 MW HVDC subsea cable connecting DK2 and DE	2030	Under Consideration	New Investment	RGBS common investigations for TYNDP14
180	**Norway-Sweden North**								
		1017	Nedre røssåga	Grundfors	If realized the line most probably will replace the existing 220 kV line between Nedre Røssåga (northern Norway) and Grundfors (northern Sweden).	2030	Under Consideration	New Investment	RES, SoS, Market
183	**DKW-DE, Westcoast**								
		1018	Niebüll (DE)	Endrup (DKW)	new 380 kV cross border line DK1-DE for integration of RES and increase of NTC	2022	Planning	Investment on time	in TYNDP12 this investment was part of 43.A90
187	**St. Peter - Pleinting**								
		997	Pleinting (DE)	St. Peter (AT)	new 380-kV-line Pleinting (DE) - St. Peter (AT) on exting OHL corridor	2022	Under Consideration	New Investment	new investment

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
190	**Norway-Great Britain**								
		1033	Sima	Peterhead	A 650 km long 500 kV 1400 MW HVDC subsea interconnector between western Norway and eastern Scotland.	2020	Design & Permitting	New Investment	Project application to TYNDP 2014.
191	**OWP TenneT Northsea Part 2**								
		952	Cluster DolWin 5 (NOR-1-1)	Halbemond	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 250 km. Line capacity: 900 MW	2021	Under Consideration	New Investment	new investment
		953	Cluster DolWin 6 (NOR-3-3)	Halbemond	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 60km. Line capacity: 900 MW	2021	Under Consideration	New Investment	new investment
		954	Cluster BorWin 5 (NOR-7-1)	Halbemond	Connecton of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 260km. Line capacity: 900 MW	2022	Under Consideration	New Investment	new investment
		211	Cluster DolWin 4 (NOR 3-2)	Unterweser	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 190km. Line capacity: 900 MW	2020	Under Consideration	Investment on time	on time
		656	Cluster BorWin3	Emden/Ost (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 160 km. Line capacity: 900 MW	2018	Design & Permitting	Investment on time	
		658	Cluster BorWin4 (DE)	Emden/Ost (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 172 km. Line capacity: 900 MW	2019	Design & Permitting	Investment on time	
192	**OWP Northsea TenneT Part 3**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		946	NOR-11-1	Elsfleth/West	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 230km. Line capacity: 900 MW	2026	Under Consideration	New Investment	new investment
		948	NOR-12-1	Wilhelmshafen	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 230km. Line capacity: 900 MW	2027	Under Consideration	New Investment	new investment
		950	NOR-13-1	Kreis Segeberg	Connection of new offshore wind parks. New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 330km. Line capacity: 900 MW	2025	Under Consideration	New Investment	new investment
		955	Cluster BorWin6 (NOR-7-2)	Unterweser	Connection of new offshore wind parks.New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 180km. Line capacity: 900 MW	2023	Under Consideration	New Investment	new investment
		659	Cluster SylWin2 (DE)	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205 km. Line capacity: 900 MW	2023	Under Consideration	Investment on time	
197	**N-S Finland P1 stage 2**								
		742	Pyhänselkä (FI)	Petäjävesi (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. Will replace existing 220 kV lines.	2023	Design & Permitting	Delayed	Rescheduled due to timing of system changes that trigger the investment. End station name updated.
198	**Area of Lake Constance**								

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		984	Herbertingen	Tiengen	Herbertingen – Tiengen: Between the two substations Herbertingen and Tiengen a new line will be constructed in an existing corridor. Enhancement of the grid, which will increase transmission capacity noticeably, is needed at the substation Herbertingen.	2020	Planning	Investment on time	Progess as planned. This project is a concretion of TYNDP12 project 44.A77. Due to the ongoing planning stage, this section was developed and an own investment item was created.
		985	point Rommelsbach	Herbertingen	Rommelsbach – Herbertingen: Between point Rommelsbach and substation Herbertingen a new line will be constructed in an existing corridor. This will significantly increase transmission capacity (grid enhancement).	2018	Planning	Investment on time	Progess as planned. This project is a concretion of TYNDP12 project 44.A77. Due to the ongoing planning stage, this section was developed and an own investment item was created.
		986	point Wullenstetten (DE)	point Niederwangen (DE)	Point Wullenstetten – Point Niederwangen Between point Wullenstetten and point Niederwangen an upgrade of an existing 380-kV-line is necessary (grid enhancement). Thereby, a significantly higher transmission capacity is realized. The 380 kV substation station Dellmensingen is due to be extended (grid enhancement).	2020	Planning	Investment on time	This project is a concretion of TYNDP 2012 project 44.A77. Due to the ongoing planning stage, this section was developed and an own investment item was created.
		1043	Neuravensburg	border area (AT)	Point Neuravensburg – Point Austrian National border (AT) Between switching point Neuravensburg and Austrian National border (AT) a new line with a significantly higher transmission capacity will be constructed in an existing corridor (grid enhancement).	2023	Planning	Investment on time	This project is a concretion of TYNDP 2012 project 44.A77. This investment is caused by the investment 136 "Bodensee Studie". Due to the ongoing planning stage, this section was developed and an own investment item was created.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		136	Border area (DE-AT)	Rüthi (CH)	380 kV Rüthi – Meiningen and 380 kV Meiningen - Border Area AT-DE	2022	Planning	Investment on time	investment 136 now comprises the cross-border part of former investment 136, and investment 1099 is the Swiss part of former investment 136.
201	**Upgrade Meeden - Diele**								
		1066	Meeden		Increase of the interconection capacity between NL and DE by approximately 1000 MW by adding two new phase shifting transformers and upgrade of an existing tie line between Meeden and Dielen	2018	Planning	New Investment	In a crossborder study the investment along the existing Meeden - Diele corridor has been identified as feasible and cost effective
204	**N-S transmission DE_par_line_2**								
		686	Schalkau / area of Altenfeld (DE)	area of Grafenrheinfeld (DE)	New double circuit OHL 380-kV-line (130 km)	2024	Under Consideration	Rescheduled	Delay due to missing confirmation by the regulator
205	**N-S transmission DE_par_line_1**								
		153	Redwitz (DE)	Grafenrheinfeld (DE)	Upgrade of 220kV connection Redwitz - Grafenrheinfeld to 380kV, including new 380kV switchgear Eltmann. Line length: 97km.	2015	Design & Permitting	Delayed	Delayed due to delaye of related investment 45.193 and unexspected long permitting process of the investment itself
		193	Vieselbach (DE)	Redwitz (DE)	New 380kV double-circuit OHL between the substations Vieselbach-Altenfeld-Redwitz with 215km length combined with upgrade between Redwitz and Grafenrheinfeld (see investment 153). The Section Lauchstädt-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 Eastern and Western Germany and is right	2015	Design & Permitting	Delayed	Previously "mid term" is now updated to specific date. Partly under construction (section Vieselbach – Altenfeld). 3rd section (Altenfeld – Redwitz) in permitting process, long permitting process with strong public resistance.

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
					downstream in the main load flow direction. The project will help to avoid loop flows through neighboring grids.				
206	**Reinforcement Southern DE**								
		682	Großgartach (DE)	Endersbach (DE)	AC-extension of the "C corridor" at one ending point in Southern Germany towards the consumption areas allowing the existing grid to deal with the additionnal flows from DC-link	2019	Planning	Investment on time	Standard processing 2018-2019
		687	Redwitz (DE)	Schwandorf (DE)	New double circuit OHL 380 kV line in existing OHL corridor Redwitz-Mechlenreuth-Etzenricht-Schwandorf (185 km)	2020	Planning	Investment on time	
		688	Raitersaich (DE)	Isar (DE)	New 380 kV line in existing OHL corridor Raitersaich - Ludersheim - Sittling - Isar or Altheim (160 km)	2024	Under Consideration	Rescheduled	Delay due to missing confirmation by the regulator
		990	Grafenrheinfeld (DE)	Großgartach (DE)	AC-extension of the "C corridor" between two of its ending points in Southern Germany allowing the existing grid to deal with the additional flows from DC-link	2019	Planning	New Investment	Standard processing
207	**Reinforcement Northwestern DE**								
		939	Conneforde	Emden/Ost	New 380-kV-line in existing OHL corridor for integration of RES	2019	Planning	Delayed	In TYNDP 2012 part of investment 43.A89
		940	Emden/Ost	Halbemond	New 380-kV-line Emden - Halbemond for RES integration incl. new transformers in Halbemond	2021	Under Consideration	Rescheduled	In TYNDP 2012 part of investment 43.A89

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		675	Conneforde (DE)	Unterweser (DE)	Upgrade of 220-kV-circuit Unterweser-Conneforde to 380kV , Line length: 32 km.	2024	Under Consideration	Rescheduled	Delay due to missing confirmation by the regulator
		676	Dollern (DE)	Elsfleht/West (DE)	New 380 kV line in existing OHL corridor Dollern - Elsfleht/West Length:100 km	2024	Under Consideration	Rescheduled	Delay due to missing confirmation by the regulator
208	**N-S Western DE_section North_1**								
		150	Conneforde (DE)	Fedderwarden (DE)	New 380kV double circuit (OHL, partly underground) Conneforde - Wilhelmshaven (Fedderwarden, former Maade) including new 400kV switchgear Fedderwarden. Length: 35 km.	2018	Design & Permitting	Investment on time	
		151	Wehrendorf (DE)	Ganderkesee (DE)	New line (length: ca. 95km), extension of existing and erection of substations, erection of 380/110kV-transformers.	2017	Design & Permitting	Delayed	delay due to long permitting process
		156	Niederrhein (DE)	Dörpen/West (DE)	New 380 kV double circuit overhead line Dörpen - Niederrhein including extension of existing substations.	2018	Design & Permitting	Delayed	The project is delayed due to delays in public-law and civil-law licensing procedures.
209	**Reinforcement Northeastern DE**								
		935	Kreis Segeberg	Göhl	New 380-kV-lineKreis Segeberg - Lübeck - Siems - Göhl, including five new transformers	2021	Under Consideration	Rescheduled	Investment was part of investment 43.A90 in TYNDP 2012. Now seperatly
		937	Audorf	Kiel	New 380-kV-line in existing OHL corridor including 4 new transformers and new 380-kV-switchgears in Kiel/West and Kiel/Süd	2021	Under Consideration	Rescheduled	In TYNDP 2012 this investment was part of investment 43.A90
		667	Brunsbüttel (DE)	Niebüll	About 135 km new 380-kV-lines and around 10 new transformers for integration of onshore Wind in Schleswig-Holstein and increase of NTC between DE and DK	2018	Planning	Delayed	The old investment 43.A90 is now divided in several parts.
		147	Dollern (DE)	Hamburg/Nord (DE)	New 380kV double circuit OHL Dollern - Hamburg/Nord. Length:43km. First circuit 2015, second cicuit 2017	2017	Under Construction	Delayed	Delay due to long permitting process

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		148	Audorf (DE)	Hamburg/Nord (DE)	New 380kV double circuit OHL Audorf - Hamburg/Nord including two new 380/220kV transformers in substation Audorf and new 380 kV Switchgear in Kummerfeld. Length: 65km.	2017	Design & Permitting	Delayed	delay due to long permitting process
225	2nd Interconnector Belgium – Germany								
		1107	BE (TBD)	DE (TBD)	This investment item envisions the possibility of a second 1 GW interconnection between Belgium and Germany. Subject to further studies.	2030	Under Consideration	New Investment	Preliminary studies on high RES scenario's have indicated potential for further regional welfare & RES integration increase by further increasing the interconnection capacity between Belgium & Germany towards time horizon 2025-2030.
		898	Idomlund (DK)	Tjele (DK)	Upgrade of 400 kV OHL Idomlund-Tjele to double circuit	2020	Planning	New Investment	Replace investment no. 436
		959	Lubmin (DE)	Güstrow (DE)	380-kV-grid enhancement and structural change Lubmin-Lüdershagen-Bentwisch-Güstrow	2024	Under Consideration	New Investment	New Investment
		960	Lubmin (DE)	Pasewalk (DE)	380-kV-grid enhancement and structural change area Lubmin-Iven-Pasewalk.	2030	Under Consideration	New Investment	New Investment
		965	Hamburg/Nord (DE)	Hamburg/Ost (DE)	AC Enhancement Hamburg	2024	Under Consideration	New Investment	New Investment
		966	Krümmel (DE)	Hamburg/Nord (DE)	AC Enhancement Krümmel	2024	Under Consideration	New Investment	New Investment
		967	control area 50Hertz		Contructions of new substations, Var-compensation and extension of existing substations for integration of newly build power plants and RES in 50HzT control area	2023	Planning	New Investment	Commisioning date for different substations varies from 2015 to 2023 depending on local increase of RES or commisioning of power plants. The investment includes the old investments 204 and 205.

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		974	Elsfleht/West	Ganderkesee	new 380 kV OHL in existing corridor for RES integration between Elsfleth/West, Niedervieland and Ganderkesee	2030	Under Consideration	New Investment	new investment
		975	Irsching	Ottenhofen	new 380-kV-OHL in existing corridor between Irsching and Ottenhofen	2030	Under Consideration	New Investment	new investment
		976	Dollern	Alfstedt	new 380-kV-OHL in existing corridor in Northern Lower Saxony for RES integration	2030	Under Consideration	New Investment	new investment
		977	Unterweser	Elsfleth/West	new 380-kV-OHL in existing corridor for RES integration in Lower Saxony	2030	Under Consideration	New Investment	new investment
		978	Conneforde	Unterweser	new 380-kV-OHL in existing corridor for RES integration in Lower Saxony	2030	Under Consideration	New Investment	new investment
		993	Röhrsdorf (DE)		Installation of new PSTs in Röhrsdorf	2016	Planning	New Investment	New Investment. Commissioning date between 2016-2023.
		1067	Klostermannsfeld (DE)	Lauchstädt (DE)	TBA	2024	Planning	New Investment	New Investment
		1088	Mengede (DE)	Wanne (DE)	Reconductering of existing 380kV line Mengede - Herne - Wanne.	2014	Under Construction	Investment on time	Progress as planned
		1089	Point Ackerstraße	Point Mattlerbusch	Reconductering of existing 380kV line between Point Ackerstraße-Mattlerbusch	2014	Under Construction	Investment on time	Progress as planned
		1090	Niederhein (DE)	Utfort (DE)	New lines and installation of additional circuits, extension of existing and erection of several 380/110kV-substations.	2018	Design & Permitting	Investment on time	Progess as planned
		1091	Günnigfeld (DE)	Wanne (DE)	Reconductering of existing 380kV line	2018	Design & Permitting	Investment on time	Progress as planned
		1092	Landesbergen (DE)	Wehrendorf (DE)	Installation of an additional 380-kV circuit between Landesbergen and Wehrendorf	2023	Planning	New Investment	Due to high RES infeed in the north of Germany additional grid reinforcements are necessary.
		1093	Point Okriftel	Farbwerke Höchst-Süd	The 220kV substation Farbwerke Höchst-Süd will be upgraded to 380kV and integrated into the existing grid.	2022	Planning	Investment on time	Progress as planned

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1094	Several		This investment includes new 380/220kV transformes in Walsum, Sechtem, Siegburg, Mettmann and Brauweiler.	2024	Planning	New Investment	In order to avoid bottlenecks within transmission grid new 380/220kV transformes are needed in Walsum, Sechtem, Siegburg, Mettmann and Brauweiler.
		1095	Lippe (DE)	Mengede (DE)	Reconductering of existing 380kV line between Lippe and Mengede.	2024	Under Consideration	New Investment	Additional grid reinforcements between Lippe and Mengede are needed.
		1096	Lüstingen and Gütersloh	Gütersloh	The subsations Lüstingen to Güthersloh will be upgrade to use the line Lüstingen to Güthersloh with 380 kV.	2024	Planning	New Investment	New Investment.
		1097	Several		This investment includes several new 380/110kV transformers in order to integrate RES in Erbach, Gusenburg, Kottigerhook, Niederstedem, Öchtel, Prüm and Wadern. In addition a new 380kV substation and transformers in Krefeld Uerdingen are included.	2019	Planning	New Investment	In order to integrate RES several new 380/110kV transformers are needed in Erbach, Gusenburg, Kottigerhook, Niederstedem, Öchtel, Prüm and Wadern. In addition a new 380kV substation and transformers in Krefeld Uerdingen are included.
		1100	Herbertingen (DE)	point Neuravensburg (DE)	Between the 380-kv-station Herbertingen and point Neuravensburg a new line with a significantly higher transmission capacity will be constructed (Grid enhancement).	2034	Under Consideration	Investment on time	This project is a concretion of TYNDP 2012 project 44.A77. The need for this long-term investment was not confirmed by the regulatory authority within the national grid development plan 2012. Therefore further studies on this project are ongoing.
		1101	Büttel	Wilster	new 380-kV-line in extisting corridor in Schleswig - Holstein for integration of RES especially wind on- and offshore	2021	Under Consideration	New Investment	new investment due to German NDP 2014

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		1102	junction Mehrum	Mehrum	new 380-kV-line junction Mehrum (line Wahle - Grohnde) - Mehrum including a 380/220-kV-transformer in Mehrum	2019	Under Consideration	New Investment	new investment due to German NDP 2014
		1103	Borken	Mecklar	new 380-kV-line Borken - Mecklar in existing corridor for RES integration	2021	Under Consideration	New Investment	new investment due to German NDP 2014
		1104	Borken	Gießen	new 380-kV-line Borken - Gießen in existing corridor for RES integration	2022	Under Consideration	New Investment	new investment due to German NDP 2014
		1105	Borken	Twistetal	new 380-kV-line Borken - Twistetal in existing corridor for RES integration	2021	Under Consideration	New Investment	new investment due to German NDP 2014
		1106	Wahle	Klein Ilsede	new 380-kV-line Wahle - Klein Ilsede in existing corridor for RES integration	2018	Under Consideration	New Investment	new investment due to German NDP 2014
		1108	Metzingen-Oberjettingen	Oberjettingen-Engstlatt	New 380kV OHL Metzingen-Oberjettingen (32 km) and new 380kV OHL Oberjettingen-Engstlatt (34 km)	2020	Planning	New Investment	New investment
		1109	Großgartach	Pulverdingen	New circuit 380kV OHL Großgartach-Pulverdingen (30 km) combined with reconductering existing circuit 380kV OHL Großgartach-Pulverdingen (30 km)	2024	Planning	New Investment	New investment
		1110	Dellmensingen	Rotensohl-Niederstotzingen	New circuit 380kV OHL Dellmensingen-Rothensohl (67 km) combined with reconductering existing circuit 380kV OHL Dellmensingen-Niederstotzingen (41 km)	2024	Planning	New Investment	New investment
		327	Kozienice (PL)	Oltarzew (PL)	New 130 km 400 kV 2x1870 MVA OHL double circuit line Kozienice - Ołtarzew + upgrade and extension of 400 kV switchgear in substation Kozienice for the connection of new line.	2019	Design & Permitting	Delayed	The investment has been postponed due to prolonged tendering process (land acquisition). The line is planned on very densely populated area. The benefit of the investment is recognized on the regional and local scale (supply of Warsaw area, export needs).

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		168	Goldshöfe (DE)	Dellmensigen (DE)	Upgrade the line Goldshöfe - Dellmensigen from 220kV to 380kV . Line length:114km. Included in the investment : 3x 380kV substations, 2 transformers.	2014	Under Construction	Investment on time	No change to be reported
		138	tbd (CZ)	tbd (DE) - South-Eastern 50 Hertz	Possible increase of interconnection capacity between CEPS and 50Hertz Transmission is under consideration: either a new 400kV tie-line (OHL on new route) or a reinforcement of the existing 400kV tie-line Hradec (CEPS) – Röhrsdorf (50Hertz Transmission).	2032	Under Consideration	Investment on time	Thisinvestment item is possible after all projects in CZ area related to the are commissioned - still under consideration
		408	Kristiansand, Feda (NO)		Reactive compensation due to HVDC links NorNed and Skagerak 4. Reactive power devices in 400kV substations.	2014	Under Construction	Investment on time	NA
		428	Kassø (DK)	Tjele (DK)	Rebuilding of a 400kV OHL of 173km from a single-circuit to a double-circuit . This increases the transfer capacity with approx. 1000 MW.	2014	Under Construction	Investment on time	Under construction as scheduled
		407	Tonstad (NO)	Arendal (NO)	Voltage upgrading of existing single circuit 400kV OHL Tonstad-Solhom-Arendal.	2020	Design & Permitting	Investment on time	market
		409	Feda, Tonstad (NO)		Reactive power devices in 400kV substations.	2014	Under Construction	Investment on time	new interconnectors
		419	Namsos (NO)	Storheia (NO)	New 119km 800MVA single circuit Namsos-Roan-Storheia OHL to connect new wind power generation at Fosen.				
		174	Bruchsal Kändelweg (DE)	Ubstadt (DE)	A new 380kV OHL Bruchsal Kändelweg - Ubstadt. Length:6km.	2014	Under Construction	Investment on time	The permitting procedure has allowed the beginning of the construction
		175	Birkenfeld (DE)	Ötisheim (DE)	A new 380kV OHL Birkenfeld-Ötisheim (Mast 115A). Length:11km.	2020	Planning	Investment on time	No change to be reported
		178	Goldshöffe and Engstlatt		Installation of 2x250 MVAr 380kV capacitance banks (1x250 MVar Goldshöfe and 1x250MVar Engstlatt).	2014	Under Construction	Investment on time	No significant change

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		182	Kriftel (DE)	Obererlenbach (DE)	New 400 kV double circuit OHL Kriftel - Obererlebenbach in existing OHL corridor.	2015	Design & Permitting	Delayed	The project is delayed due to delays in public-law and civil-law licensing procedures.
		185	Hanekenfähr (DE) and Ibbenbüren (DE)	Uentrop (DE)	In order to facilitate the integration of RES (especially wind) several grid reinforcements in the area of Münsterland/Westphalia are needed. This project will affect mainly the following substations: Hanekenfähr, Uentrop, Gütersloh, Wehrendorf, Lüstringen, Westerkappeln and Ibbenbüren. Within this area new lines and installation of additional circuits are planned. In addition the necessity for extension of existing and erection of several 380/110kV-substations is given.	2020	Design & Permitting	Investment on time	Major section will be commissoned in 2014. Last sections are planned to be commissoned 2020.
		186	Gütersloh (DE)	Bechterdissen (DE)	New lines and installation of additional circuits, extension of existing and erection of 380/110kV-substation.	2014	Under Construction	Investment on time	Progess as planned.
		187	Utfort (DE)	Rommerskirchen (DE)	New lines and installation of additional circuits, extension of existing and erection of several 380/110kV-substations.	2018	Under Construction	Delayed	The investment is delayed due to delays in public-law and civil-law licensing procedures. Serveral section will be commissioned before 2018.
		189	Niederrhein (DE)	Utfort (DE)	New 400 kV double-circuit OHL Niederrhein-Utfort	2017	Design & Permitting	Investment on time	In the moment no delays are known.
		190	St. Barbara (DE)	Mittelbexbach (DE)	New lins, extension of existing and erection of several 380/110kV-substations	2014	Design & Permitting	Investment on time	Progress as planned.
		170	Großgartach (DE)	Hüffenhardt (DE)	New 380kV OHL Großgartach Hüffenhardt. Length: 23km. Included in the project : 1 new 380kV substation, 2 transformers.	2013	Under Construction	Delayed	Delay in the authorization process due to protest from local landowners
		172	Mühlhausen (DE)	Großgartach (DE)	Upgrade of the line Mühlhausen-Großgartach from 220kV to 380kV. Length: 45km.	2014	Under Construction	Investment on time	The permitting has allowed the beginning of the construction

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		173	Hoheneck (DE)	Endersbach (DE)	Upgrade of the line Hoheneck-Endersbach from 220kV to 380kV. Length:20km.	2014	Under Construction	Investment on time	The permitting procedure has allowed the construction to begin
		678	Hamm/Uentrop (DE)	Kruckel (DE)	Extension of existing line to a 400 kV single circuit OHL Hamm/Uentrop - Kruckel and extension of existing substations.	2018	Planning	Investment on time	Progess as planned.
		679	Pkt. Blatzheim (DE)	Oberzier (DE)	New 400 kV double circuit OHL Pkt. Blatzheim - Oberzier including extension of existing substations.	2018	Under Consideration	Investment on time	The need for this investment was not confirmed by the German Network development Plan 2012. Therefore further studies on this project are ongoing.
		681	Bürstadt (DE)	BASF (DE)	New line and extension of existing line to 400 kV double circuit OHL Bürstadt - BASF including extension of existing substations.	2024	Planning	Rescheduled	Rescheduled: Investemt was not confirmed by the national regulatory authority within the national grid development plan 2012. Further studies are ongoing.
		673	Pkt. Metternich (DE)	Niederstedem (DE)	Construction of new 380kV double-circuit OHLs, decommissioning of existing old 220kV double-circuit OHLs, extension of existing and erection of several 380/110kV-substations. Length: 108km.	2021	Planning	Investment on time	Progress as planned.
		672	Area of West Germany (DE)		Installation of reactive power compensation (eg. MSCDN, SVC, phase shifter). Devices are planned in Kusenhorst, Büscherhof, Weißenthurm and Kriftel. Additional reactive power devices will be evaluated.	2016	Planning	Investment on time	Progess as planned.
		191	Neuenhagen (DE)	Vierraden (DE)	Project of new 380kV double-circuit OHL Neuenhagen-Vierraden-Bertikow with 125km length as prerequisite for the planned upgrading of the existing 220kV double-circuit interconnection Krajnik (PL) – Vierraden (DE Hertz Transmission).	2017	Design & Permitting	Delayed	longer than expected permitting procedure

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		197	Neuenhagen (DE)	Wustermark (DE)	Construction of new 380kV double-circuit OHL between the substations Wustermark-Neuenhagen with 75km length. Support of RES and conventional generation integration, maintaining of security of supply and support of market development.	2018	Under Construction	Investment on time	Previously "mid-term" updated to specific date.
		199	Lubmin (DE)	Bertikow (DE)	Construction of new 380kV double-circuit OHLs in North-Eastern part of 50HzT control area and decommissioning of existing old 220kV double-circuit OHLs, incl. 380-kV-line Bertikow-Pasewalk (30 km). Length: 135km.Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	2018	Design & Permitting	Delayed	The investment is split into two investments with different commissioning dates. From Lubmin to Pasewalk long term. From Pasewalk to Bertikow in 2018.
		200	Güstrow (DE)	Wolmirstedt (DE)	380-kV-grid enhancement and structural change Magdeburg/Wolmirstedt, incl. 380-kV-line Gustrow-Wolmirstedt (195 km).	2020	Planning	Investment on time	Investment on time
		202	Bärwalde (DE)	Schmölln (DE)	Upgrading existing double-circuit 380kV OHL in the South-Eastern part of the control area of 50Hertz Transmission. Bärwalde-Schmölln length approx. 50km. Support of RES and conventional generation integration in North-Eastern Germany, maintaining of security of supply and support of market development.	2015	Under Construction	Expected earlier than planned previously	Investment is needed earlier, commissioning is being prepared.
		206	Röhrsdorf (DE)	Remptendorf (DE)	Construction of new double-circuit 380-kV-overhead line in existing corridor Röhrsdorf-Remptendorf (103 km)	2021	Planning	Delayed	

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		158	Irsching (DE)	Ottenhofen (DE)	Upgrade of 220kV connection Irsching - Ottenhofen to 380kV, including new 380kV switchgear Zolling. Length 76km.	2017	Planning	Delayed	
		683	Wolmirstedt (DE)	Wahle (DE)	New double circuit OHL 380 kV; Line length 111 km	2022	Planning	Investment on time	
		684	Vieselbach (DE)	Mecklar (DE)	New double circuit OHL 400 kV line in existing OHL corridor . (129 km)	2022	Planning	Investment on time	
		375	Plock (PL)	Olsztyn Matki (PL)	New 400 kV line Płock-Olsztyn Mątki.	2030	Under Consideration	Rescheduled	In depth analysis showed lower than anticipated utilization of the line. The implementation of this project is under consideration.
		732	Olsztyn Matki (PL)		Development 400 kV switchgear in Olsztyn Mątki substation.	2019	Design & Permitting	Expected earlier than planned previously	The investment is at the design stage.
		387	Tartu (EE)	Sindi (EE)	A new 162km internal connection will be established on existing route resulting in double circuit line with 2 different voltages (330kV / 110kV). 110kV circuit.	2014	Under Construction	Investment on time	According to working schedule
		734	Tartu (EE)	Sindi (EE)	A new 162km internal connection will be established on existing route resulting in double circuit line with 2 different voltages (330kV / 110kV). 330kV circuit.	2014	Under Construction	Investment on time	According to work schedule
		388	Harku (EE)	Sindi (EE)	New double circuit OHL with 2 different voltages 330 kV and 110 kV and with capacity 1200 MVA/240 MVA and a length 140 km. Major part of new internal connection will be established on existing right of way on the Western part of Estonian mainland. 330kV circuit.	2018	Design & Permitting	Investment on time	According to schedule
		423	Skaidi (NO)	Varangerbotn (NO)	New 230 km single circuit 400kV OHL.	2027	Planning	Rescheduled	Postponed due to uncertainty regarding demand timeframe

Project ID	Project name	Investment ID	from substation name	to substation name	description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
		430	Revsing (DK)	Landerupgård (DK)	New 27km single circuit 400kV line via cable with capacity of approx. 1200 MW.	2021	Planning	Rescheduled	Commisioning date adapted accounting for later grid connection plans for wind power and new interconnectors
		435	Endrup (DK)	Revsing(DK)	Upgrade of 30km double-circuit 400kV OHL to reach a capacity of approx. 2000MW.	2017	Design & Permitting	Delayed	commissioning date depending on grid connection plans for wind power and new interconnectors
		432	Bjaeverskov (DK)	Hovegaard (DK)	New 39km single circuit 400kV line via cable with capacity of approx. 1200 MW.	2017	Design & Permitting	Delayed	Re-prioritization, taking several other projects in the area into account (see national grid development plan.) size changes to ~800 MW.
		433	Amagerværket (DK)	Glentegård & H.C. Ørstedværket (DK)	New 22km single circuit 400kV line via cable with capacity of approx. 1200MW.	2030	Under Consideration	Cancelled	Change of general grid structure => drivers vanished. cancelled in current national plan. Projects might still be useful at a later stage in case some of the conceptual projects of this TYNDP might be built.
		324	Dobrzen (PL)	Wroclaw/Pasikurowice (PL)	New 76 km 400 kV 2x1870 MVA double circuit line from Dobrzeń to splitted Pasikurowice - Wrocław + upgrade and extension of 400 kV switchgear in substation Dobrzeń for purpose of generation connection.	2017	Design & Permitting	Investment on time	The investment is built mainly for purpose of power evacuation from planned new generation in Opole power plant. The benefit of the investment is recognized on the regional and local scale (supply of Wrocław agglomeration area, export needs).
		874	Samnanger (NO)	Sauda (NO)	Voltage upgrade of existing 300kV line.	2021	Under Consideration	Investment on time	market

11.1.3 List of commissioned investments from TYNDP and RgIPs 2012

Investment ID	TYNDP 2012 index	from substation name	to substation name	short description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	ev de
338	101. 338	Kozienice (PL)	Mory/ Piaseczno (PL)	Replacement of conductors (high temperature conductors) on existing 2x220 kV OHL.	2013	Commissioned	Commissioned ahead of time	Th ca Co
180	180	Mengede (DE)	Kruckel (DE)	Installation of a second circuit 380kV OHL from Mengede to Kruckel	2012	Commissioned	Commissioned	In
192	192	Hamburg/Krümmel (DE)	Schwerin (DE)	This 380kV double-circuit OHL project will close the missing gap in North-East German grid infrastructure. Only 65km of new line must be constructed, 22km already exist.	2012	Commissioned	Commissioned	Pr in fro
321	321	Kromolice (PL)	Patnów (PL)	New 79km 400kV 1870 MVA OHL interconnection line Kromolice - Pątnów - with one circuit from Plewiska to Koninn temporarily on 220kV after dismantling of 220kV line Plewiska - Konin.	2012	Commissioned	Commissioned	Co
322	322	Kromolice (PL)		A new AC substation between existing substations Plewiska and Ostrów and Pątnów in Poznań Agglomeration Area with transformation 400/110kV 400 MVA. New substation Kromolice is connected by splitting and extending existing line Ostrów-Plewiska and Pątnów -	2012	Commissioned	Commissioned	Co
854	333	Swiebodzice (PL)		New 400kV Świebodzice substation with 1x500MVA, 400/220kV transformation and 1x400 MVA, 400/110kV transformation.	2013	Commissioned	Commissioned ahead of time	Co
855	333	Pasikurowice (PL)	Swiebodzice (PL)	New 400kV OHL interconnection line Pasikurowice - Wrocław, including new Wrocław substation.	2013	Commissioned	Commissioned ahead of time	Co
856	333	Pasikurowice (PL)	Swiebodzice (PL)	New 400kV Wrocław substation with 2x400 MVA, 400/110kV transformation.	2013	Commissioned	Commissioned ahead of time	Co
857	333	Wroclaw (PL)	Swiebodzice (PL)	New 400kV 1870 MVA line Świebodzice - Wrocław.	2013	Commissioned	Commissioned ahead of time	Co
858	333	Wroclaw (PL)	Swiebodzice (PL)	New 400kV 1870 MVA line Pasikurowice-Wrocław.	2013	Commissioned	Commissioned ahead of time	Co

Investment ID	TYNDP 2012 index	from substation name	to substation name	short description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	ev d
859	333	Pasikurowice (PL)	Swiebodzice (PL)	A new AC substation in Wrocław Agglomeration Area. New substation Wrocław is connected to new 135km (sum) 400kV 1870 MVA lines: Pasikurowice-Wrocław and Świebodzice - Wrocław. New 400kV Wrocław substation with 2x400 MVA, 400/110kV transformation. New 400k	2013	Commissioned	Commissioned ahead of time	Co
333	333	Pasikurowice (PL)	Swiebodzice (PL)	New 400kV OHL line Wrocław - Świebodzice after dismantling of 220kV line Świebodzice - Biskupice.	2013	Commissioned	Commissioned ahead of time	Co
410	410	Kristiansand (NO)		Spare transformer for the HVDC Skagerak interconnection transformer.	2013	Commissioned	Commissioned	ne
152	42. 152	Dörpen/West (DE)		New substation for connection of offshore wind farms.	2013	Commissioned	Commissioned	
159	42. 159	Cluster BorWin1 (DE)	Diele (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205km. Line capacity: 400MW.	2013	Commissioned	Commissioned	
653	42. 163	Büttel (DE)		New substation Büttel and connection of this new substation with the existing OHL Brünsbüttel - Wilster.	2013	Commissioned	Commissioned	
181	44. 181	Dauersberg (DE)	Limburg (DE)	New line from Dauersberg to point Fehl-Ritzhausen	2012	Commissioned	Commissioned	In
391	63. 391	Missing (FI)	Anttila (FI)	A new HVDC (450kV) connection will be built between Estonia and Finland. On the Finnish side, a 14km DC overhead line will be built to a new substation Anttila where the converter station will be placed. On the Estonian side, a 11km DC cable line will be	2014	Commissioned	Commissioned	Co
736	63. 391	Püssi (EE)	Anttila (FI)	A new HVDC (450kV) connection between Estonia and Finland.	2014	Commissioned	Commissioned	Th as
737	63. 391	Püssi (EE)	missing (EE)	A new HVDC (450kV) connection between Estonia and Finland.	2014	Commissioned	Commissioned	Th or
738	63. 391	Anttila (FI)		A new HVDC (450kV) connection will be built between Estonia and Finland. On the Finnish side, a 14km DC overhead line will be built to a new substation Anttila where the converter station will be placed. On the Estonian side, a 11km DC cable line will be	2014	Commissioned	Commissioned	Co

Investment ID	TYNDP 2012 index	from substation name	to substation name	short description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	ev de
372	59. 372	Oltarzew (PL)		372-Ołtarzew	2014	Commissioned	Commissioned ahead of time	Th co
384	60. 62. 384	RigaCHP1 (LV)	Imanta (LV)	A new 12.5km AC 330kV cable from RigaCHP1 substation to Imanta substation.	2013	Commissioned	Commissioned	De se re co
392	64. 392	Yllikkälä (FI)	Huutokoski (FI)	New 155km single circuit 400kV OHL and renovation of 400kV substations in Yllikkälä and Huutokoski. Expected capacity: 1850 MVA.	2013	Commissioned	Commissioned	In pl co
166	42. 166	Offshore Wind park Riffgat (DE)	Emden /Borßum(DE)	New AC-cable connection	2014	Commissioned	Commissioned	

11.1.4 List of cancelled investments from TYNDP and RgIPs 2012

Investment ID	TYNDP 2012 index	from substation name	to substation name	short description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
833	168a	Region South-West Bavaria (DE)	Region South-West Bavaria (DE)	Upgrading the existing 220kV OHL to 380kV,length 100km and the extension of existing substations, erection of 380/110kV-transformers.	-	Cancelled	Cancelled	Originally the investment was very unprecise. It has been replaced by more precise OHL upgrade investments
198	198	Wuhlheide (DE)	Thyrow (DE)	Berlin South Ring: replacement of an existing old 220kV double-circuit OHL by a 380kV double-circuit OHL. Length: 50km.	-	Cancelled	Cancelled	Project is cancelled because at present no necessity is seen.
341	341	Patnów (PL)	Wloclawek (PL)	Upgrading of sag limitations OHL 220kV (389 MVA).	-	Cancelled	Cancelled	Cancelled.
346	346	Halemba (PL)		Halemba substation is connected by splitting and extending of existing 220kV lines Kopanina - Katowice.	-	Cancelled	Cancelled	Cancelled
137	35. 137	Vitkov (CZ)	Mechlenreuth (DE)	New 400kV single circuit tie-line between new (CZ) substation and existing (DE) substation. Length: 70km.	-	Cancelled	Cancelled	Project was cancelled due to unfeasibility to built the project (enviromental aspects and technical difficulty to connect to existing grid).
381	381	Visaginas (LT)	Liksna (LV)	Upgrade single circuit OHL (943 MVA, 50km).	-	Cancelled	Cancelled	This line was expected if Visaginas NPP would reach the installed capacity of NPP 2000 MW and more.
171	44. 171	Hüffenhardt (DE)	Neurott (DE)	Upgrade of the line from 220kV to 380kV. Length: 11km. Included with the investment : 1 new 380kV substation.	-	Cancelled	Cancelled	The need for this long-term investment was not confirmed by the German Network development Plan 2012 and therefore it has been cancelled. The Plan 2012 has set up more global solutions for long-term
154	45. 154	Redwitz (DE)		New 500 MVAr SVC in substation Redwitz.	-	Cancelled	Cancelled	new concept
155	45. 155	Raitersaich (DE)		New 500 MVAr SVC in substation Raitersaich.	-	Cancelled	Cancelled	new concept

Investment ID	TYNDP 2012 index	from substation name	to substation name	short description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
433	73. 433	Amagerværket (DK)	Glentegård & H.C. Ørstedværket (DK)	modified due to new drivers	-	Cancelled	Cancelled	Change of general grid structure => drivers vanished. cancelled in current national plan. Projects might still be useful at a later stage in case some of the conceptual projects of this TYNDP might be built.
320	57. 320	Dargoleza (PL)		A new AC 400/110kV substation	-	Cancelled	Cancelled	The investment's driver was RES connection. The investment was removed from the plans due to change on generation (RES) side.
807	104. A51	Svartisen (NO)	Nedre Røssåga (NO)	New 116km 400kV OHL	-	Cancelled	Cancelled	Awaiting results of on-going Arctic Grid study
806	104. A59	Råbäcken (SE)	Trolltjärn (SE)	New 55 km single circuit 400kV OHL	-	Cancelled	Cancelled	Slower RES increase than planned in the area. The investment is now included in investment 403.
399	87. 399	Dingtuna (SE)	Karlslund (SE)	Upgrade of existing 220kV lines to 400kV	-	Cancelled	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
786	87. A56	Ängsberg (SE)	Horndal (SE)	New 85 km single circuit 400kV OHL	-	Cancelled	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
787	87. A57	Horndal (SE)	Dingtuna (SE)	New 90 km single circuit 400kV OHL	-	Cancelled	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
788	87. A58	Hamra (SE)	Dingtuna (SE)	New 50km single circuit 400kV OHL	-	Cancelled	Cancelled	The investment is now a part of investment 403 that consists of several line sections and stations.
417	93. 417	Aura/Viklandet (NO)	Fåberg (NO)	Voltage upgrading of existing single circuit 300kV OHL Aura/Viklandet-Fåberg.	-	Cancelled	Cancelled	On time

Investment ID	TYNDP 2012 index	from substation name	to substation name	short description	current tyndp expected commissioning	current tyndp status name	evolution since last tyndp	evolution driver description
746	67. 402	Barkeryd (SE)	Tveiten (NO)	New double HVDC VSC line between Barkeryd (SE) and Tveiten (NO)	-	Cancelled	Cancelled	New interconnections from and reinforcements internally in Norway, has led to reduced need and benefit from an electricity market perspective for a new interconnection between Norway and Sweden.
411	67. 411	Rød (NO)	Sylling (NO)	Voltage upgrading of existing single circuit 300kV OHL Rød-Tveiten-Flesaker-Sylling in connection with the new HVDC line to Sweden, the Syd Vest link.	-	Cancelled	Cancelled	Investment is rescheduled to long term horizon in order to reconsider the benefits of the investment

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11.1.5 Storage projects

Complying with Regulation EC 347/2013, ENTSO-E proposed to PCIs storage promoters to assess their projects according to the CBA methodology.

Caveats

- This section displays the assessment of storage projects, when their promoters sent the input data to ENTSO-E. Eventually, some are indeed listed as PCIs; some are not. Conversely, when PCIs promoters have not sent any data to ENTSO-E, no assessment can be displayed.
- The economic benefits of projects in the SEW focus on the “energy only” part of the total economic benefits. **The SEW must be completed with an appraisal of the “capacity” part of the benefits (i.e. the availability of net power generating capacity) and the “flexibility” part of the benefits (i.e. the capability of adapt quickly the power output to the system needs).** “Flexibility” issues relate to real time phenomena that the 60-minute quantum used in the TYNDP market studies and steady state load flows in networks studies fails to capture:
    - Expanding wide area market modelling with a resolution beneath one hour to address close to real time phenomena is challenging with respect to computations capabilities and would rather involve complementary tools
    - Moreover common definitions of such close to real time benefits among all stakholders must be first agreed upon.
- **The SEW presented in the TYNDP 2014 is thus a conservative assessment of the economic benefits**. This remark is valid both for transmission and storage projects, but is all the more important for storage projects that the investment costs are larger. **Profitability of storage projects can never be concluded upon with the present assessment**.
- The definition of technical resilience and flexibility (B6 and B7) for storage projects also only partially capture their benefits. Presently the application of assessment rules result in quite low numbers compared to intuitive expectations. They must be revised with the involvement of stakeholders for the TYNDP 2016.
- S1 and S2 indicators must be re-defined for storage and the final release of the TYNDP will bear for storage projects "NA" (instead of "less than 15 km"; the latter does indeed not reflect the environmental impact of storage projects).

Project index	Project description	GTC (MW)	S1 indicator	S2 indicator	b6 technical resilience	b7 flexibility	scenario	SoS (MWh/yr)	SEW (Meuros/yr)	RES spillage (MWh/yr)	Losses variation (MWh/yr)	CO2 emissions variation (kT/yr)
211	Muuga HPSPP is a 500 MW Hydro Pump-Storage Power plant that locates at Estonian North coast	500	NA	NA	2	2	Scenario Vision 1 - 2030	-	[1;2]	0	[8100;9900]	[27;33]
							Scenario Vision 2 - 2030	-	[4;5]	[36000;44000]	[18000;22000]	[60;73]
							Scenario Vision 3 - 2030	-	[2;3]	[18000;22000]	[55000;67000]	[14;17]
							Scenario Vision 4 - 2030	-	[17;20]	[45000;55000]	[68000;84000]	[-41;-34]
212	Installation of 5th 225MW unit in Kruonis pump storage power plant	225	NA	NA	2	2	Scenario Vision 1 - 2030	-	0	0	[4500;5500]	[8;9]
							Scenario Vision 2 - 2030	-	[3;4]	0	[3600;4400]	[21;26]
							Scenario Vision 3 - 2030	-	0	0	[14000;18000]	[9;11]
							Scenario Vision 4 - 2030	-	[8;9]	[18000;22000]	[18000;22000]	[-12;-9]

11.2 Appendix 2 – Additional projects investigated

Project 57: PolBaltic Integration

Description of the project

A set of 400 kV lines in N-W Poland. The projects enables the development of additional interconnections to the Scandinavian countries, also provides necessary capacity for connection of Renewable Energy Sources.

Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
320	Dargoleza (PL)		A new AC 400/110kV substation between existing substations Słupsk and Żarnowiec.	0	removed from RgIPs	2020	Cancelled	The investment's driver was RES connection. The investment was removed from the plans due to change on generation (RES) side.
326	Pelplin (PL)		Construction of new 400/110kV substation Pelplin between existing substation Grudziądz and planned substation Gdańsk Przyjaźń.	0	Planning	2019	Expected earlier than planned previously	The change in commissioning date stems from the recent update of National Development Plan and the schedule of planned generation connection.
328	Pila Krzewina (PL)	Bydgoszcz Zachód (PL)	New 400 kV double circuit line Piła Krzewina - Bydgoszcz Zachód temporarily on 220kV.	0	Design & Permitting	2019	Delayed	The commissioning date of the investment has been adopted to meet the schedule of generation connection in the region of northern Poland. The project is in the process of obtaining permits.
329	Zydowo Kierzkowo (PL)	Slupsk (PL)	New 70km 400kV 2x1870 MVA OHL double circuit line Żydowo - Słupsk	0	Planning	2019	Expected earlier than planned previously	The change in the comissioning date due to rescheduling introduced in the latest investment

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								plan. Investment is in the planning phase.
330	Zydowo Kierzkowo(PL)	Gdansk Przyjazn (PL)	New 150 km 400 kV 2x1870 MVA double circuit OHL line Żydowo Kierzkowo - Gdańsk Przyjaźń. A new AC 400 kV substation Gdańsk Przyjaźń in Gdańsk Agglomeration Area connected by splitting and extending of one circuit of existing line Żarnowiec - Gdańsk Błonia.	0	Planning	2019	Expected earlier than planned previously	Investment is in the planning phase.
334	Patnów (PL)	Grudziadz (PL)	New 174 km 400 kV 2x1870 MVA double circuit OHL line Pątnów - Grudziądz after dismantling of 220kV line Pątnów - Jasiniec (two parallel lines) and Jasiniec - Grudziądz with extension of existing substations Patnów and Jasiniec. One circuit from Pątnów to Grudziądz via Jasiniec temporarily on 220kV.	0	Planning	2020	Investment on time	The project is in the planning phase.
352	Dunowo (PL)	Plewiska (PL)	Construction of a new double circuit 400kV OHL Dunowo - Żydowo (2x1870 MVA) partly using existing 220 kV line + Construction of a new 400kV OHL Plewiska - Piła Krzewina - Żydowo (2x1870 MVA); single circuit temporarily working as a 220kV + A new AC 400kV	0	Planning	2020	Investment on time	Investment is in the planning phase.

			switchgear in existing substation Piła Krzewina + upgrade of substation Dunowo					
724	Zydowo Kierzkowo (PL)		Construction of new AC 400/110kV substation Żydowo Kierzkowo next to existing 220/110kV substation in Northern Poland with transformation 400/110kV 450 MVA.	0	Planning	2019	Expected earlier than planned previously	The expected date of commissioning change to meet the schedule of generation connection.
725	Gdansk Przyjazn		New substation Gdańsk Przyjaźń is connected by splitting and extending of one circuit of existing line Żarnowiec - Gdańsk Błonia and new 150km 400kV 2x1870 MVA double circuit OHL line Żydowo - Gdańsk Przyjaźń with one circuit from Żydowo to Gdańsk temporarily on 220kV after dismantling of 220kV line Żydowo - Gdańsk.	0	Planning	2019	Expected earlier than planned previously	Investment on time.
804	Gdansk Blonia (PL)		Extension and upgrade of an existing 400/110 kV substation Gdańsk Błonia for connection of planned 900 MW power plant.	0	Planning	2020	Investment on time	The project is in the planning phase.
805	Grudziadz (PL)	Gdansk Przyjazn (PL)	Construction of new 400 kV line Grudziądz Węgrowo - Pelplin - Gdańsk Przyjaźń for planned generation connection.	0	Planning	2019	Expected earlier than planned previously	Investment on time.

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CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 0	South=>North: 0	2	2	NA	NA	430-1000

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	-	[0;30]	3000 MW	[0;-3000]	[3000;3600]

Additional comments

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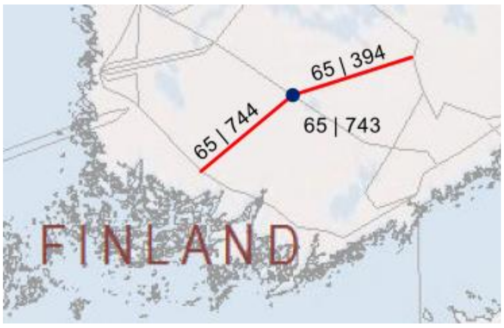
Project 65: 65 South-West in Finland

Description of the project

400 kV overheadline reinforcements due to changed exchange patterns and reliable grid operation of South-West Finland. Two new cross-border HVDC links have been connected in Southern Finland and this project helps to secure the system and utilize the cross-border capacity.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
394	Hikiä (FI)	Forssa (FI)	New 80km single circuit 400kV OHL.	800	Design & Permitting	2015	Investment on time	Investment is progressing as planned
743	Forssa (FI)		Building of 400 kV substation in Forssa.	800	Design & Permitting	2015	Investment on time	Investment progresses as planned.
744	Forssa (FI)	Lieto (FI)	New 67km single circuit 400 kV OHL.	800	Design & Permitting	2017	Investment on time	Investment progresses as planned

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
=>: 800	=>: -	4	4			46-77

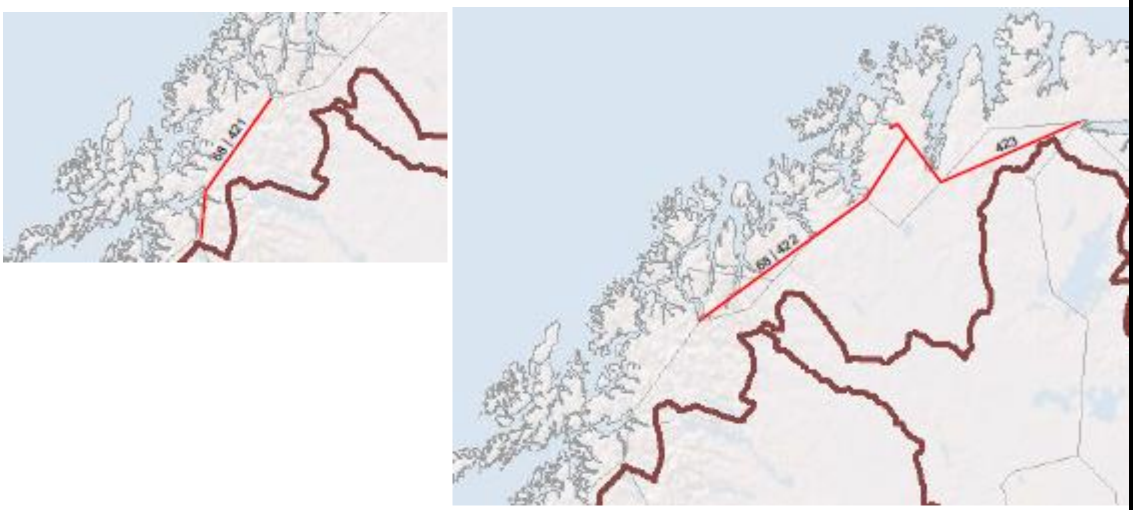
CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	[300;570]	[0;30]	[100;400] MW	0	[0;500]

Additional comments

Project 68: Northern part of Norway

Description of the project

A 500 km long overhead line (Ofoten-Balsfjord-Skaidi-Hammerfest) in the northern part of Norway is planned to be realized in the years 2017 to 2021. The first step (Ofoten to Balsfjord) is planned to be realized by 2017, whereas the part from Balsfjord to Hammerfest is planned realized some years later. The line will improve security of supply and will be most important for petroleum industry in the northern part of Norway. Additional the line will be facilitating renewable energy (wind parks in the northern Norway). The line is planned to be a 420 kV overhead AC line.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
421	Ofoten (NO)	Balsfjord (NO)	New 160km single circuit 400kV OHL.	1000	Design & Permitting	2017	Investment on time	Progress as planned.
422	Balsfjord (NO)	Hammerfest (NO)	New 360 km single circuit 400kV OHL.	700	Design & Permitting	2022	Delayed	Demand driver Melkøya gas terminal postponed. Longer construction time expected.

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
=>: 350-1500	=>: -	4	4			940-1600

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	[30;300]	[0;30]	[450;950] MW	0	[0;500]

Additional comments

entsoe

Project 70: Integration Norway - Denmark

Description of the project

A 240 km long interconnector (140 km subsea) between Norway and Denmark is planned to be in operation late 2014. The main driver for the project is to integrate the hydro-based Norwegian system with the thermal/wind/solar-based Danish/Continental system. The interconnector will improve security of supply both in Norway in dry years and in Germany in periods with negative power balance (low wind, low solar, high demand etc.). Additional the interconnector will be positive both for the European market integration, for facilitating renewable energy and also for preparing for a power system with lower CO2-emission. The interconnector is planned to be a 500 kV 700 MW HVDC subsea interconnector between southern Norway and northern Denmark.

Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
405	Kristiansand (NO)	Rød (NO)	Voltage upgrading of an existing single circuit 300kV OHL.	1000	Under Construction	2014	Investment on time	Progress as planned.
426	Kristiansand (NO)	Tjele (DK)	The interconnector is planned to be a 500 kV 700 MW HVDC subsea interconnector between southern Norway and northern	1000	Under Construction	2014	Investment on time	Progress as planned.

			Denmark.					
751	Rød (NO)	Bamle (NO)	New section of OHL between Rød and Bamle.	0	to be deleted	2014	Investment on time	To be part of project "Eastern corridor"

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
=>: 700	=>: -	2	4			470-790

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	-	[30;100]	[450;950] MW	0	[500;1000]

Additional comments

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Project 93: RES/SoS Norway/Sweden phase 1

Description of the project

A 300 km OHL Ørskog-Sogndal in Norway and shunt compensation in cut 2 in Sweden will accomplish SoS, RES integration and market integration for mid-Norway (Møre and Romsdal mainly) and RES integration in northern Sweden. Investments before 2020.

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
413	Ørskog (NO)	Sogndal (NO)	New 285 km single circuit 400kV OHL.	0	Under Construction	2016	Delayed	Delayed due to delayed permits in certain areas
414	Fardal (NO)	Sogndal (NO)	Voltage upgrading of existing single circuit 300kV OHL Sogndal-Aurland Extension of 413 - Ørskog - Fardal.	0	Planning	2018	Expected earlier than planned previously	On time
895	Sweden bidding area SE2+SE3		Shunt compensation in several existing stations for increased capacity in cut 2 between SE2 and SE3 in Sweden	700	Planning	2019	Delayed	Delay due to changed implementation, the installation will be done during several years. Commissioning dates expected to be between 2016 and 2020

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
=>: 2250	=>: -	4	2			560-930

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	[30;300]	[30;100]	[450;950] MW	0	[500;1000]

Additional comments

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Project 97: 97 FV connections

Description of the project

Investments required to connect Fennovoimas new 1 250-1 700 MW nuclear power plant that will be built in Pyhäjoki.The new line will have an equivalent capacity. The investor has stated that the plant will produce energy by 2024, expected commissioning of the lines by 2024.

Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
802	Valkeus (FI)	Lumimetsä (FI)	New double circuit 400 kV OHLs required to connect Fennovoimas new 1 250-1 700 MW nuclear power plant that will be built in Pyhäjoki	-	Under Consideration	2024	Investment on time	Investment progresses as planned, Ending station names have been updated. New estimated commissioning time

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CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
FI=>FI: 1250-1700	FI=>FI: 1250-1700	2	4	Negligible or less than 15km	Negligible or less than 15km	25-60

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	-	[0;30]	0	0	[500;1000]
Scenario Vision 1 - 2030	-	[590;720]	0	0	0
Scenario Vision 4 - 2030	-	[440;540]	0	0	0

Additional comments

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Project 98: 98 OL4 connection

Description of the project

Three 400 kV overheadlines required to connect TVO's new 1 000-1 800 MW nuclear power plant that will be built in Olkiluoto, Finland. The investor has requested additional time for the decision in principle and estimates that the plant will produce energy by the latter part of 2020's. Expected commissioning of the lines according to the plans of investor by the latter part of 2020's.

Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
803	Rauma (FI)	Forssa (FI)Lieto (FI)Ulvila (FI)	New single circuit 400 kV OHLs required to connect TVO's new 1 000-1 800 MW nuclear power plant that will be built in Olkiluoto	-	Under Consideration	2020	Investment on time	Investment progresses as planned. Estimated commissioning late 2020's

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
FI=>FI: 1000-1800	FI=>FI: 1000-1800	0	0	Negligible or less than 15km	Negligible or less than 15km	56-130

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	-	[0;30]	0	0	[500;1000]
Scenario Vision 1 - 2030	-	0	0	0	0
Scenario Vision 4 - 2030	-	[440;540]	0	0	0

Additional comments

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Project 104: RES Mid Norway/Sweden north

Description of the project

A new 250 km OHL (partly subsea cable) and upgrade of an existing 300 kV line to 420 kV in Mid Norway and series compensation in cut 1 in Sweden will accomplish RES integration and SoS in mid-Norway (Trøndelag and Nordland) and RES integration in northern Sweden

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
398	Under consideration (SE)		New series compensation of OHL in Cut 1	900	Under Consideration	2018	Delayed	Rescheduled following a review of priorities and dependencies for all grid reinforcements. Thanks to postponment of this investment, other internal investments will be commissioned on time

415	Namsos (NO)	Klæbu (NO)	New line and voltage upgrade of 286km single circuit 400kV OHL	0	Design & Permitting	2017	Delayed	Other projects in Statnetts portfolio evaluated as more critical
416	Klæbu (NO)	Aura/ Viklandet (NO)	Voltage upgrading of existing single circuit 300kV OHL Klæbu-Aura.	0	Design & Permitting	2020	Investment on time	Progress as planned.
418	Nedre Røssåga (NO)	Namsos (NO)	Upgrade of 70km single circuit 400kV OHL	0	Design & Permitting	2019	Investment on time	Progress as planned.
420	Snillfjord (NO)	Trollheim (NO)	New 60 km single circuit 400kV OHL	0	Design & Permitting	2019	Investment on time	Investment dependent on confirmed investment decisions wind power.
807	Svartisen (NO)	Nedre Røssåga (NO)	New 116km 400kV OHL	0	Cancelled		Cancelled	Awaiting results of on-going Arctic Grid study
1006	Namsos	Storheia	120 km, 420 kV, overhead line for RES-integration	0	Planning	2019	New Investment	RES-integration
1007	Storheia	Snillfjord	70 km new AC line for RES-integration, incl. 8km subsea cable	0	Planning	2022	New Investment	RES

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
=>: 1200	=>: -	4	2			870-1500

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	-	[0;30]	[450;950] MW	0	[0;500]

Additional comments

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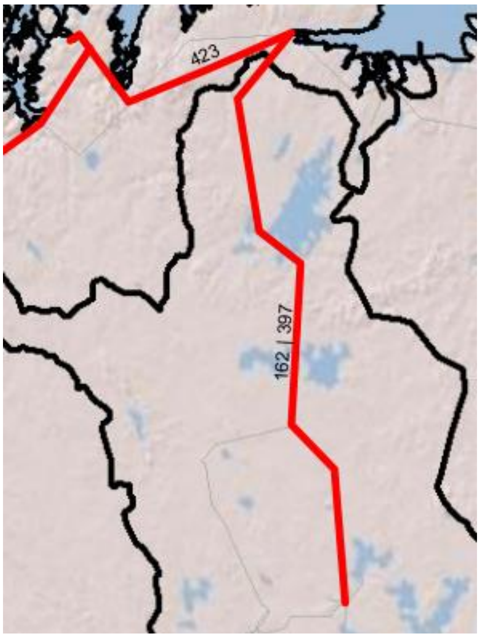
Project 162: Finland Norway

Description of the project

Studied alternatives for capacity increase btw Finland and Northern Norway. 400 kV or smaller increase.
Fingrid and Statnett have decided to study increasing capacity of the existing 220kV line instead of a new 400 kV line, thus the expected capacity increase is less than 500 MW, and the project is moved to Regional plan



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
397	Varangerbotn (NO)	Pirttikoski or Petäjäskoski (FI)	New single circuit 380 - 400kV OHL (500km). Alternative to smaller capacity increase of parallel and series compensation	-	Under Consideration	2030	Investment on time	Fingrid and Statnett have decided to study increasing capacity of the existing 220kV line instead of a new 400 kV line, thus the

								expected capacity increase is less than 500 MW, and the project is moved to Regional plan

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
North=>South: 100-500	South=>North: 100-500	2	4			300-700

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	[5;15]	[3;5]	0	[0;40000]	0

Additional comments

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Project 166: DKE-PL interconnection

Description of the project

This project candidate investigates the possibility of establishing an interconnector between Bjæverskov (Denmark) and Dunowo (Poland). This very first conceptual study looks at a 500 kV 600 MW HVDC subsea connection, testing the idea of connecting these markets.

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
994	Bjæverskov	Dunowo	This project candidate investigates the possibility of establishing an interconnector between Bjæverskov (Denmark) and Dunowo (Poland). This very first conceptual study looks at a 500 kV 600 MW HVDC subsea connection, testing the idea of connecting these markets.	-	Under Consideration	2030	New Investment	This is a conceptual project. In case the assessment is promising, it might be taken to a next step, in case it is not, it will be cancelled.
994	Bjæverskov	Dunowo	This project candidate investigates the possibility of establishing an	-	Under Consideration	2030	New Investment	This is a conceptual project. In case the assessment is

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			interconnector between Bjæverskov (Denmark) and Dunowo (Poland). This very first conceptual study looks at a 500 kV 600 MW HVDC subsea connection, testing the idea of connecting these markets.					promising, it might be taken to a next step, in case it is not, it will be cancelled.
994	Bjæverskov	Dunowo	This project candidate investigates the possibility of establishing an interconnector between Bjæverskov (Denmark) and Dunowo (Poland). This very first conceptual study looks at a 500 kV 600 MW HVDC subsea connection, testing the idea of connecting these markets.	-	Under Consideration	2030	New Investment	This is a conceptual project. In case the assessment is promising, it might be taken to a next step, in case it is not, it will be cancelled.
994	Bjæverskov	Dunowo	This project candidate investigates the possibility of establishing an interconnector between Bjæverskov (Denmark) and Dunowo (Poland). This very first conceptual study looks at a 500 kV 600 MW HVDC subsea connection, testing the idea of connecting these markets.	-	Under Consideration	2030	New Investment	This is a conceptual project. In case the assessment is promising, it might be taken to a next step, in case it is not, it will be cancelled.

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CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKE=>PL: 600	PL=>DKE: 600	3	3	NA	NA	460-1100

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[19;24]	[27000;33000] MWh	[180000;220000]	[1400;1700]
Scenario Vision 2 - 2030	-	[35;42]	[27000;33000] MWh	[-220000;-180000]	[1400;1800]
Scenario Vision 3 - 2030	-	[47;58]	0	[170000;200000]	[-3000;-2400]
Scenario Vision 4 - 2030	-	[130;160]	[130000;150000] MWh	[170000;200000]	[-2400;-2000]

Additional comments

Project 178: DKW - SE3

Description of the project

This project candidate includes an additional 700 MW subsea HVDC connection between Denmark- West and Sweden-3, called ContiScan-3. The HVDC line could be connected to the Danish 400 kV substation V. Hassing. Besides the HVDC interconnector with all necessary equipment, the project would trigger some internal grid reinforcements in both countries, which partly are specified in this regional plan, e.g. for Denmark a 400 kV HVAC cable between V. Hassing and Ferslev, reconductoring and reconstruction of the existing 400 kV HVAC OHL between Ferslev and Tjele, and a 400 kV HVAC cable between Tjele and Trige. Some of these investments are already known from the TYNDP2012 and considered in the list of investments.

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
429	Ferslev (DK)	Vester Hassing (DK)	New 20km single circuit 400kV line via a cable with a capacity of approx. 800 MW.	800	Under Consideration	2030	Rescheduled	cancelled in National Plan due to changed plan. But would be necessary in case Kontiscan III to Sweden would be built.
431	Tjele (DK)	Trige (DK)	New 46km single circuit	700	Under Consideration	2030	Rescheduled	cancelled due to changed

			400kV line via cable with capacity of approx. 1200 MW.					national plan. But necessary if Kontiscan 3 would be implemented
1015	Vester Hassing (DK1)	Station SE3	new 700 MW HVDC subsea cable between DK1 and SE3	700	Under Consideration	2030	New Investment	RGBS common investigations for TYNDP14

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific						
GTC direction 1 (MW)	**GTC direction 2 (MW)**	**B6 Technical Resilience**	**B7 Flexibility**	**S1 - protected areas**	**S2 - urban areas**	**C1 Estimated cost (Meuros)**
DKW=>SE: 700	SE=>DKW: 700	3	4	NA	NA	390-910

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[44;53]	[63000;77000] MWh	[500000;620000]	[790;960]
Scenario Vision 2 - 2030	-	[6;7]	0	[170000;210000]	[410;510]
Scenario Vision 3 - 2030	-	[20;25]	0	[160000;200000]	[-18;-15]
Scenario Vision 4 - 2030	-	[99;120]	[160000;200000] MWh	[350000;430000]	[-450;-370]

Additional comments

Comment on the security of supply: the project is improves the SoS of Northern Jutland.
Comment on the RES integration: The significant increase of RES between Vision 1 and Vision 4 in both countries contributes to an increased number of hours with more volatile prices and thus higher flows in both directions. Additionally, the higher CO2 price in vision 4 causes a shift between coal and gas in the merit order, which increases the price spread between high and low RES hours. This explains the spread of the SEW indicator between these two extreme visions.

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Project 180: Norway-Sweden North

Description of the project

A new 420 kV line between Norway and northern part of Sweden is in the pre-study-phase. If realized the line most probably will replace the existing 220 kV line between Nedre Røssåga (northern Norway) and Grundfors (northern Sweden). The main driver of the line will be renewables, especially in northern Norway. The line will be facilitating renewable energy and also lower potential price-differences between Norway and Sweden. Additional the line might improve the security of supply in the region. If realised the new line will be approximately 200 km.

Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1017	Nedre røssåga	Grundfors	If realized the line most probably will replace the existing 220 kV line between Nedre Røssåga (northern Norway) and Grundfors (northern Sweden).	-	Under Consideration	2030	New Investment	RES, SoS, Market

CBA results

The tables below summarize the Cost Benefits Analysis results of this project.

CBA results non scenario specific

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GTC direction 1 (MW)	GTC direction 2 (MW)	B6 Technical Resilience	B7 Flexibility	S1 - protected areas	S2 - urban areas	C1 Estimated cost (Meuros)
NO=>SE: 750	SE=>NO: 750	4	4	Negligible or less than 15km	Negligible or less than 15km	140-330

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[0;1]	[900;1100] MWh	0	[45;56]
Scenario Vision 2 - 2030	-	[2;3]	[4500;5500] MWh	[-28000;-23000]	[46;57]
Scenario Vision 3 - 2030	-	[4;5]	[5400;6600] MWh	[-53000;-43000]	[-26;-21]
Scenario Vision 4 - 2030	-	[2;3]	[13000;15000] MWh	[-61000;-50000]	[-28;-23]

Additional comments

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11.1 Appendix 3 - Installed generation and demand in Baltic Sea Region

11.1.1 Nordic Generation Capacities

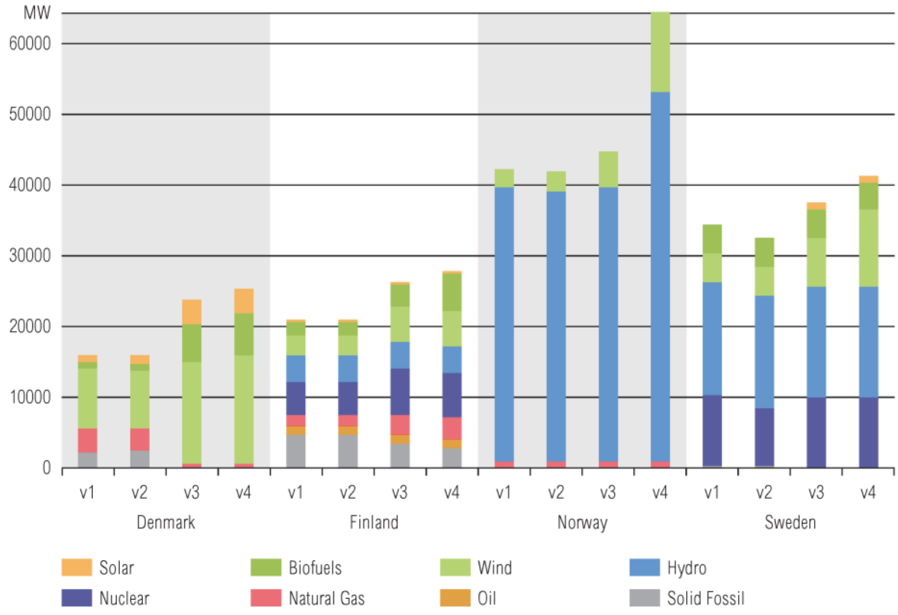

Figure 86 Generation portfolio mixture in Nordic countries for each Visions 1, 2, 3 and 4, installed generation capacity in MW.

Table 4 Generation capacities for all 4 visions divided on countries and generation type in 2030

	Vision	Solid Fossil	Oil	Nat_Gas	Nuclear	Hydro	Wind	Biofuels	Solar
Denmark	v1	2270	0	3391	0	0	8360	1029	1110
	v2	2647	0	2931	0	0	8360	817	1110
	v3	0	0	737	0	0	14290	5433	3430
	v4	0	0	737	0	0	15290	6032	3430
Finland	v1	4673	1360	1400	4890	3740	2810	1812	10
	v2	4673	1360	1400	4890	3740	2810	1812	10
	v3	3355	1360	2900	6490	3740	4940	3170	40
	v4	2855	1360	2900	6490	3740	4910	5295	10
Norway	v1	0	0	905	0	38900	2740	0	0
	v2	0	0	855	0	38390	2750	0	0
	v3	0	0	855	0	39090	5000	0	0
	v4	0	0	855	0	52490	11400	0	0
Sweden	v1	180	10	190	9952	15947	4235	3880	0
	v2	180	10	190	8159	15947	4235	3880	0
	v3	0	0	0	9952	15947	6900	3880	1000
	v4	0	0	0	9952	15947	10700	3880	1000

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11.1.2 Germany/Polish Generation Capacities

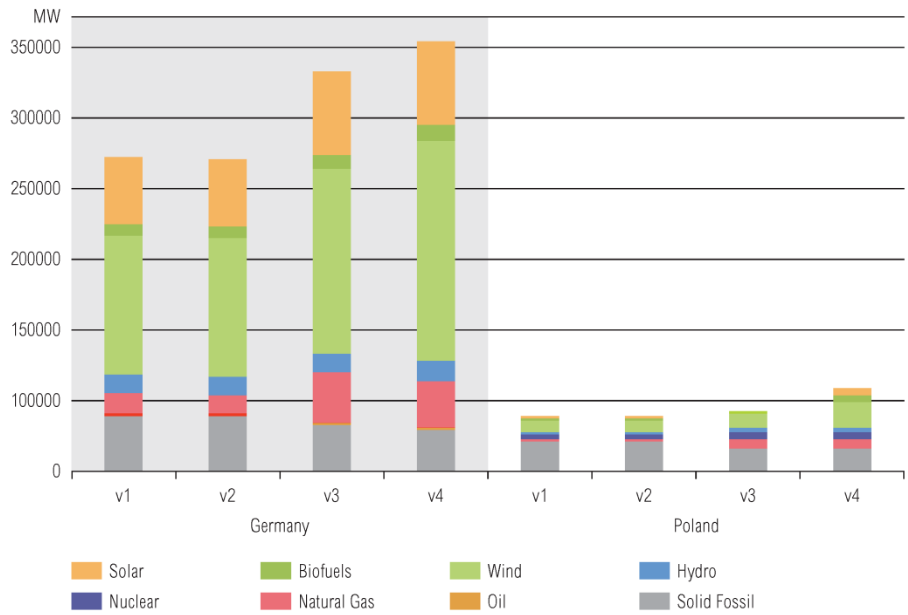

Figure 87 Generation portfolio mixture in Germany, Poland for each Visions 1, 2, 3 and 4, installed generation capacity in MW

Table 5 Generation capacities for all 4 visions divided on countries and generation type in 2030

	Vision	Solid Fossil	Oil	Nat_Gas	Nuclear	Hydro	Wind	Biofuels	Solar
Germany	v1	46071	1197	18523	0	15650	114000	8800	55100
	v2	46071	1197	15933	0	15650	114000	8800	55100
	v3	39116	1197	41264	0	15950	153400	11100	68800
	v4	35008	1197	39301	0	15950	181500	13500	68800
Poland	v1	24661	0	1950	4500	2546	8900	1890	500
	v2	24661	0	1950	4500	2546	8900	1890	500
	v3	20592	0	7130	6000	2656	11000	945	1000
	v4	20592	0	7130	6000	2656	20900	6245	5300

11.1.3 Baltic Generation Capacities

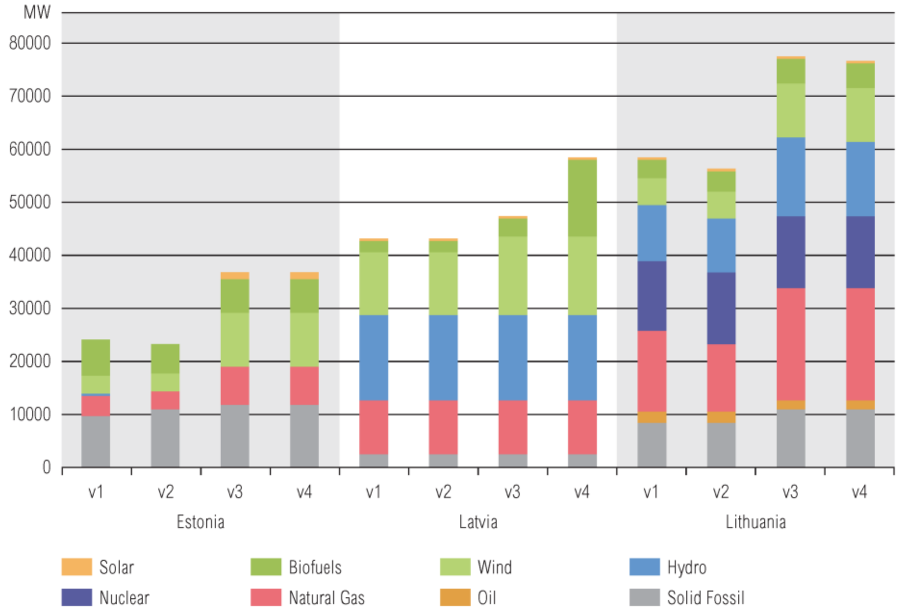

Figure 88 Generation portfolio mixture in Baltic States for each Visions 1, 2, 3 and 4, installed generation capacity in MW.

Table 6 Generation capacities for all 4 visions divided on countries and generation type in 2030.

MW	Vision	Solid Fossil	Oil	Nat_Gas	Nuclear	Hydro	Wind	Biofuels	Solar
Estonia	v1	971	0	407	0	10	350	694	
	v2	1107	0	328.75	0	10	350	558	
	v3	1181	0	723	0	20	1000	659	100
	v4	1181	0	723	0	20	1000	659	100
Latvia	v1	270	0	995	0	1602	1195	230	5
	v2	270	0	995	0	1602	1200	230	10
	v3	270	0	995	0	1602	1500	360	20
	v4	270	0	995	0	1602	1500	1460	20
Lithuania	v1	870	188	1518	1350	1031	510	340	10
	v2	870	188	1291.5	1350	1031	510	340	10
	v3	1090	188	2137	1350	1483	1020	440	20
	v4	1090	188	2137	1350	1404	1020	440	20

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11.1.4 Demand in Baltic Sea region

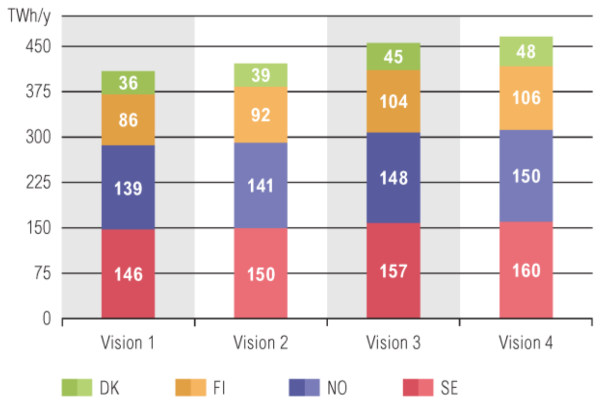

Figure 89 Annual consumption (TWh) in Nordic Countries for Visions 1, 2, 3 and 4.

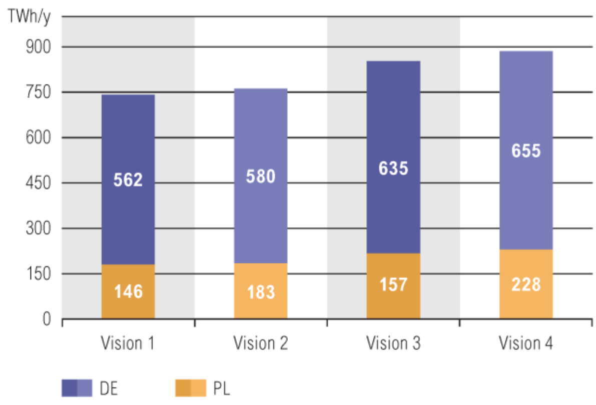

Figure 90 Annual consumption (TWh) in Germany, Poland for Visions 1, 2, 3 and 4.

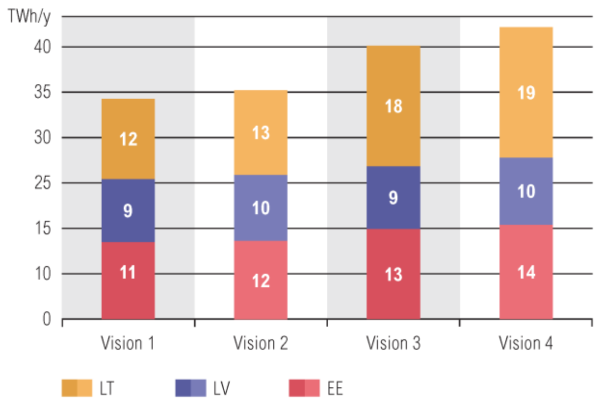

Figure 91 Annual consumption (TWh) in Baltic States for Visions 1, 2, 3 and 4.

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11.2 Appendix 4 – Flow and price differences of Visions

11.2.1 Annual energy flows in Baltic Sea region

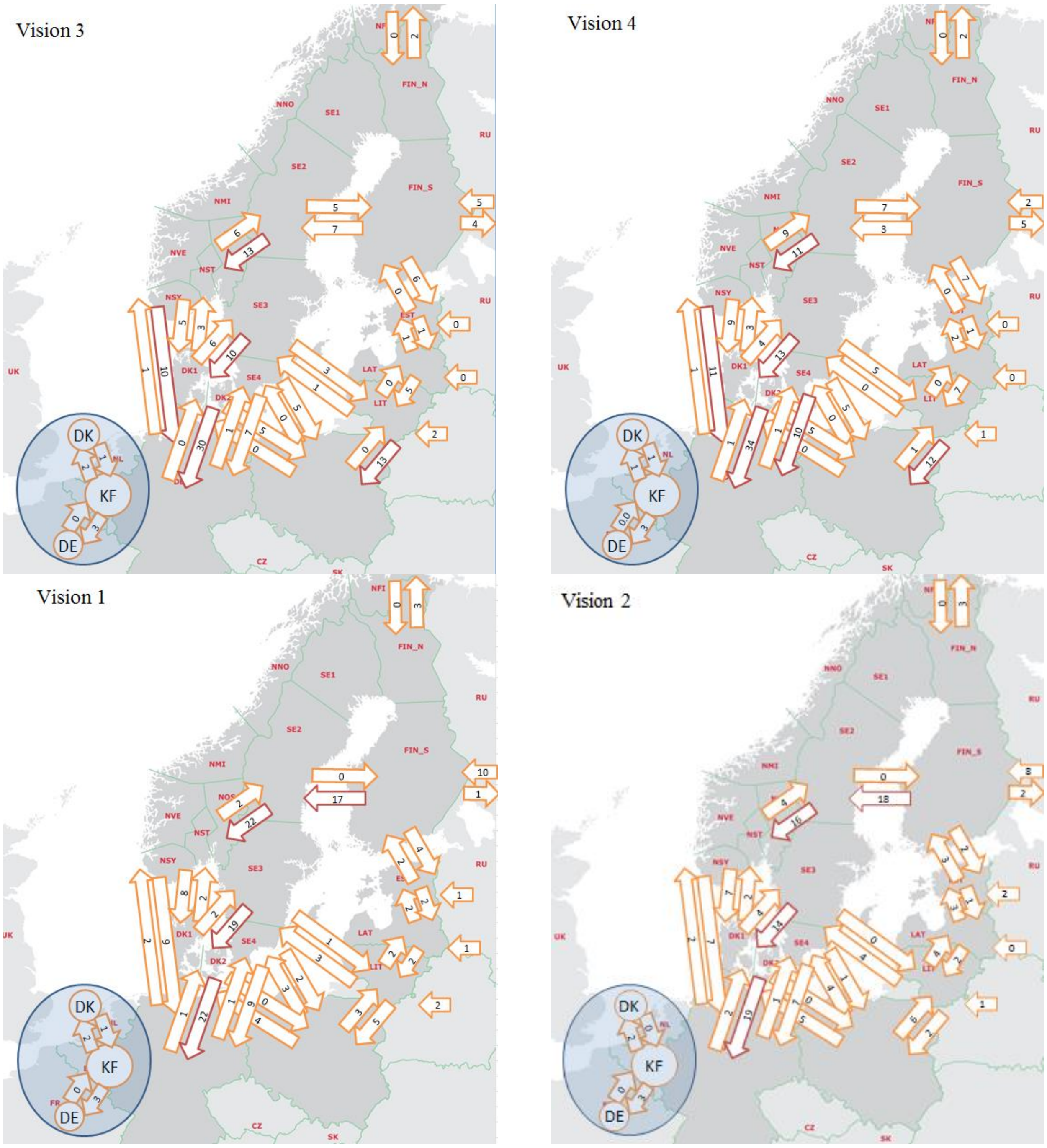

Figure 92 Energy flows in TWh

11.2.2 Price differences and utilization of cross-sections between market areas

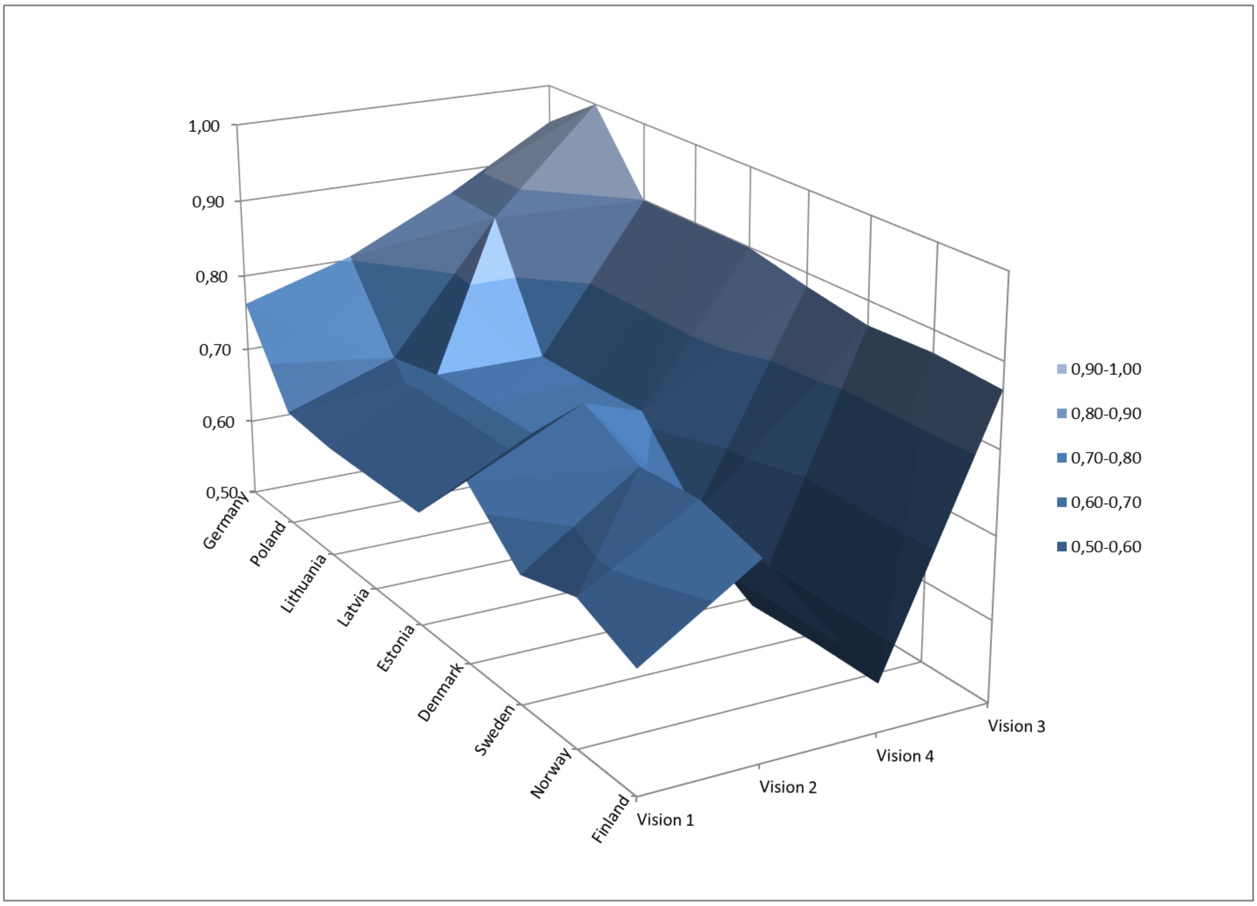

Figure 93 Relative price level by vision and area.

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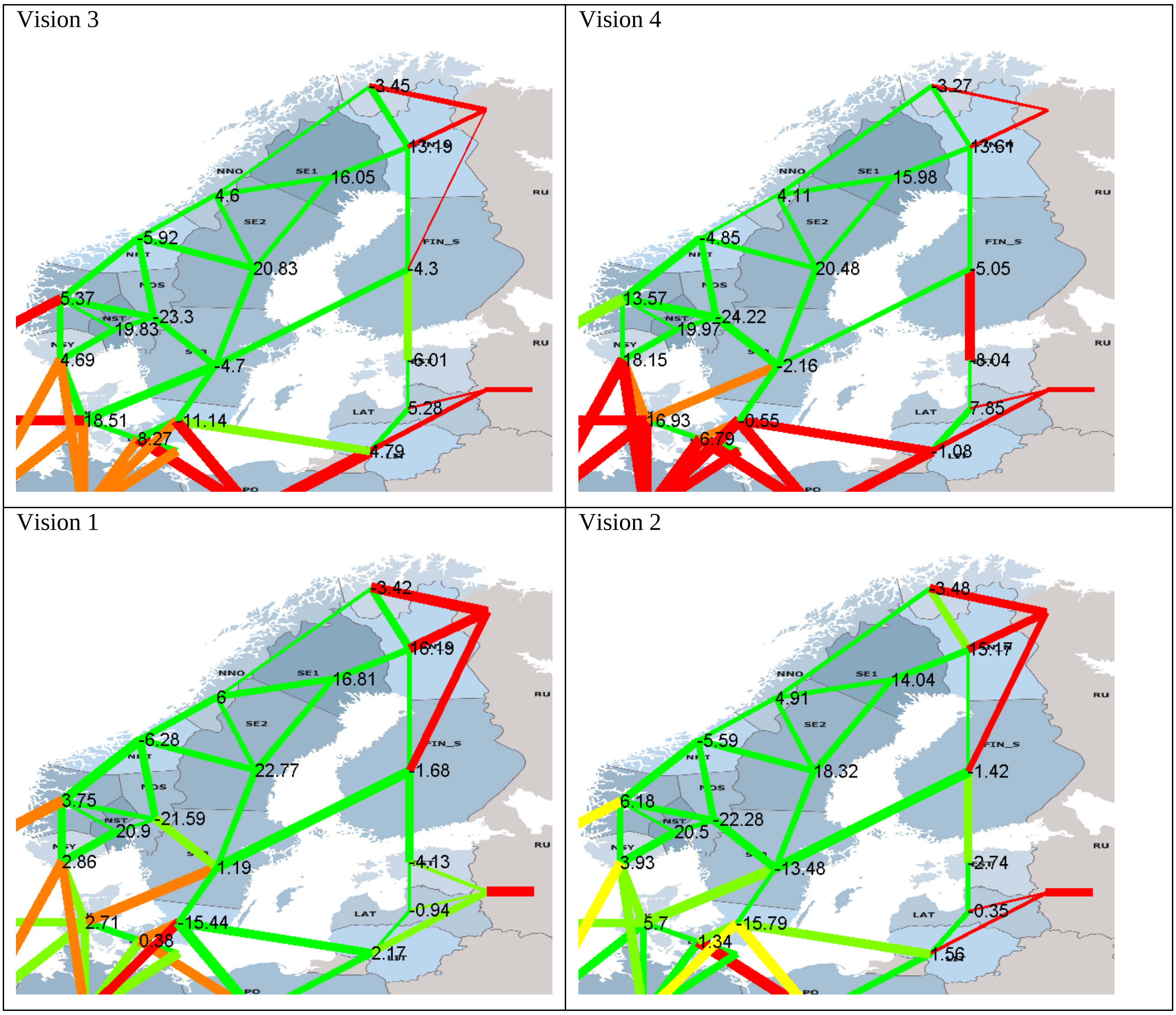

Legend:

Areas numbers: Energy balance

Interconnectors: thickness = utilization of line

Interconnectors: color = red (green) means high (little) price difference

Figure 94 Price differences and cross-section utilization.

11.3 Appendix 5 – Generation and balances in Nordics and Baltics

In following chapters the Annual generation are presented by their type for Nordic countries and Baltic States. Also the net balances per country are presented, including modelled annual electricity inflow and outflow. German and Polish results are presented in the reports of other regional groups (CCE Regional Investment Plan)

11.3.1 Nordic countries

The region has a positive yearly energy balance, but due to seasonal variations in inflow the power flow varies considerably between summer and winter. In addition to today's balance variations, the expected consumption growth will cause longer periods with negative balance and increased need for grid capacity to ensure secure of supply. With an increased yearly power surplus in a 2030 scenario today's exchange trend from all countries will be enhanced. This applies especially for the summer period due to high level of non-flexible hydro in combination with reduced consumption. Numerous interconnectors also lead to periods with major import to the Nordic region when the prices on the European continent are low. This results in low generation from hydropower and northward flow in the entire system. Increased industry consumption and petroleum in the North can provide northbound flow even from central Norway to the North. The consequence of the increased HVDC capacity will result in fewer hours with maximum utilization of the exchange-capacity as the flexibility in the hydropower system is challenged.

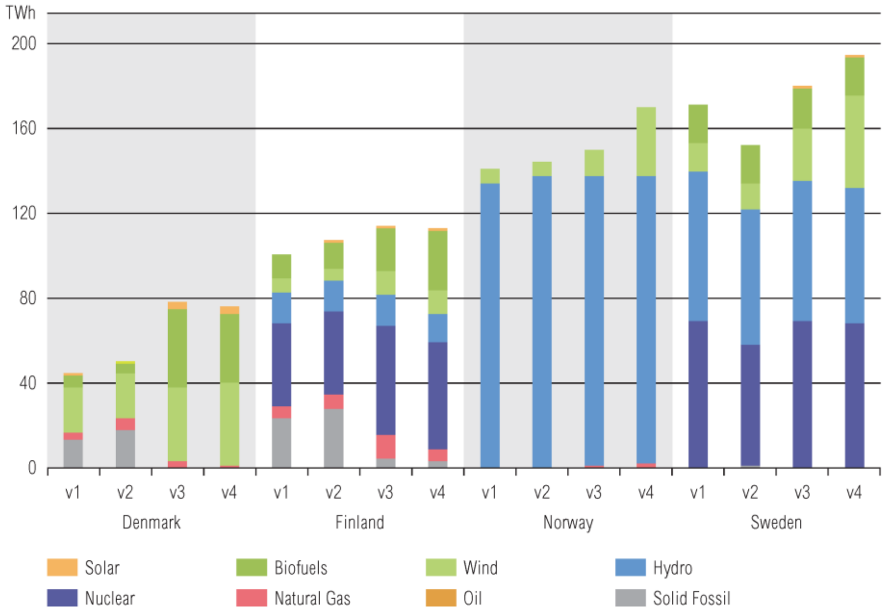

Figure 95 Electricity production in Nordic countries by source type for different visions.

Vision 4 is a green vision with a considerable amount of new renewable production and hydro pumping power to match the need for fast regulation. In such an environment the inter-area transmission capacities will play a crucial role, not only for transfer of energy but also for making regulating power available for the whole system. New wind power must be built where there are possible available areas, many times offshore, and this may be far from the consumption or the market. With a high CO2 price, energy production from coal fired thermal power plants is substituted by renewable production with low variable production cost. Price differences are generally higher than in Vision 1 and the socio-economic benefit of new transmission capacity is also higher. Auxiliary services must be available throughout the interconnected market areas and this put strain on transmission capacities that are already highly utilized for energy transfer in Vision 4. To have a functioning and integrated market both for energy and auxiliary services, transmission capacities must be dimensioned to handle both to a much larger extent than in Vision 1.

Figure 96 Annual inter-area flows in Nordic countries for different visions. Positive value is corresponding to total out goings flows and negative value to total income flows.

11.3.2 Baltic Countries

Baltic States have good overall diversity both in installed capacities and annual production. The highest share of production in Baltics belongs to Renewables, especially in Vision 3 and 4. In Lithuania the dominating production comes from nuclear power and in Latvia the majority of production comes from Renewable sources – Wind, Bio fuels and Hydro. In Estonia the biggest share of production belongs to wind power and in Vision 1 and Vision 2 there are also thermal capacities.

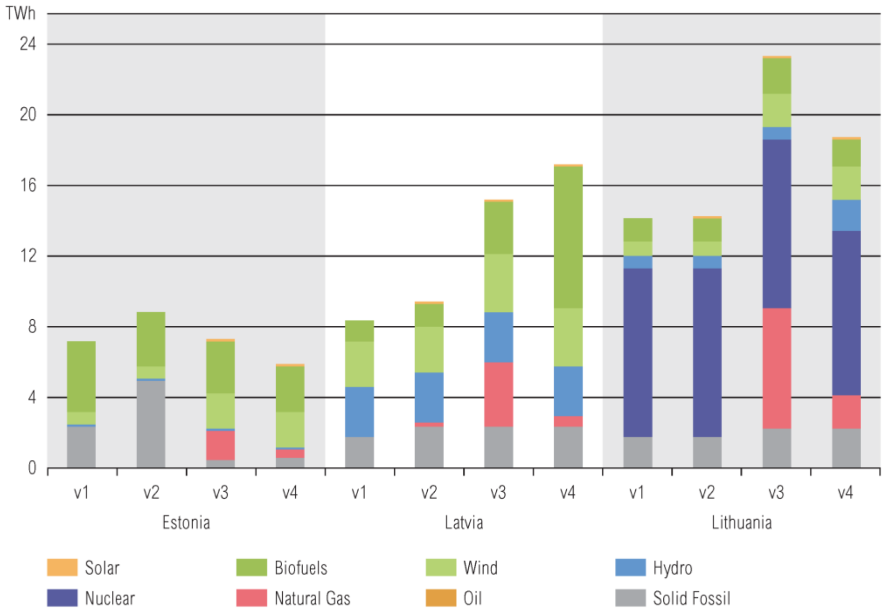

Figure 97 Electricity production in Baltic States by source type for different visions.

The Baltics in Vision 1, 2 and 4 are in deficit and exporter in Vision 3. The biggest importer is Estonia, and the biggest import share is in Vision 4. The biggest exporter is Latvia in Vision 3 and Vision 4 where there is a high share of Biomass and Wind energy in the portfolio. Import, Export and balances are shown on a figure above.

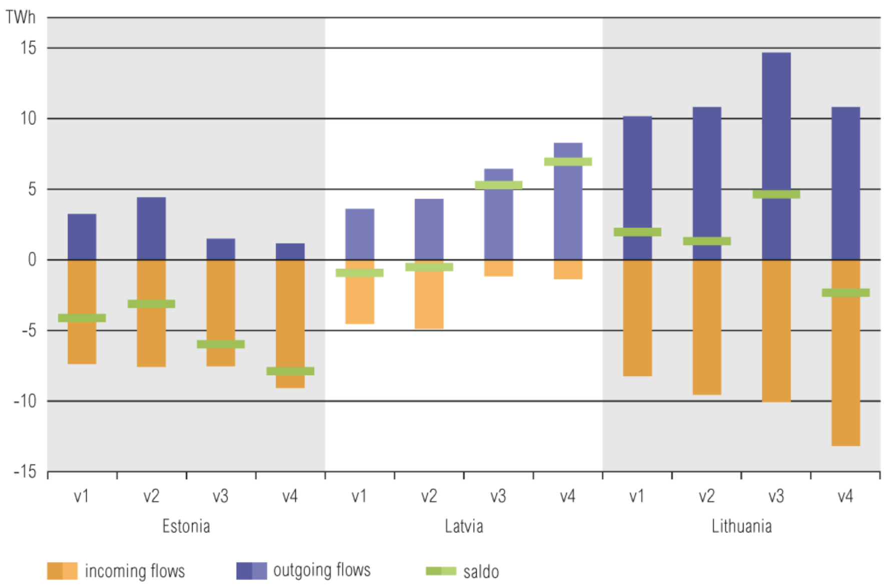

Figure 98 Annual inter-area flows in Nordic countries for different visions in Baltic States for different visions. Positive value is corresponding to total out goings flows and negative value to total income flows.

11.4 Appendix 6 - Network Studies Results

Following study cases present examples of the network study with the focus on possible system evolution by 2030. The system evolution implies implementing of additional investments due to increased transmission capacity demand with the neighboring system and integration of significantly more wind and RES.

11.4.1 Study Case 1

Possible system evolution is explained by the following steps and illustrations in the following page:

- Step 1 is the initial system stage of the system 2030 according to the national grid-development plan of Denmark.
- Step 2 is as Step 1 and with additional transmission capacity of the assessed connectors between Denmark and the neighboring systems. The usage of additional transmission capacity has increased power transport throughout and introduced overloading of the Danish 400 kV grid.
- Step 3 is as Step 2 and with enabled additional investments into the Danish 400 kV grid, which are beyond the national grid-development plan. Those additional investments have removed unacceptable line overloading in N-0 and N-1 and fully allowed utilization of the assessed transmission capacity. This step represents the TYNDP-2014 Vision 1 – the bottom-up vision of ENTSO-E, and Vision 2 – the top-down vision, – with additional investments into the Danish transmission grid.
- Step 4 is as Step 3 and with further increase of the transmission capacity with the neighboring systems, massive integration of wind and RES and massive increase of the electricity consumption. This scenario has again introduced overloading of the Danish 400kV and also 150 kV and 132 kV transmission system.
- Step 5 is as Step 4 and with enabling more investments into the Danish grid: the 400 kV system expansion in Denmark East and the 150 kV system reinforcement in the North-West coast of Jutland (Denmark West) as well as upgrades of some 400 kV system components. This step represents the TYNDP-2014 Vision 4 – the top-down vision of ENTSO-E, and Vision 3 – the bottom-up vision, – with grid investments.

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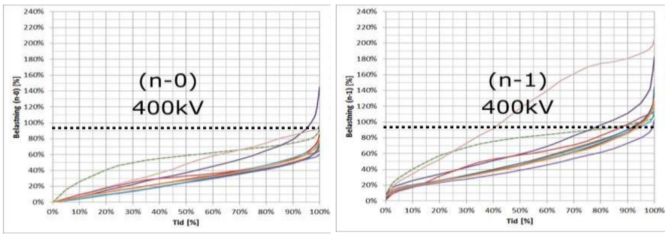
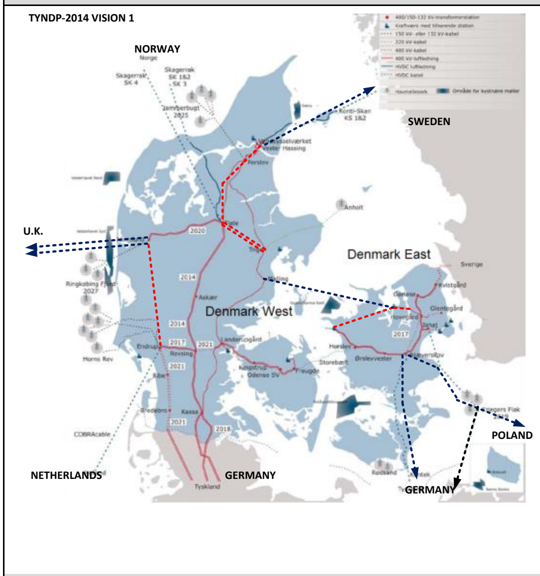
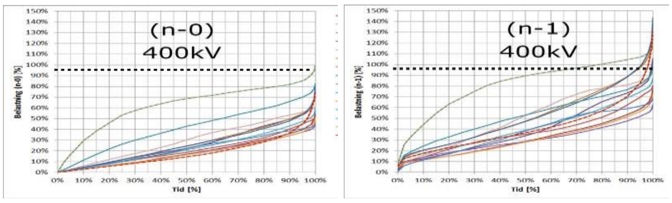
Step 1: For the 2030 grid-development stage, no additional investments and no additional connectors from Denmark, the transmission system is in acceptable operation ranges.

Step 2: For the 2030 grid-development stage, no additional investments, but with additional assessed connectors from Denmark as Vision 1 (and Vision 2), the 400 kV system becomes overloaded. The shown line loadings are for Denmark West.

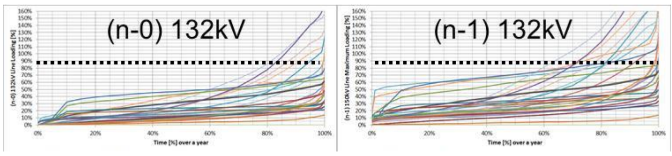


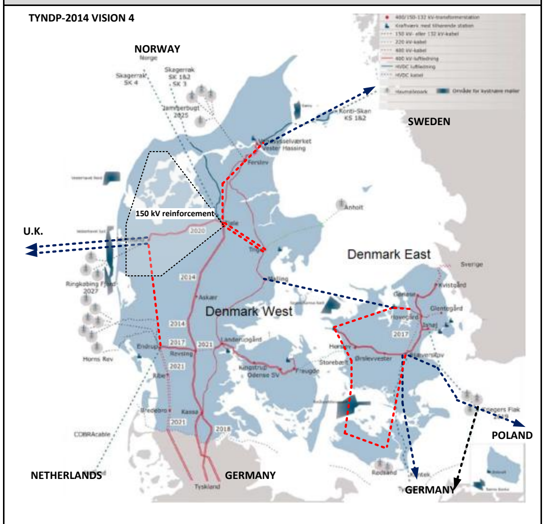


Step 3: Additional investments have removed line-overloading and brought the Danish system into acceptable operation ranges, illustrated for Denmark West as Vision 1 (and Vision 2).



Step 4: Increased power transport and significant increase of wind and RES as Vision 4 (and Vision 3), but with no extra investments. The shown line loadings are for Denmark East.





Step 5: Expansion of the 400 kV system in Denmark East and massive reinforcement of the 150 kV system in Denmark West with additional redesign of 400 kV components have brought the Danish system as Vision 4 (and Vision 3) into acceptable operation ranges. The shown line loadings are for Denmark East.

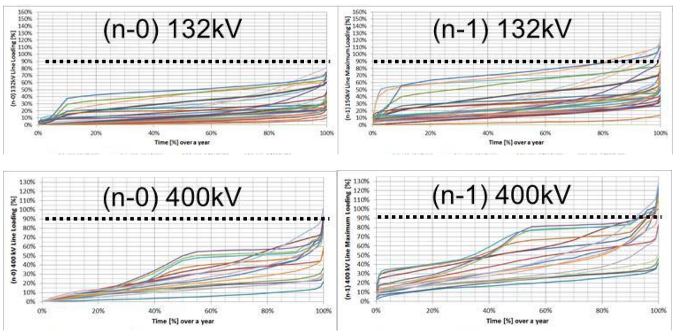


Figure 99 Study Case 1 illustration. Representation of the network reinforcements and step results in flow durations comparison vs. the given limits.

11.4.2 Study Case 2

On following figures an effect of additional 3rd interconnector is given in certain snapshot. The balances and flows of the snapshot are shown below on a figure on the bottom, where the flow from Latvia towards Estonia is 1888 MVA and from Estonia to Finland 606 MVA. Estonia is importing country with system load of 2270 MW and generation of 1097 MW. Latvia is Exporting country with system load of 1702 MW and generation of 3666 MW.

In upper-left figure is a snapshot of PSSE network model where Estonia-Latvia 3rd interconnector is taken out and Estonia-Latvia existing interconnectors are heavily overloaded. Also some internal lines are overloaded. If Estonia-Latvia 3rd AC interconnector is in operation it can reduce the overloaded line loadings to acceptable level and enable power exchange without congesting the inter-area flows. 3rd interconnector can significantly improve the system steady state stability, increase inter-area power exchange and improve security of supply in both neighboring systems. Red color on following figures illustrates the overloading of the modelled lines, where the flows in the AC circuits exceed the given limits.

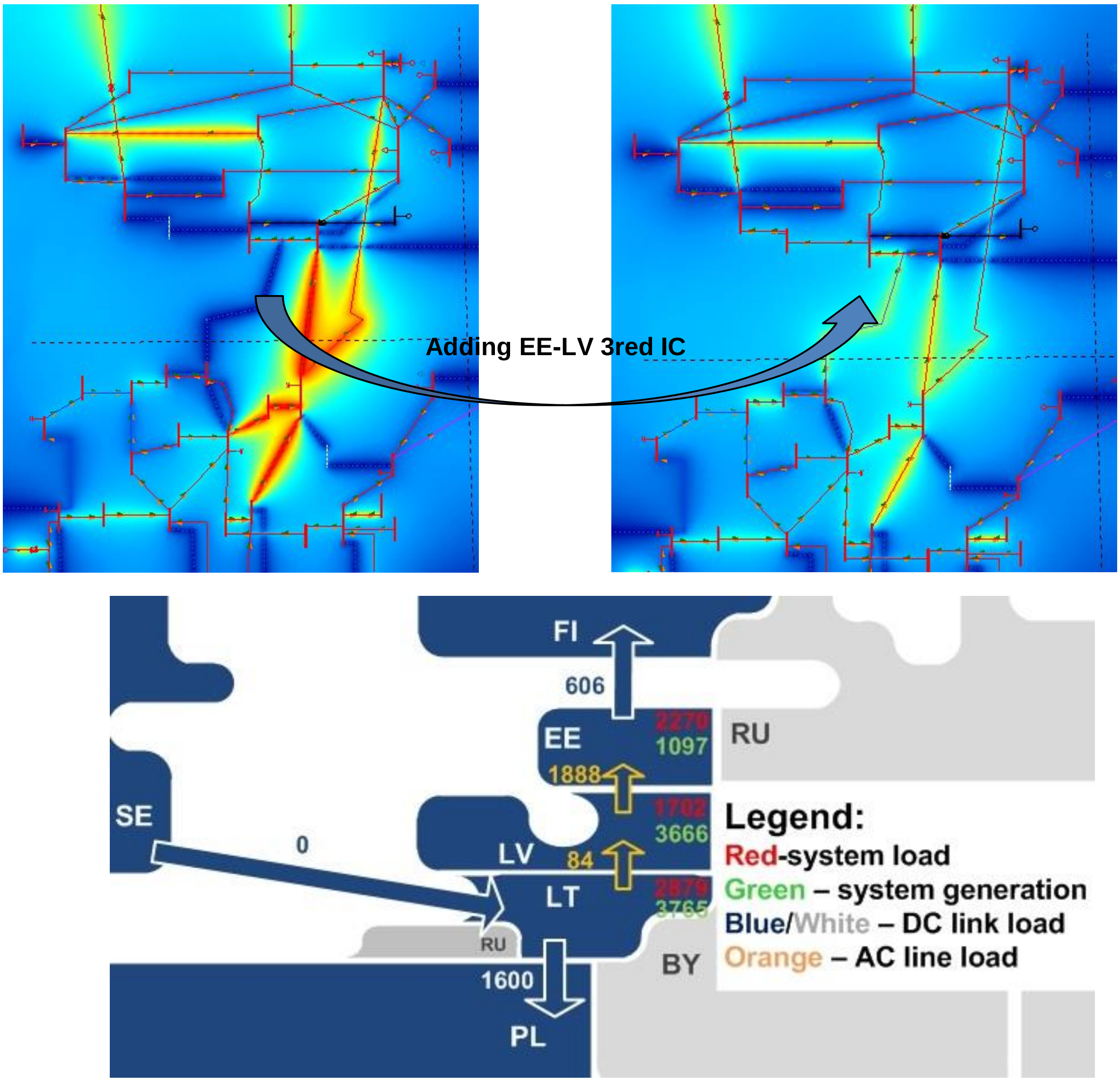


Figure 100 Study Case 2 illustration. Comparison of line loadings with and without 3rd interconnector between Estonia and Latvia and the representation of the studied N-1 snapshot balances and flows.

11.4.3 Study Case 3

In following figures an example of post fault situation is shown where the largest generating unit in Southern Finland has tripped off. Instantaneously after the trip power deficit is covered by increased power flow through the AC tie lines between Northern Sweden and Northern Finland. Initial flow before the contingency was below 1600 MW to Finland at the cross-section. In case of only two circuits the cross-section is overloaded, by adding the 3rd circuit, overloads can be avoided without reducing cross-border capacity. Red color on following figures illustrates the overloading of the modelled lines, where the flows in the AC circuits exceed the given limits.

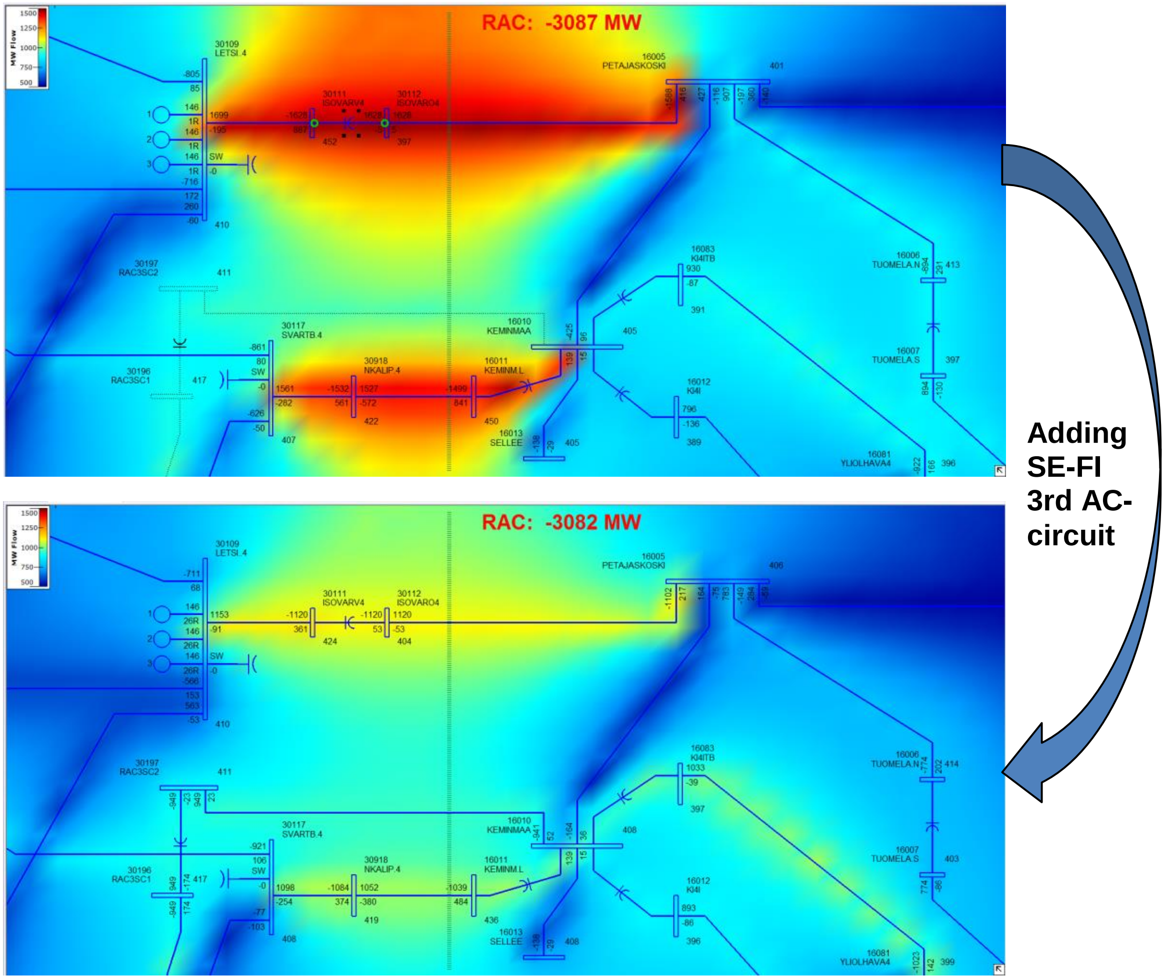


Figure 101 Study Case 3 illustration. Comparison of line thermal loadings with and without the SE-FI 3rd AC circuit in case of described snapshot and N-1 situation.

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11.5 Appendix 7 - Sensitivity analyses

11.5.1 Baltic Sea Green Vision

In addition to four common Visions, it was decided to assess “Baltic Sea Green Vision”, derived from Vision 3. Motivation of the study was to variate some of the elements that were common throughout V1-V4, and to examine to what extent this kind of bottom-up scenario would fall inside the “space” cornered by the common visions. However, no project or indicator assessment was performed in Baltic Sea Green Vision.

Initial data was equal to Vision 3, while TSOs were able to change demand and generation capacity. National adequacy requirements, which forced some condensing generation capacity in the common visions, were abolished (TSOs could choose whether they were met or not). Fuel prices were derived from IEA WEO 2013 (New Policies Scenario). Consequently, the scenario featured both a merit order where coal-fired generation became before gas-fired generation and fairly large share of RES. Biomass prices were increased compared to common visions, thus dismantling the prioritized position of bio-based generation which was in place in V1-V4. Russia was modelled assuming no CO2 cost and gas price of 85 % of European level (~ 27 EUR/MWh). The modelling assumptions for Russia are described in the main report under chapter “Market Study Methodology”. As a result of the changes made, demand and RES capacity as well as conventional condensing capacity in BS Green Vision were lower compared to Vision 3.

Overall, BS Green Vision results differed a bit from all four common visions, and differences were – logically – accountable to the different starting assumptions. A comparison of power balances in BS Green Vision compared to V1-V4 is presented below. German and Polish balances moved from V3 towards V1 levels due to lower demand (Germany) and higher coal- and lignite-based generation (Poland). Finland moved from being a clear net exporter in V1-V4 to net importer in BS Green Vision due to lower thermal output, since condensing capacity was lower due to abolishing national adequacy requirements and nuclear availability was equal to the rest of the region. Higher biomass price and lower CO2 price caused bio-based generation to be less “prioritized” over coal and gas-fired generation, which in turn decreased surplus especially in Denmark compared to Vision 3. Norwegian surplus was higher compared to common visions due to comparably higher RES output and lower demand. Overall, share of RES of total electricity generation was fairly in line with V3, since both RES output and demand were slightly lower in BS Green Vision. Total CO2 emissions, however, were larger in BS Green Vision due to coal running before gas in the merit order.

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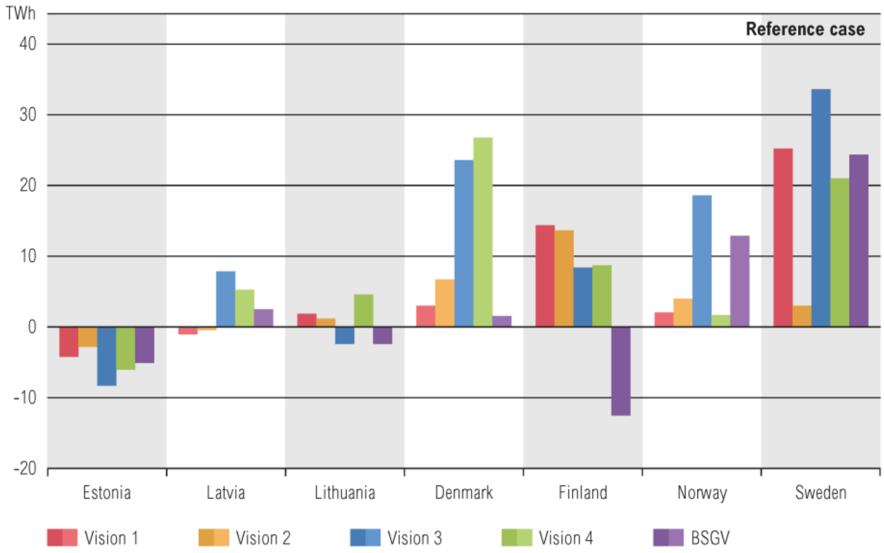

Figure 102 Comparison of balances with Baltic Sea Green Vision

Comparison of flows between Vision 3 and BS Green Vision is presented in figure below. In general, deficits/surpluses were smaller in BS Green Vision compared to common Visions, thus cross-border flows were also more versatile. This is visible especially in flows between Nordic/Baltic countries and Central Europe, as well as between the Baltic countries. Largest differences in the flows were between Finland and Sweden, where relatively balanced exchange in Vision 3 was changed to fairly continuous import from Sweden to Finland in BS Green Vision. The change was attributable to the change in Finnish balance. Exchange between Sweden and Norway remained fairly balanced in BS Green Vision, however the main flow direction was changed.

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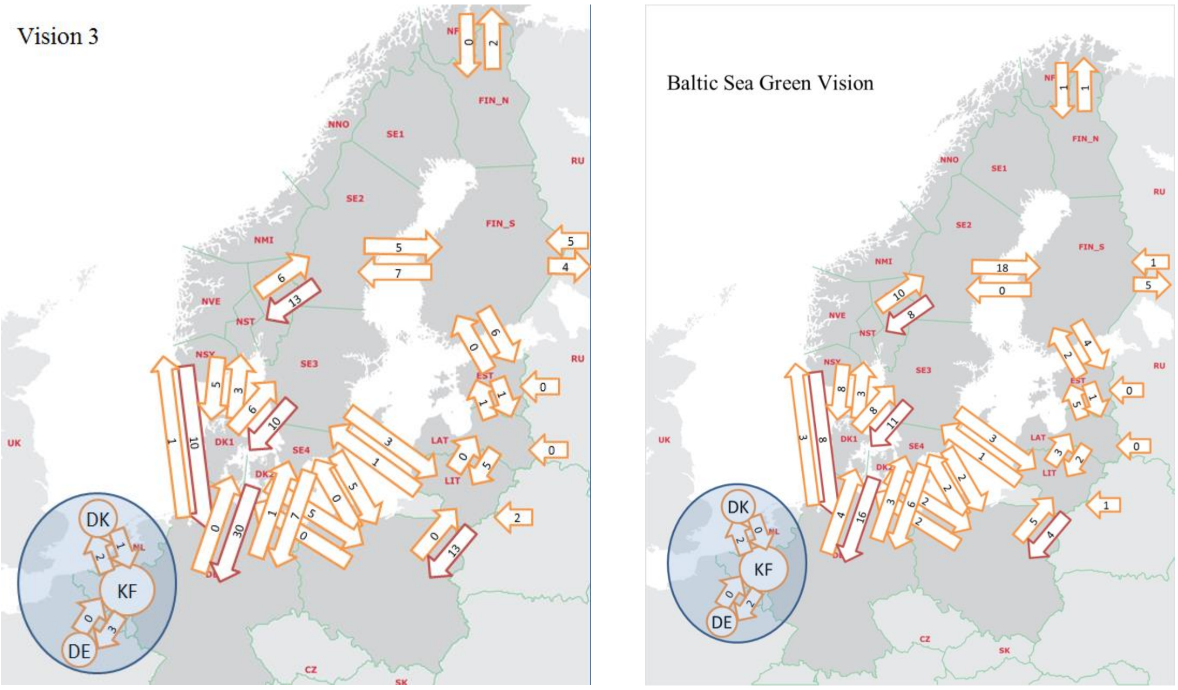

Figure 103 Flows comparison of Baltic Sea Green Vision with Vision 3, TWh

For the majority of countries in Baltic Sea region, BS Green Vision results fell in the “space” cornered by V1-V4. Deviations that took place in some countries were logically due to changes in inputs, mainly those that differed from all four common visions. Thus, it is worth acknowledging the role of different starting assumptions in the outcome of each vision. Overall, BS Green Vision results support the main conclusions drawn from V1-V4; the importance of interconnections between Nordics and Central Europe and the importance of integration of Baltic countries.

11.5.2 Low Nuclear

Reduced Nuclear is a sensitivity case based on Visions 1 and 4 with a reduced nuclear power capacity. The nuclear disaster in Japan has affected the European opinion and people are questioning the safety and longevity of nuclear power. Germany has already decided to decommission their nuclear power plants until 2022 and future plans for new nuclear power plants can be affected. New nuclear power is planned in Finland, Lithuania and Poland in the main scenario as well as reinforcements of several reactors in Sweden. In “Reduced Nuclear”, nuclear power capacity in Finland, Sweden and Poland is reduced compared to the reference case.

Table 7 Nuclear capacities in reference case and Sensitivity case „Low nuclear“

Country	**Price Area**	**Capacity, reference case (MW)**	**Capacity, sensitivity case (MW)**
Sweden	SE3	9.952	8.159
Finland	Finland	4.890 - 6.890	3.290
Lithuania	Lithuania	1.350	1.350
Poland	Poland	4.500	3.000

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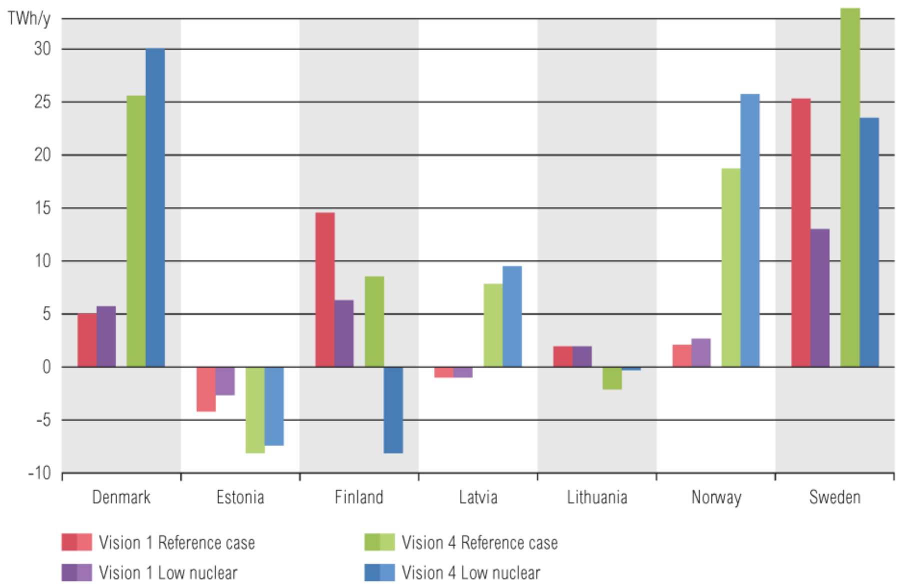

Figure 104 Annual balances. Comparison of reference case with sensitivity case, Visions 1 and 4.

A comparison of power balances in reference cases and Low Nuclear sensitivity cases of Visions 1 and 4 is presented above. Largest differences can be observed both for Finland and Sweden. Finland moved from being a clear net exporter in to net importer in the sensitivity case due to reduced nuclear capacity. Danish and Norwegian surplus was higher compared to reference cases if Visions 1 and 4 due to comparably higher hydropower and RES generation.

The major difference in flows (see next figure) can be noticed in Vision 4 –reduced nuclear capacity will cause flows from Finland towards central Europe to change direction due to deficit in Finland and reduced surpolus in Sweden.

Ther average market price difference compared to reference cases are observed mainly in Nordic and Baltic countries, reaching up to 6 €/MWh in Vision 1 and 21 €/MWh in Vision 4. The market price in continental Europe is similar to reference cases. Total CO2 emissions, however, were larger in the sensitivity case due to increased coal and gas production, the increase for the region is 15-21 MTons compared to reference cases.

It can be concluded that decreased nuclear capacity will change market prices, flows and balances remarkably in Finland and Sweden, causing possibly increase of benefits of projects within Scandinavia. At the same time price difference between Nordic and Central Europe is decreasing and benefits of these projects can be reduced.

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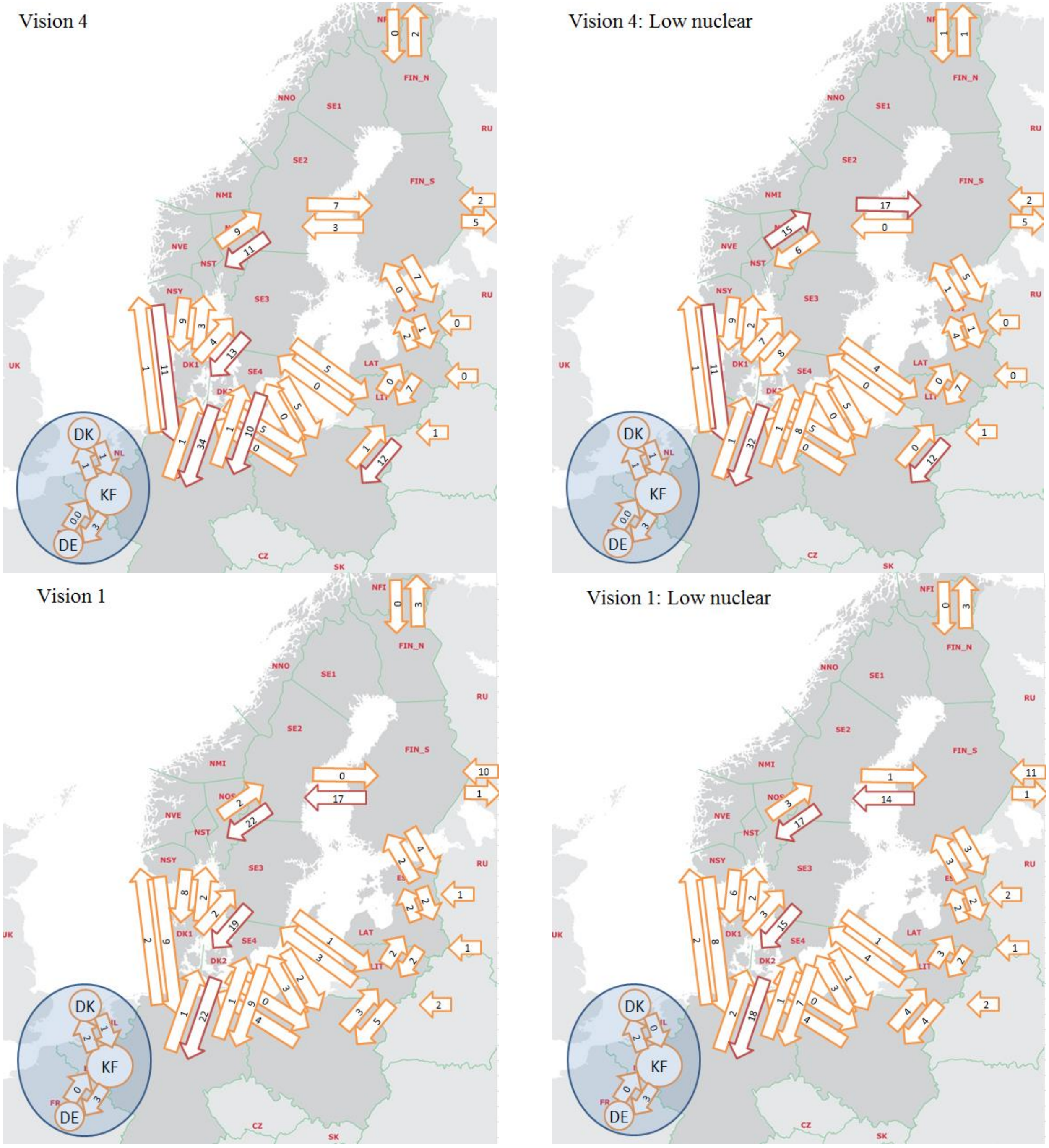

Figure 105 Energy flows in TWh; comparison of reference case with sensitivity case, Visions 1 and 4.

11.5.3 Delay of Projects

Approximately 63% of the investments are proceeding as planned compared to TYNDP 2012, together with the commissioned and cancelled investments they make a share of 70 % of the investment portfolio.

As it is unknown at present time which projects will be delayed in the future, assumption is made based on historical statistics for TYNDP 2012 projects. Socio-economic welfare is calculated as an annual value in the market models. The best estimate for the upper and lower bound for having 4 projects (around 30%) delayed for one year, could be found by taking out one project at a time. If the most beneficial projects are taken out – this would give an upper bound for how big the lost benefit could become ($SEW_{ref\ case} - SEW_{four\ projects\ out}$). If we take the least beneficial projects out (one at a time) this would give a lower bound. The difference in socioeconomic welfare is the estimated annual loss. We do the same for the 4 least beneficial projects to create a lower bound for annual SEW losses.

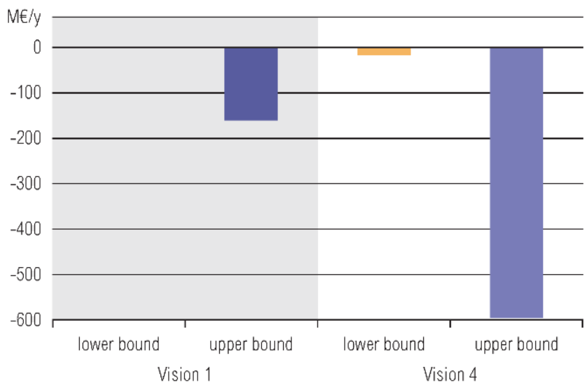

Figure 106 Annual decrease in socioeconomic benefit due to dalays in projects

The largest loss of SEW happens when the four most benefitial projects are taken out of Vision 4. The total annual SEW loss is presented in the figure above.

It can be concluded that total loss caused by delays can reach 150-600 M€ annually if ca 30% of investments are delayed. In addition, there are also other benefits (CO2, SoS, etc) that are reduced with delays of commissioning of projects, but are not assessed.

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11.6 Appendix 8 - Discussion of projects assessment results

The process of compiling the TYNDP 2014 investment plan started with Exploratory Phase. The main outcome was a list of project candidates for further investigation and cost benefit analyses in the Assessment phase. The proposed project candidates were covering six main areas of interest according to input from all TSO’s in the Regional Group Baltic Sea:

- Reinforcing the Nordic synchronous area
- North-South reinforcement in Nordic countries
- Increased capacity between the Nordic synchronous area and Continental European synchronous area (and UK)
- Increased North-South capacity through Baltic States
- Power Flow control on Estonia/Latvia - Russia border
- Baltics synchronization with Continental Europe

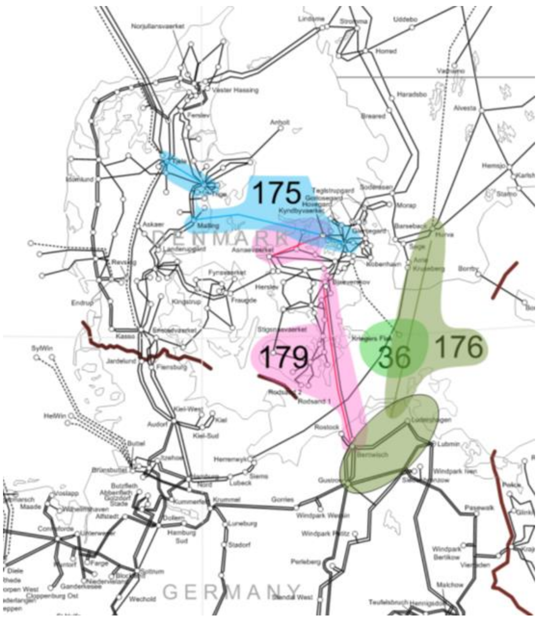
According to CBA methodology and changes in implementation plans of some TYNDP 2012 projects, some of the projects from TYNDP 2012 were reassessed within the framework of TYNDP 2014.

In addition two third-party projects were submitted to be assessed by RG Baltic Sea, both of the projects were hydro pump storage projects. Third-party storage projects were assessed equally with other projects.

Based on previous analyses and project assessment results within the framework of TYNDP 2014 discussion about assessment results are presented by focus areas as following:

- Focus area – Cross section between the Nordic and Continental European synchronous areas – 4 new projects
- Focus area – Internal interconnections in the Nordic synchronous area – 5 projects
- Focus area – Integration of Baltics with internal energy market – 9 new projects

11.6.1 Focus area – Cross section between the Nordic and Continental European synchronous areas



Project Id	Project name	Increase MW (market)
36	Kriegers Flak CGS	400
175	Denmark East-Denmark West (Great Belt 2)	600
176	SE4-DE Hansa Power Bridge	600
179	Kontek 2	600

Figure 107 Map representing assessed project in the cross section between the Nordic and Continental European synchronous areas in RGBS region and a table with relevant project names.

The cross section between the Nordic and Continental European synchronous areas covers a number of projects. All of the projects are subsea HVDC cables connecting and Continental European synchronous

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areas via converter stations. The reason for high interest in this particular area is the need to combine conventional power plants and wind power with flexible and well balancing hydro power plants. Additionally in the Northern Nordic countries there is a tendency to have much lower electricity price than in Continental Europe, which leads to frequent congestions in this cross section. In TYNDP 2014 four different projects are assessed and presented in the development plan. The projects are presented on the map figure and table above.

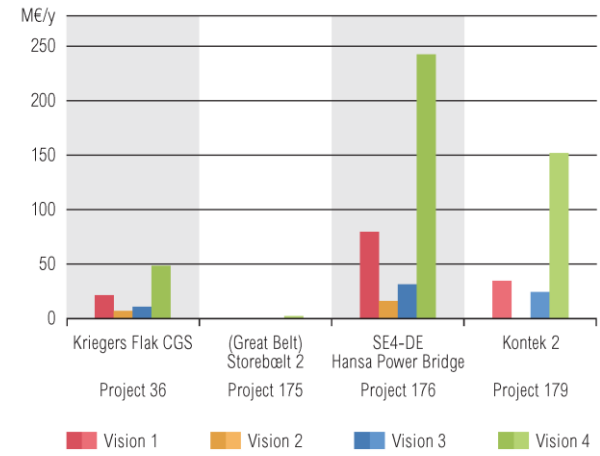

Figure 108 Socio-Economic welfare for projects in the cross section between the Nordic and Continental European synchronous areas.

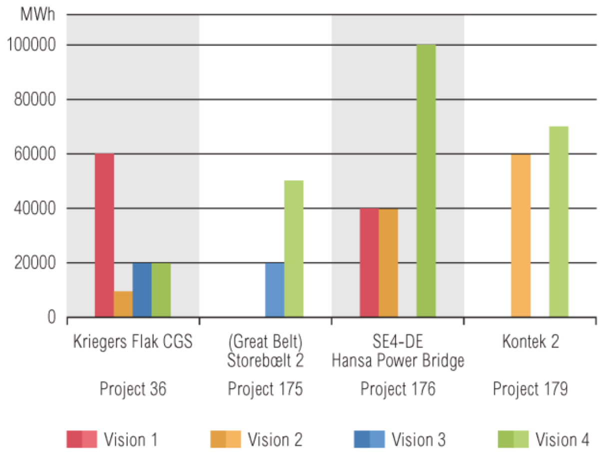

Figure 109 RES increase results for projects in the cross section between the Nordic and Continental European synchronous areas.

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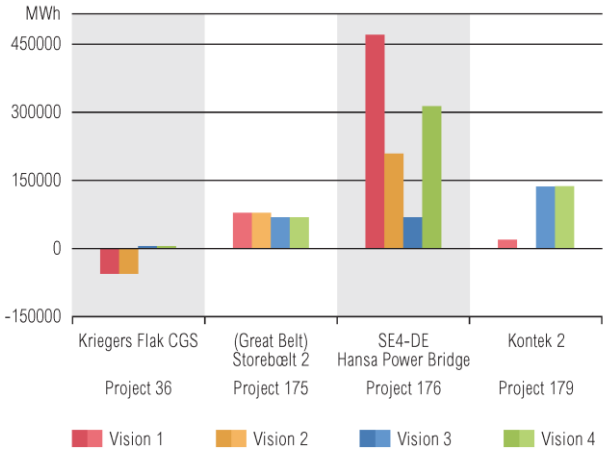

Figure 110 Increase in losses for projects in the cross section between the Nordic and Continental European synchronous areas. (German losses are not taken into account in the presented results)

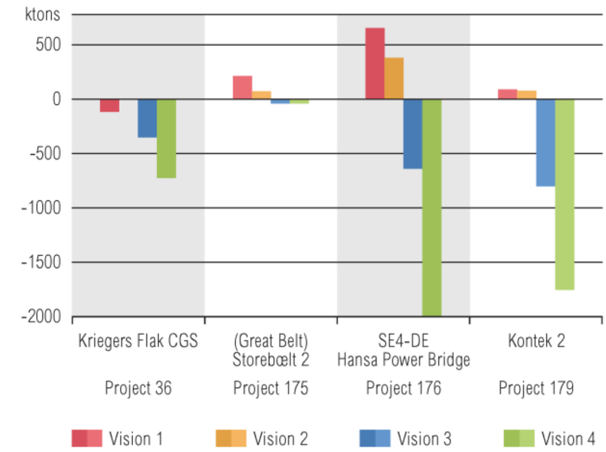

Figure 111 CO_2 increase for projects in the cross section between the Nordic and Continental European synchronous areas.

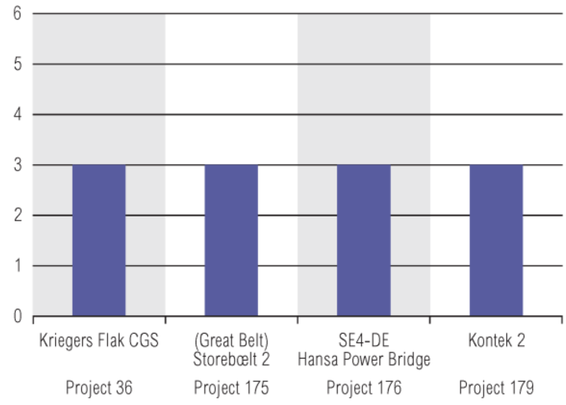

Figure 112 Resilience in the cross section between the Nordic and Continental European synchronous areas.

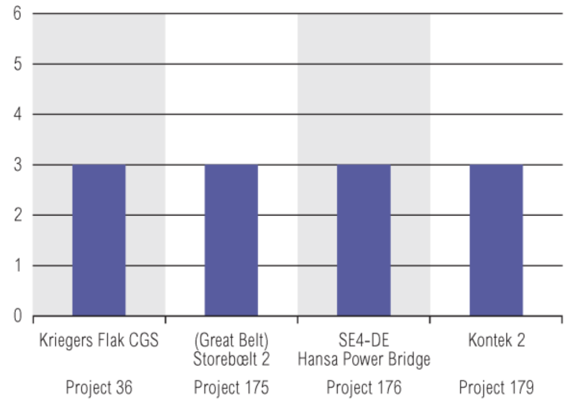

Figure 113 Flexibility/Robustness results for projects in the cross section between the Nordic and Continental European synchronous areas.

The benefits differ in different visions as can be concluded from the illustrated indicator results table above. Regarding SEW value, the projects provide highest benefit in vision 4 as also for RES increase and CO2 reduction. The projects do not have that much influence on RES in vision 1 and 2 as the visions are mainly based on thermal production and there is no need to restrict RES production. The projects have influence to CO2 increase in case of Vision 1 and 2 because enabling additional possibilities for thermal power plants through higher export capacities, especially in Poland where majority of the generation is based on brown coal. The projects are beneficial in all visions and are not depending so much on other projects. Also the HVDC technology enables to be very flexible in power flow fully control the flow on interconnectors. Therefore the Flexibility and Robustness indicator is assessed at very high level. The resilience comes mostly from the fact that the new fully controllable HVDC links increase the possibility to survive different severe contingencies and increase the reserves in case of losing severe amount of local production.

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Together with the HVDC links also internal high voltage networks need to be reinforced. The amount of internal reinforcements is described more in detail under each project summary in Appendix 1

As a conclusion, the assessed projects provide a good SEW benefit for the entire region, allow increasing the SoS level and allow more RES into the system. It also opens the new possibility for the whole electricity market and integrates the Nordic and Continental European power systems to a new qualitative level. Depending on the future developments additional increasing capacities may be studied and the good starting can be the mentioned alternatives as listed in the table before.

Additionally to the given project candidates above some further projects were screened, but not included into the development plan content as being considered as immature and unrealistic to be constructed together with all the rest of the projects at the same time. Also the selection of the projects was done based on preliminary assessment results. More studies have to be performed in the future to find out the exact needs and possibilities of additional alternatives to the selected ones. The additional projects that were studied are given in the table below:

Table 8 Additional projects in the cross section between the Nordic and Continental European synchronous areas, analyzed during assessment of projects.

Project Id	Project name	Increase MW (market)
166	1. Denmark East-Poland (DK2-PL)	600
	2. Sweden South-Poland (SE4-PL)	600
	3. Sweden South-Germany (SE4-DE)	600
	4. Sweden Mid-Latvia (SE3-LAT)	700
	5. Denmark East-Germany DK2-DE	600
Projects 2-4 are alternatives to each other		

A majority of the assessed projects in the observed cross section show really good SEW values and RES increase. The projects tend to increase the losses because of losses in AC/DC/AC conversion and also influence of long distance DC cables. The projects show really good performance in Resilience and Robustness.
Deep the Polish integration within Baltic Sea energy market require reinforcements of Polish internal transmission grid throughout following investments from cluster 57 PolBaltic Integration: 400kV line Piła Krzewina – Bydgoszcz Zachód, 400kV substation Pelplin, 400kV line Żydowo- Słupsk, 400kV line Żydowo – Gdańsk Przyjaźń, 400kV line Pątnów – Grudziądz, 400kV line Dunowo – Plewiska, 400kV substation Żydowo Kierzkowo, 400kV substation Gdańsk Przyjaźń, 400kV substation Gdańsk Błonia, 400kV line Grudziądz – Gdańsk Przyjaźń. These investments in north – western part of Poland allow full utilization of PL-SE4 HVDC cable, integration of renewable energy sources, evacuation of power from conventional power plants and also implementation of Denmark East – Poland (DK2-PL) project. The main benefits of the projects are observed on the regional and local scale.

11.6.2 Focus area – Internal interconnections in the Nordic synchronous area

Internal interconnections in the Nordic countries include both grid reinforcements in Northern part of the area, as well as massive reinforcement North-South in the grid.

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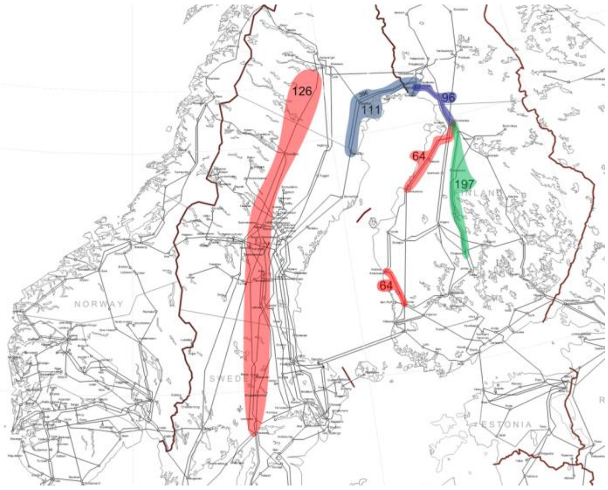

ID	Project name	Increase (MW) market
111	3rd AC Finland-Sweden north	500/800
126	Sweden North-Sweden Mid and Sweden Mid-Sweden Central SE1-SE2 and SE2-SE3	800/800 and700/0
64	North South in Finland (P1) phase 1	-
96	Keminmaa – Pyhänselkä	-
197	North South in Finland (P1) phase 2	-

Figure 9 Assessed projects – Internal interconnections in Nordic synchronous area

In Northern Nordic countries there are several factors implying the need for investigating increased grid capacity in the Northern Nordic area; expected major increase in wind power, plans for new nuclear power plants in Finland as well as expected considerable consumption growth in Northern Norway. The expected growth of consumption is mainly due to increased activity in the petroleum and mining industry.

The power system in the Northern Nordic countries is characterized by large distances, a sparsely population and a relatively low consumption. The region has a positive yearly energy balance but due to seasonal variations in inflow the power flow varies considerably between summer and winter. In addition to today's balance variations, the expected consumption growth in Northern Norway will cause longer periods with negative balance and increased need for grid capacity to ensure secure of supply.

In studies several alternatives for reinforcing the area has been identified. These alternatives have also been studied in the market and grid integrated analyses and proposed as new project candidates.

Plans for major new installations of wind power in Finland in addition to the planned nuclear power plants, makes it necessary to study the need for increased exchange capacity between Northern Sweden and Northern Finland. It may also be beneficial to increase additionally the exchange capacity between Northern Norway and Finland.

The area south of Ofoten in Norway, is mainly characterized by a large positive yearly balance as well as considerably variations in flow patterns. Approximately 20% of Norway's storage plants are situated here and the flexibility (price sensitivity) of the plants is one of the reasons for the major fluctuations in flow patterns. In addition to the Norwegian surplus, Sweden also has a considerable amount of run of river plants connected along the Swedish side of the 420kV line Ofoten-Ritsem-Porjus. The non-flexible hydropower contributes to limit the export from Norway to Sweden. Ofoten is also connected southwards in Norway with only one (400km) 420kV line to Nedre Røssåga. In situations with highly loaded lines, the outage of either Ofoten-Porjus or the Norwegian North-South stretch may cause dynamic challenges in the system. For that reason the area has several protection schemes connected to the different operation states and outages. Towards 2030 the surplus is expected to increase both in Sweden and Norway due to plans for new wind power in both countries as well as Norwegian small scale hydro, which will amplify the constraints even more.are several factors implying the need for investigating increased grid capacity in the Northern Nordic area; expected major increase in wind power, plans for new nuclear power plants in Finland as well as expected considerable consumption growth in Northern Norway. The expected growth of consumption is mainly due to increased activity in the petroleum and mining industry.

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North-South flows

The flow pattern through Sweden is mainly from the Swedish surplus areas SE1 and SE2 towards the Swedish deficit areas SE3 and SE4. During daytime the power flow continue even further south through the connections to Denmark, Germany and Poland.

Under normal conditions Norway have similar flow pattern as Sweden. The Northern area is characterized by surplus with export to the demand centers in the south. The south and southwest areas are also characterized as a positive hydrological area with eastern flow to the Oslo area. The exchange between the countries mainly depends on the hydrological balance and consumption in both countries.

The power flow through the connections linking southern Norway with SE3 are commonly referred to as the "Hasle-snittet". In the winter, the interconnection is seldom fully utilized due to internal constraints. There are several factors influencing the exchange, for example availability on nuclear in Sweden and hydro storage in Norway. There are also some internal north-south limitations that can limit the exchange here as well.

The flow on the Northern interconnections between Sweden and Norway (NO4-SE1, NO4-SE2) is lower than on the southern connections. The flow is influenced by the hydro production in both countries. If the production level is high, usually Norway will export to Sweden, and contribute to increasing the North-South flow in Sweden.

A north-south flow also characterizes the power flow in the Finnish grid. The flow through the Finnish cross section P1 is most of the time southwards. The connections between Swedish area 1 (SE1) and Northern Finland during wet and normal years mostly are used for export from Sweden. There are also transit flows from SE1 through Finland and back to SE3 through the Fenno-Skan.

During a normal year, SE1 imports power from Northern Norway. The imported power is then transferred via the AC power lines down to the south of Sweden where it is either supplying load or exported to the continent via the HVDC links. Transit flows also occurs from time to time from northern Norway through the Swedish cross section 1 through SE2 to central Norway where there often is a high demand for power.

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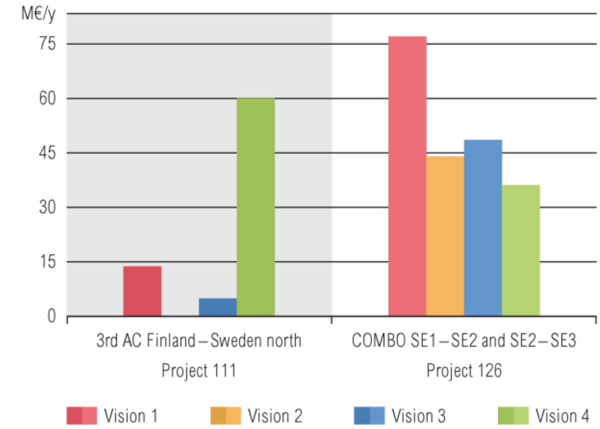

Figure 114 Socio-Economic welfare for projects related to Internal interconnections and reinforcements in the Nordic countries.

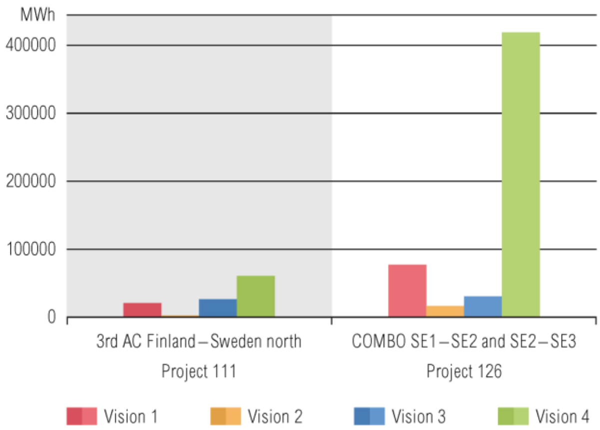

Figure 115 Increase in RES generation for internal projects in the Nordic synchronous area.

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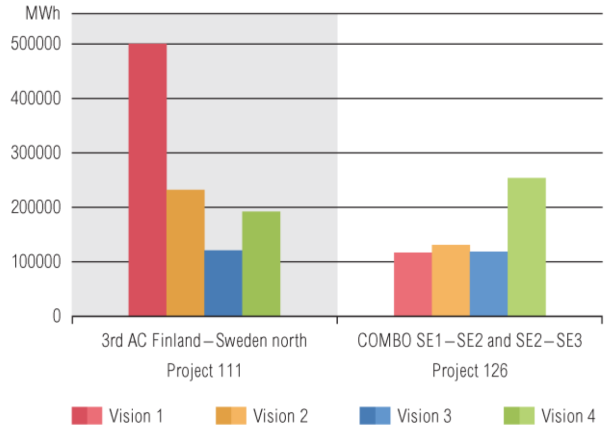

Figure 116 Increase in losses for internal projects in the Nordic synchronous area.

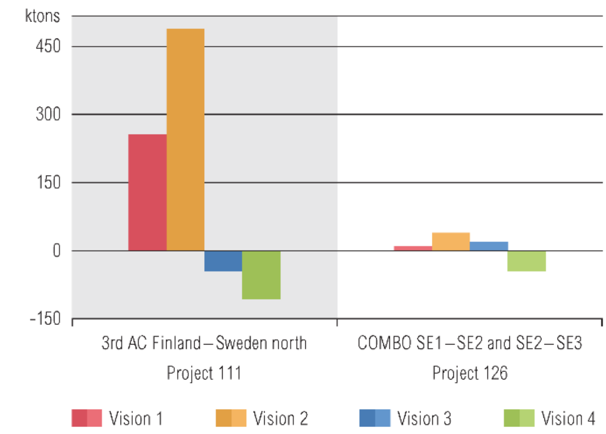

Figure 117 CO2 emission increase for internal projects in the Nordic synchronous area.

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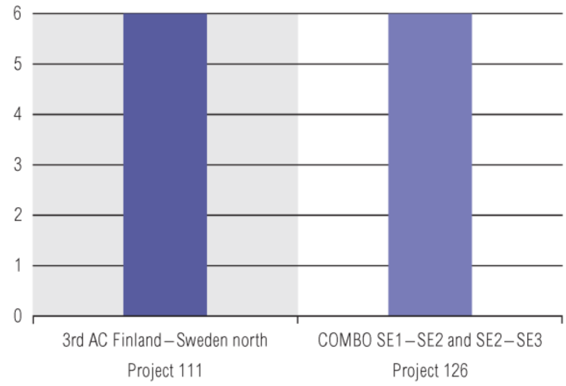

Figure 118 Resilience for internal projects in the Nordic synchronous area.

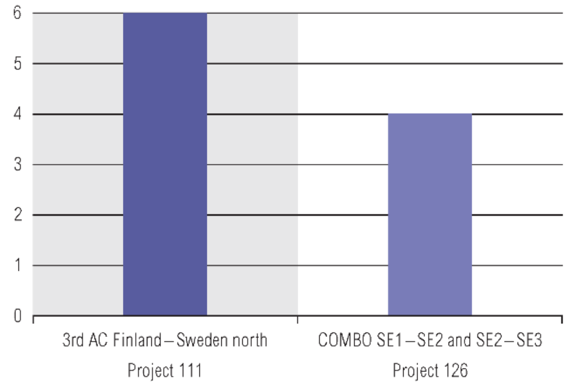

Figure 119 Flexibility/Robustness for internal projects in the Nordic synchronous area.

Additionally to the given project candidates above some further projects were screened, but not included into the development plan content as being considered as immature and unrealistic to be constructed together with all the rest of the projects at the same time. Also the selection of the projects was done based on preliminary assessment results. More studies have to be performed in the future to find out the exact needs and possibilities of additional alternatives to the selected ones. The additional projects that were studied are given in the table below:

Table 9 Additional projects in the internal Nordic synchronous area, analyzed during assessment of projects.

Project name	Increase MW (market)
1. Sweden Mid-Denmark West (SE3-DK1)	700
2. Sweden South-Denmark East (SE4-DK2)	700
3. Northern Norway – Sweden area 2 (NNO-SE2)	700
4. Norway Finnmark – Finland (NFI-FIN_N)	500

11.6.3 Focus area – Integration of Baltics with internal energy market

The three priority objectives of the EU's energy policy competitiveness, security of supply and sustainability can only be achieved through a well-interconnected and well-functioning internal energy market backed up by coordinated action by Member States to enhance their solidarity. The one of the priorities of the Commission in the framework of the Second Strategic Energy Review is to connect "energy islands" with the internal European market. In this context, the Baltic region has been identified as the first of six major sets of infrastructure projects. The integration of the Baltic States into EU energy networks is seen as one of the main objectives that will contribute to the stability and economic growth of the whole Baltic Sea Region therefore the integration of Baltics with internal energy market has set high priority within RGBS.

Due to many uncertainties for the time period beyond 2020 RGBS has studied possible ways of further transmission system evolution and has recognized a few preconditions for grid strengthening and exploitation to ensure a reliable operation of the transmission system, the electricity market integration and security of supply in Baltic area.

The weakest point in transmission system in Baltic States is recognized on cross-border EE-LV therefore since last two TYNDPs as priority is stated an establishment of 3rd interconnector between EE-LV. It is planned a 330 kV line between Kilingi-Nomme substation in Estonia to Riga CHP2 substation in Latvia. Explored possible evolutions of Visions it has been recognized that in many Visions Baltic States have been used as alternative/parallel corridor for power flows from North to South what also shows that cross-border EE-LV is going to overload much more.

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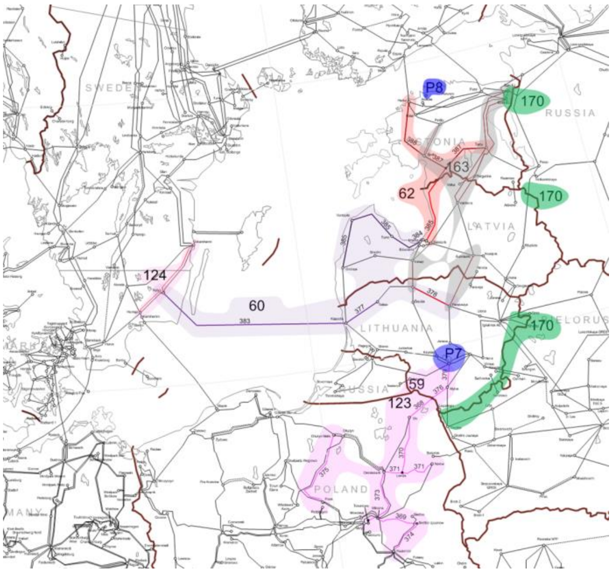

ID	Project name	Increase (MW) market
59	LitPol Link Stage 1	500
123	LitPol Link Stage 2	500
60	NordBalt phase 1	700*
124	Nordbalt phase 2	700**
62	Estonia-Latvia 3rd IC	500
170	Baltic synchronization	600
163	Baltic corridor (EE-LV-LT)	600
P7	Kruonis storage (P T1)	250
P8	Muuga storage(P T2)	500
* Project 60 will be in commission before 2020 but has been assessed since it is in the PCI list.		
** Project 124 makes it possible to use the full capacity for project 60 without using protection schemes.		

Figure 120 Map representing assessed project on Integration of Baltics with internal energy market and the table with relevant project names.

One of the outcomes from Baltic Sea Regional Investment Plan 2012 and TYNDP 2012 was that there is a need to increase the possibilities to transfer power from Northern Scandinavia to central Europe and one of the possibilities is to develop alternative corridor from Finland to Continental Europe through Baltic States. Based on this more grid reinforcements are needed in Vision 4 where flows from North to South are even higher comparing to Vision1 and more strengthening of transmission corridor and infrastructure through Baltic States is required to ensure power flows from main generation nodes to consumption centres. At the same time the internal reinforcements allow better utilization of planned interconnectors (Nordbalt, LitPol link, Estlink 1&2) and are thus contributing to large area than just Baltic States. To provide sufficient capacities the new project called Baltic corridor has explored. It gives 600 MW extra capacity starting from EE and ending in LT. At this stage the Baltic corridor is observed as an internal grid strengthening in Baltic States but the alternative way could be a grid strengthening starting from Finland which in some cases could be a reasonable option as well. The preliminary analyses in some particular scenarios show that new HVDC link between FI and EE would be beneficial and established for market integration. At the moment the border EE-FI has two HVDC links – Estlink 1 (350 MW) and Estlink 2 (650 MW), which give the total amount of transmission capacity 1000 MW. During the studies it has been recognized that existing amount of capacity is suitable and sufficient but the increase of transmission capacity on the border EE-FI in future scenarios can give more benefits for whole RGBS.

To connect and integrate the Baltic and Nordic electricity markets a new HVDC link (400 km) between LT and SE is under construction. The project called Nordbalt has been divided into two phases giving a total transmission capacity of 700 MW. The phase one is short term phase which includes construction of HVDC link and internal grid reinforcements in Latvia and Lithuania. The phase two is a long term phase which includes internal grid reinforcements in Lithuania and Sweden. Without internal grid reinforcements the full amount of HVDC link capacity won’t be able to utilize. In the TYNDP 2014 more alternative projects have been evaluated which can contribute to a stronger grid connection between the Baltic and Nordic countries. Through the visions a HVDC link between LV-SE has been recognized and based on market integration issues the project shows beneficiaries for whole RGBS. Due to the physical limitation to establish further projects from southern Sweden before 2030 the project LV-SE has been left as an option to other additional projects in the future beyond 2030. .

The second important project for integration of Baltic States within Continental European market is the LitPol link project. The project consists of two phases where phase one is short term phase which contributes to asynchronous export from Lithuania to Poland with transmission capacity of 500 MW only and phase two allow achieve target of 1000 MW transmission capacity exchange in both direction. In Vision 4 an additional increase in transmission capacity on the border of 600 MW has been evaluated.

Baltic Synchronization

Baltic Power System is at present a part of synchronous area of the Interconnected Power System of the Unified Power System (IPS/UPS).

On 11th June 2007 the Prime Ministers of the Baltic States signed the Communiqué calling TSOs from Estonia, Latvia and Lithuania to start overall studies on synchronization of the Baltic Power System with the former UCTE for full integration of the Baltic electricity market into the EU common electricity market.

On 7 September 2011, the European Commission adopted the Communication on security of energy supply and international cooperation - "The EU Energy Policy: Engaging with Partners beyond Our Borders". The Communication sets out for the first time a comprehensive target for the Baltic region - it is necessary to synchronize the Baltic States' networks with the power system of the Union.

The PCI project Estonia/Latvia/Lithuania synchronous interconnection with the Continental European networks is aimed to infrastructure development for deeper market integration and synchronous operation of the power systems of the Baltic States with the Continental European networks.

During 2012-2013, Lithuanian, Latvian and Estonian TSOs Baltic TSO-s carried out a Feasibility study “Interconnection Variants for the Integration of the Baltic States to the EU Internal Electricity Market“ to evaluate the possible technical and economic consequences and benefits of synchronizing power systems of Baltics within synchronous area of Continental Europe. One of the main objectives and outputs of the Study was identification of the optimal variant and scenario with detailed analysis of the process and steps needed for the Baltic States power systems for full synchronous interconnection with the Continental Europe power system. The study identified a clear amount of necessary grid reinforcements and associated costs. The conclusion of this study is that due to very high investments costs of grid reinforcement, synchronization the Baltic States with Continental Europe is not profitable. The Baltic Synchronization-issue will be further worked on within the TSOs in the area.

Two different landing points and two differently routed interconnections are required to achieve physical separation of the two redundant interconnections in order to establish a reliable synchronous connection between the transmission systems of Baltic States and Continental Europe networks. The first Lithuania – Poland connection is already decided and it will be the first connection. The second connection is still under investigation. Both connections have to be double circuit to ensure that there is a physical connection remaining if one circuit in one of the connections is out for maintenance and there is a double circuit fault on the other connection.

Below is the map showing summary about lines should be improved or build for Baltics synchronisation with CE project (green highlighted lines). It is difficult now to start analysis for Baltics synchronisation project now as it is unclear which way of synchronisation will be selected in the future. The problem is that option for case where synchronisation could be done is through Kaliningrad area in route Lithuania-Kaliningrad-Poland. Second option – second direct connection is very hard to implement due to crossing

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nature protected areas in Poland and difficulties in finding the new routes for new lines. Without knowing which decisions will be done is impossible to start more detailed investigations right now.

To enable power exchange with IPS/UPS, and for diversification of electricity supply into Baltic region, HVDC back-to-back links should be established on Lithuania-Belarus, Lithuania-Russia (Kaliningrad), Estonia-Russia, Latvia-Russia borders.

Figure 121 Scope of Baltic Synchronization investments in Baltic States

Discussion of project assessment results

In the TYNDP 2014 study four separate visions have been applied. The outcome of study shows that the 3rd interconnector between LV-EE is not so beneficial in all four Visions because Visaginas NPP is in operation and caused opposite power flows as it is now. To refer on the last statements of government of Lithuania Visaginas NPP project is very uncertain now and further evolution depends on common decisions made by governments of Baltic States. SEW benefit for this project is also strongly influenced by Vision assumptions related specifically to large scale RES integration into the concentrated area inside of Baltics power system and that assumption might not be fully realistic due to the limitation of district heat demand and biofuels availability. Another factor is the assumption of self-sufficient installed generation-consumption balance on country-level. The 3rd interconnector looks less beneficial comparing the indicators of other projects but in reality main bottleneck is on border EE-LV. Special sensitivity cases, especially Baltic Sea Green vision show potential for much higher benefit than highest benefit in studied visions. According to study prepared by RGBS 3rd interconnector improves the resilience and robustness and allows connect not significant amount of RES. Due to very high investments costs of grid reinforcement, synchronization the Baltic States with Continental Europe is not profitable. The Baltic Synchronization-issue will be further worked on within the TSOs in the area.High assessment indicators are expected for Nordbalt project because it connects two price zones with high price difference as well as the project decreases CO2 emissions and improves resilience and robustness in Baltic Sea region. The assessment indicators show that the NordBalt project has very high transmission losses which in reality vary according to power system operation. RES integration for project vary in wide range between Visions 1 and 4 and mainly the reason for that is input data depending on Vision.

Historically Baltic States power system was designed to serve as a back-up transmission loop between North and South of Russia, in case of severe contingencies as tripping of 750 kV main transmission lines between Leningrad and Moscow area and further to Belarus. Today the power systems of Baltic States and Russia are operating as independent power systems with their own control centers but the impact to the Baltic States power system because of the possible generation unbalances and disconnection of main transmission lines between North and South of Russia remains, regardless of internal reinforcements in Russia. All things about Russia import and export to Baltic States caused uncertainties in Russian market modelling for 2030 and also interpret the power flows from or to Russia. In the TYNDP 2014 the price for Russia was assumed as market-based power flow between the BS region and Russia, where Russia is modeled as a price function with a base price and hourly variation factors. This study assumes the exchange to be based on an efficient market mechanism, i.e. capacity payments and other cross-border fees are not assumed to affect the trade. According to Visions set by ENTSO-E and developments of generation in Baltic States the results show that in Visio 1 the import to Baltic States is small around 4 TWh but in Vision 4 it is close to 0. It means that the price levels in Baltic States and Russia in both cases are similar and price difference doesn't vary dramatically. In reality the price difference exist and will remain due to different policies in the regions but all assumptions applied for TYNDP 2014 indicate the unpredictable market rules for Russia and displays remarkable market capability for it.

As described above the NordBalt project has been divided into two phases to fulfill the CBA criteria. In the analysis the total increase in capacity was referred to phase 1. Therefor B2, B3 and B5 are only calculated for phase 1 but should be interpreted as the values for phase 1 and 2 together. The indicators B4, B6 and B7 has been calculated for both phases individually.

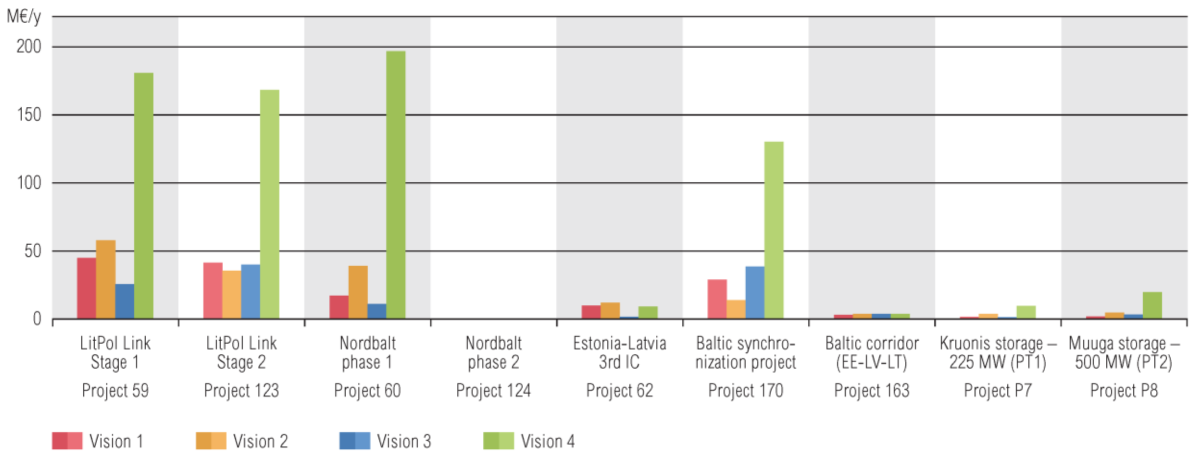

Figure 122 Socio-Economic welfare for projects related to Integration of Baltics with internal energy market.

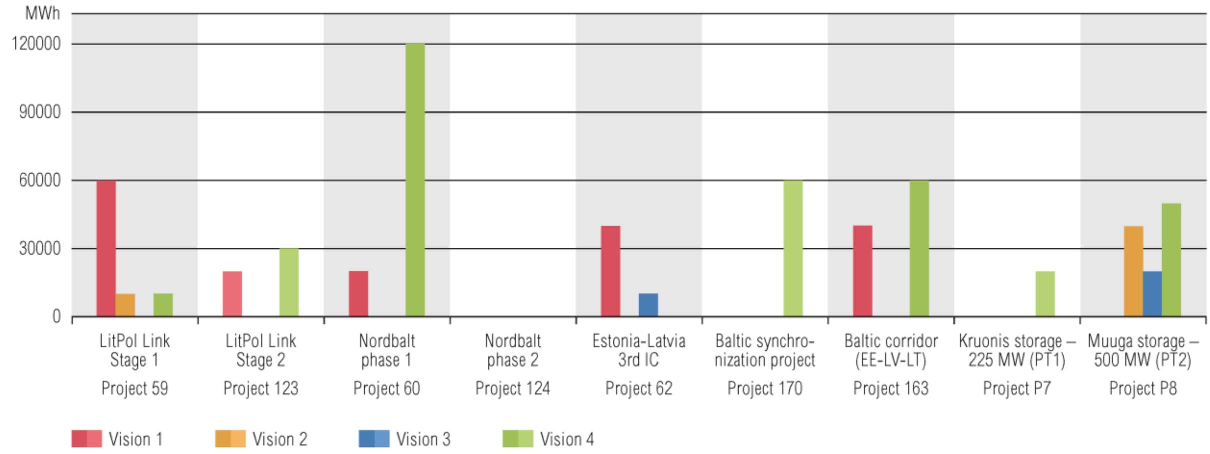

Figure 123 RES production increase for projects related to Integration of Baltics with internal energy market.

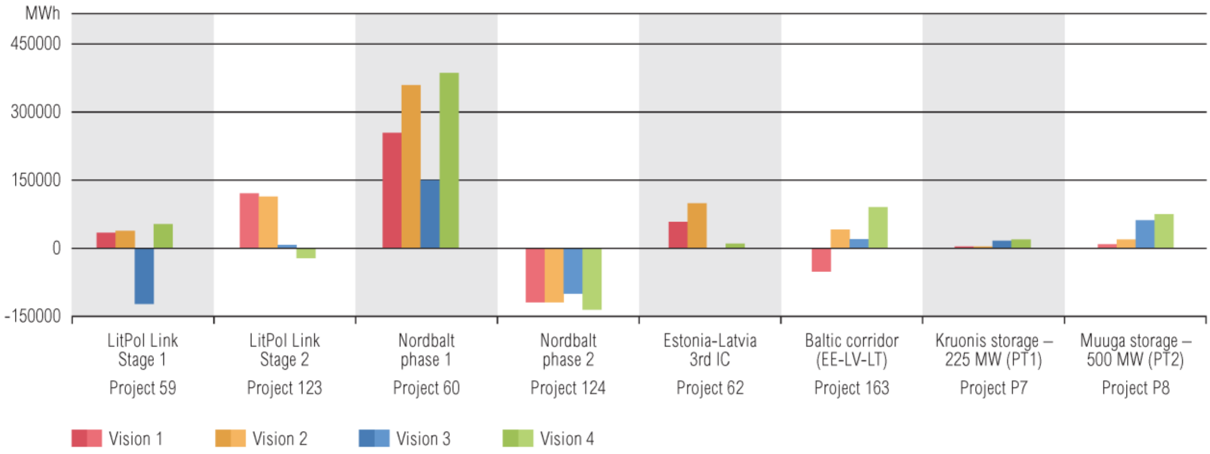

Figure 124 Losses increase for projects related to Integration of Baltics with internal energy market.

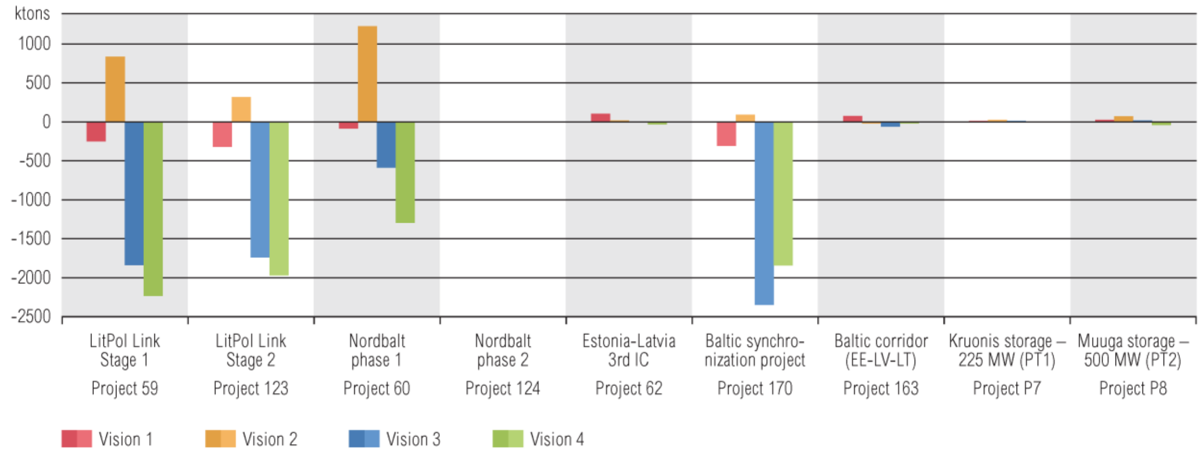

Figure 125 CO2 increase for projects related to Integration of Baltics with internal energy market.

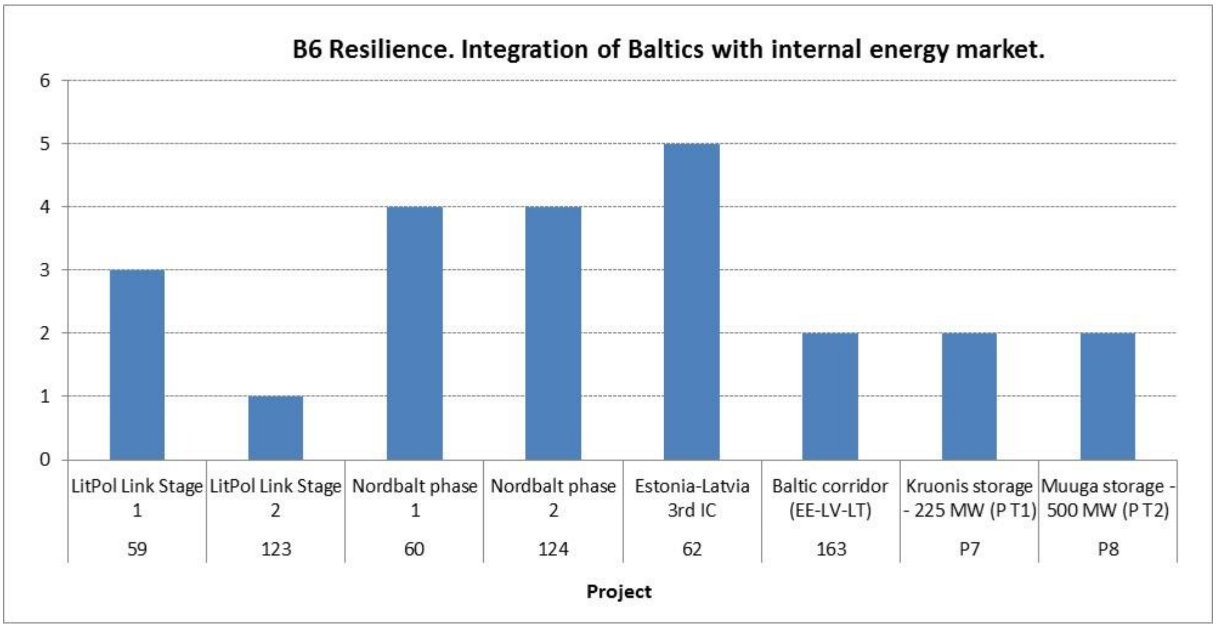

Figure 126 Resilience for projects related to Integration of Baltics with internal energy market.

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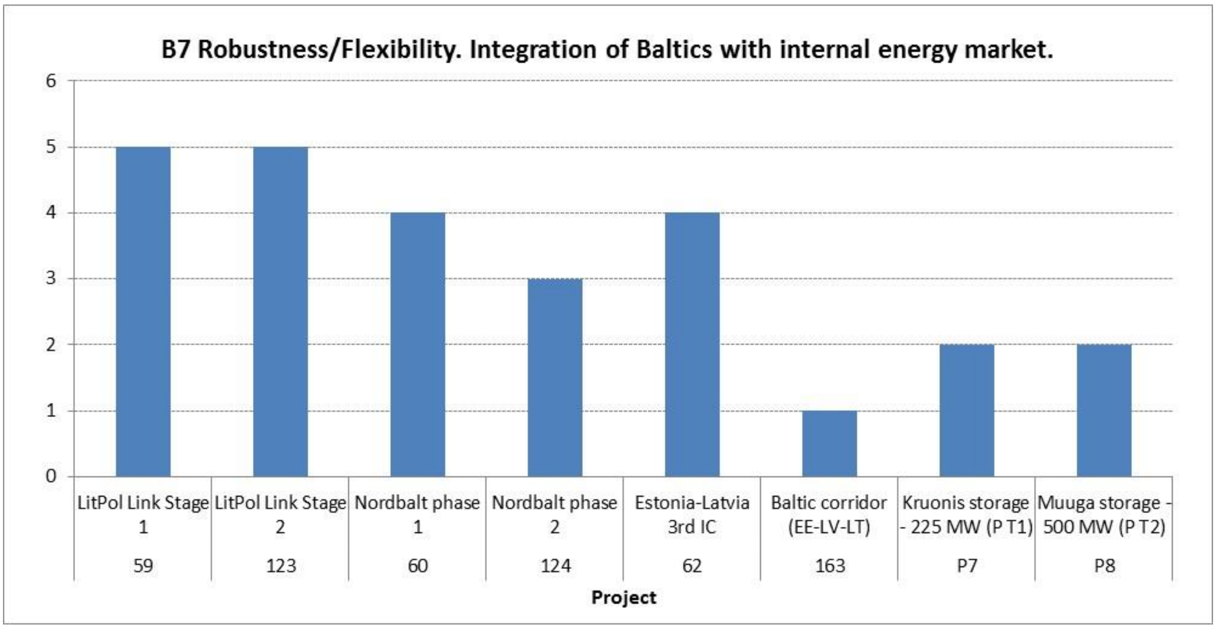

Figure 127 Flexibility/Robustness for projects related to Integration of Baltics with internal energy market.

Together with transmission projects also two 3rd party projects have been assessed. The same CBA methodology has applied for those. Both 3rd party projects are pump storage projects which located in Lithuania (Kruonis) and Estonia (Muuga) and contribute the developments of RES generation in area of Baltics. The assessment of projects shows that the pump storage of Lithuania increases robustness in power system and connect new generation of RES but the project increases transmission system losses. The pump storage in Estonia also increases direct connection of RES, improves the robustness in power system and socio-economic benefit is higher as pump storage power plant in Lithuania.