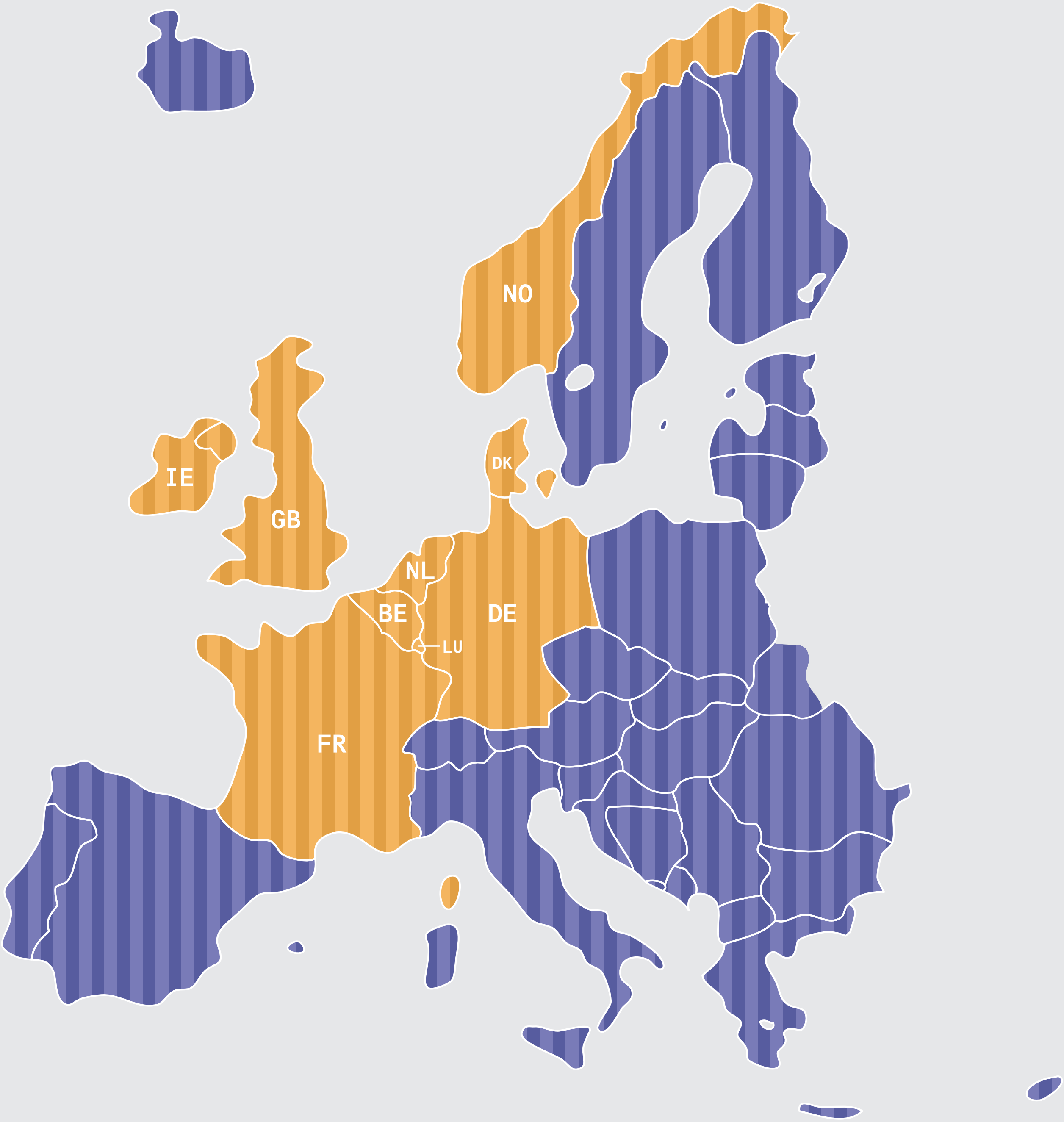
REGIONAL INVESTMENT PLAN 2014
NORTH SEA Final



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 North Sea within the ENTSO-E present this Regional Investment Plan for 2030, which includes all projects of significant importance as well as projects of regional importance where they are required to facilitate the above objectives. The North Sea region within ENTSO-E covers Belgium, Denmark, France, Germany, Ireland, Luxemburg, Norway, the Netherlands and UK.

0.2 What is new in the TYNDP 2014

- **Active Stakeholders engagement contributed to the North 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.

The recently changed energy policies with regards to renewables and nuclear have shown how sensitive the required investments are for major changes in (national and EU wide) energy policies. This is an important element to be carefully monitored, when exploring the impact of future possible energy policies on the desired shape of the power grid of the future.

0.3 Investment drivers in North Sea Region

The Regional Group North Sea covers four separate synchronous power systems which are linked mainly by AC, but supplemented by HVDC links (e.g. Ireland to UK, Scandinavia to the Continent and to Great Britain).

Regarding grid development and planning, the North Sea Region faces major challenges over the plan period, in determining the optimum solutions in facilitating an efficient European Energy market and in secure European Network whilst accommodating connection of large volumes of renewable energy sources. These challenges lead the TSOs within the Region to plan and conduct projects aiming at:

- Security of supply, for example challenges due to German and Belgian nuclear phase-out and French nuclear reduction.
- Increased integration of the European energy market.
- Large scale connection and increased integration of renewable energy sources (wind, solar and hydro).

0.4 Investment needs – based on a generation shift

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 North Sea Region, to avoid heavy curtailment of RES output, additional interconnection-capacity would be required.

The generation shift identified in the Vision requires a more flexible power system and results in new transport patterns. The key changes are as follows:

- A shift from thermal to renewables. Adding interconnectors to the system provides flexibility and avoids curtailment of variable renewable resources. 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 North Sea Region, leads to large reduction of the regional CO_2-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 CO_2-emissions.

The four charts below show the different generation portfolios being installed in each Vision.

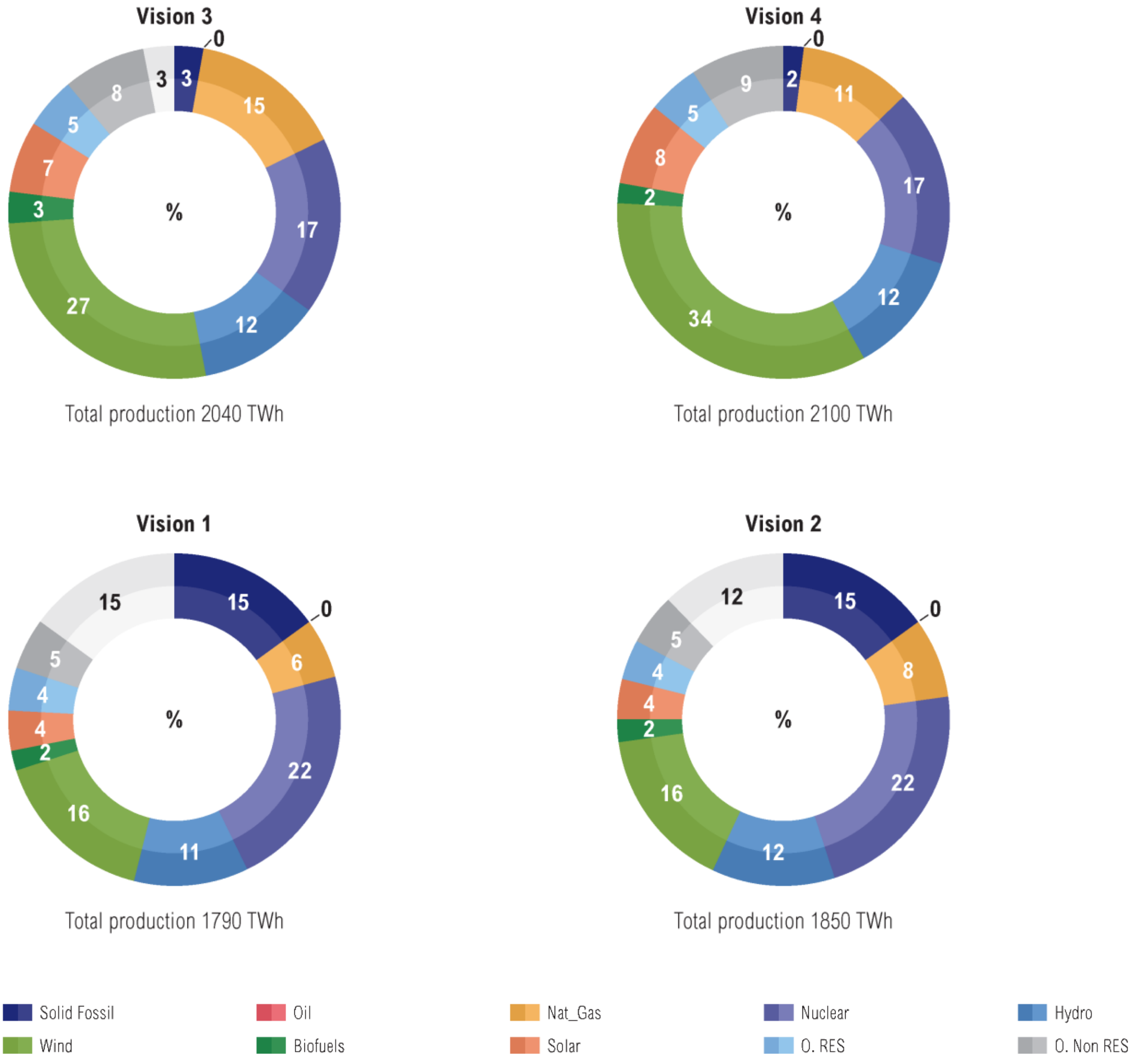


Figure 0.1 Generation portfolio mixture in North Sea Region in Visions 1, 2, 3 and 4, shares of produced energy. White area represents difference in total generation from Vision 4.

The direction of the resulting net bulk power flow is generally on the north-south and west-east axes. It varies for the different Visions being considered and in some cases flows change direction. For example, in Vision 1 and 2 the net power flows from Continental Europe to Great Britain, whilst for Vision 3 and 4 the net power flows are from GB to Continental Europe and Nordic to Continental Europe.

Offshore infrastructure, mainly radial or locally coordinated solutions, is being developed to connect offshore wind parks and point-to-point interconnections to connect market areas. Some local meshed offshore structures, which are the results of local coordination, are envisioned in some specific areas (Channel, ISLES project etc.). Large-scale meshed interconnector structures based on a broader regional coordination is not seen at this stage as a pre-requisite to accommodate the expected offshore RES in the different Visions, even when these Visions includes a substantial increased off-shore wind generation.

However, ENTSO-E strongly believes that these proposed new interconnectors should be seen as main facilitators of RES- and market integration and therefore will become part of an offshore grid in the future anyway.

0.5 Impact of the Investments

In response to the investment needs, the Regional Investment Plan 2014 for the North Sea Region includes internal projects in the region as well as several new interconnectors. In total the Regional Investment Plan assesses an investment portfolio the coming years up to 2030 of about 100 Billion Euros for the countries within the North Sea Region. Germany has the largest investment portfolio, followed by Great Britain, France, Norway and Denmark.

The investments foreseen cover several types of technology (Figure 0.2).

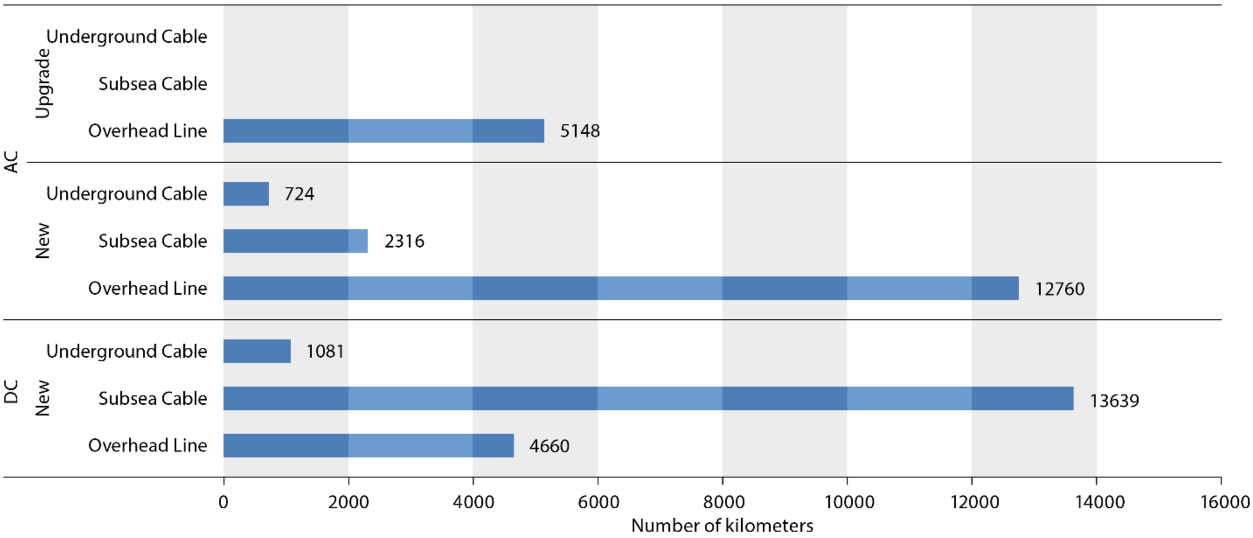


Figure 0.2 Project in the RGNS plan – breakdown by technology

When comparing the number of projects identified in TYNDP 2012 it must be recognized that TYNDP 2014 considered a greater range of future outcomes and for an extended period. ENTSO-E did test the robustness of the project portfolio against the four Visions. For the realization of Vision 4 more investments will be needed, whilst at the same time it might well be the case that not all proposed investments show a sufficient indication on their necessity for all Visions, particularly with respect to Visions 1and 2.

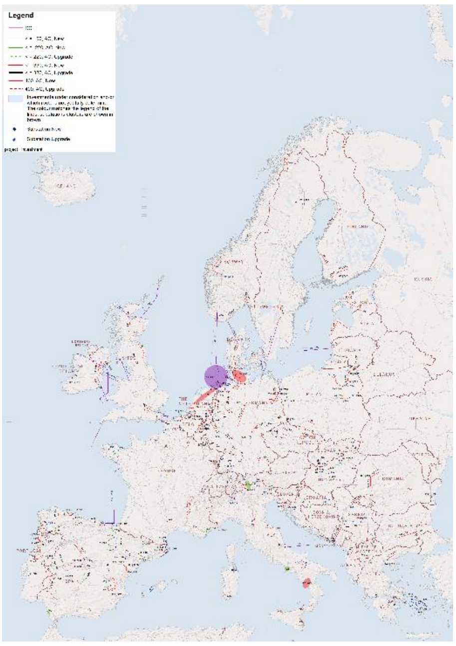


Figure 0.3 Midterm Projects

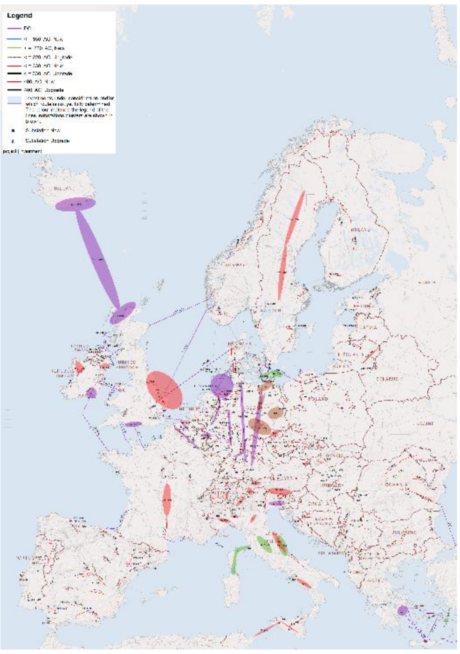


Figure 0.4 Long term projects

The analysis against the four Visions has demonstrated that in general a minimum interconnector capacity between member states should be in the region minimum of 10-15% of the installed generation capacity, Anyhow, for several countries of the North Sea region the analysis of the Visions show significantly higher needs, as e.g. for smaller countries and/ or countries with a lack of generation or a high amount of variable renewable resources. However, a balance needs to be achieved between benefits and the costs of the investments in determining whether an investment is taken forward.
The investments investigated in this report ensure the high level of security of supply to be maintained.

Results of the analysis show that the investment portfolio presented in this plan increases flexibility and results in economic networks which facilitate the fulfilment of European targets; among others a low-carbon energy future.

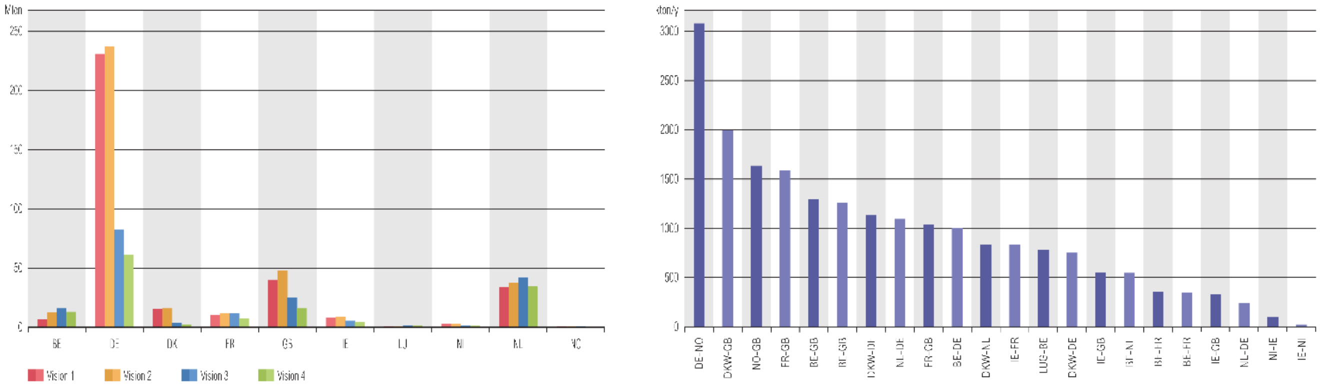


Figure 0.5 CO_2 emissions from power generation in all Visions (left) and interconnector's influence on CO_2-emissions from power generation in Vision 4 (right)The preparation of the TYNDP 2016 has already started

0.5.1 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.

0.5.2 The TYNDP methodology keeps improving

For the future TYNDPs and assessments, ENTSO-E and all interested stakeholders plan to evolve the CBA as far as needed to better match the decision makers’ needs, e.g. it is recognized that storage projects may play a more predominant role in future TYNDPs. Storage projects in some cases may 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 EU Roadmap.

0.6 Energy transition requires grid, grid requires everyone’s support

A major challenge is that the grid development may not be delivered in time, to meet the RES targets as planned. Permit granting procedures are lengthy, and often cause commissioning delays. Approximately a quarter of the projects shown in TYNDP 2012 are delayed, with the most frequent reason being difficulties in gaining permits and seeking public consent. If energy and climate objectives are to be achieved, it is of outmost importance to improve 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. However, more thorough analyses is 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 a reliable supply to European consumers.

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 objectives of the TYNDP are 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 suite of documents consisting of the:

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

This suite of documents present information of transmission network developments which are of European importance. This suite of documents complement each other, with limited repetition of information from one document to another, repetition is only included where necessary to ensure each document is sufficiently self-supported: scenarios are comprehensively depicted in the SOAF; investments needs and projects of European importance are comprehensively depicted in the RgIPs; the present Community-wide TYNDP report hence only sums up high level information with regard information for projects of pan-European significance. ENTSO-E hopes thus to meet the various expectations of their stakeholders, requiring a high level overview for grid development whilst also providing a detailed perspectives of each investment..

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 is consulted during the summer 2014 in order to be finalized in December 2014.

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

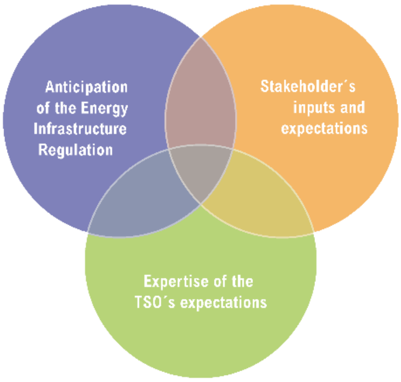
The present publication complies with the requirements of Regulation EC 714/2009 (the Regulation), in force since March 2011 whereby "ENTSO-E shall adopt a non-binding Community-wide 10 year network development plan, including a European generation adequacy outlook, every two years".

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". Also, 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 anticipates 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 37/2013 defines the status of **Projects of Common Interest** (PCIs), foresees 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 hence not only a framework for planning the European grid, supplying a long term Vision; it also now serves the assessment of every PCI candidate.

1.3 A top-down, open and constantly improving process



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 DG Energy, 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.

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[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/

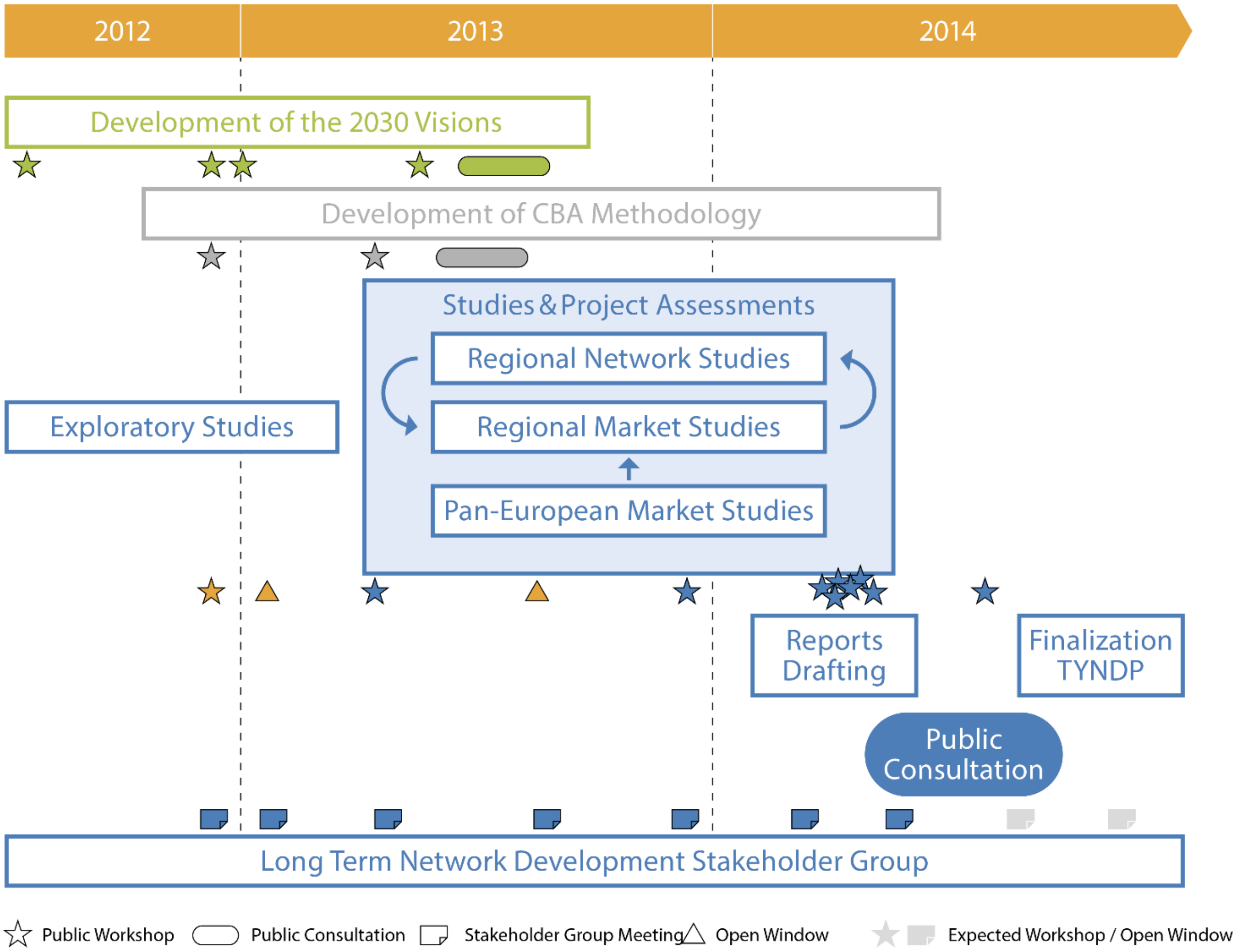

Figure 1-1 Overview of the TYNDP 2014 process

The preparation of the TYNDP 2014 was an even bigger challenge as **ENTSO-E decided to anticipate the implementation of the Energy Infrastructure Regulation** and to support DG Energy 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.
- ENTSO-E 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 so as to ensure timely and consistent results. The following chart highlights the TYNDP evolution since 2010:

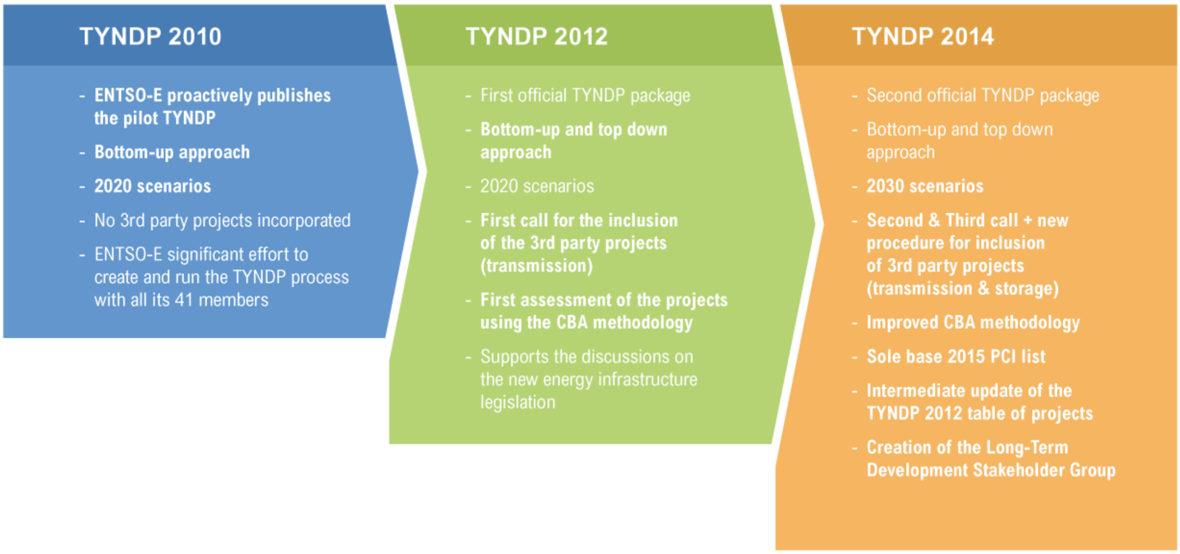

Figure 1.2 ENTSO-E is working on a continuous improvement of TYNDP

1.4 TYNDP and cooperation with NSCOGI and Penta Plus

1.4.1 Cooperation with NSCOGI

The Regional Group North Sea is involved in the North Seas Countries' Offshore Grid Initiative. This is a government initiative aiming at the facilitation of the integration and optimal exploitation of potential renewable energy and infrastructure in the North Sea area.

In December 2010, a Memorandum of Understanding was signed by the respective ten countries' governments[3], the EU Commission, ACER (Agency for the Cooperation of Energy Regulators) and ENTSO-E (European Network of Transmission System Operators for Electricity).

Its objectives are:

- To contribute to the move to a sustainable low-carbon economy while maintaining security of energy supply in a cost efficient manner;
- To maximise the potential of the renewable energy resources of the North Seas, taking account of the scale of investments required in offshore infrastructure and necessary onshore grid reinforcements;
- To identify and tackle barriers to offshore grid development, in particular as regards technical, regulatory, market, planning and authorisation issues;
- To facilitate a strategic, coordinated and cost-effective development of offshore and onshore grids.

The Regional Group North Sea cooperates with the NSCOGI by delivering study results, input to discussions and sharing information on current work, such as this Regional Investment plan and the material around it (Visions, CBA methodology etc.). Hereby valuable input was received from NSCOGI members.

NSCOGI published among others its grid implementation study in December 2012; the main results are summarized in this report and set in relation to the TYNDP Visions.

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[3] There are the same countries as represented in the Regional Group North Sea plus Sweden.

1.4.2 Cooperation with Penta++ Energy Forum

This government initiative is based on a Memorandum of Understanding signed by the Ministers and high level representatives of the Regulatory Authorities, the Transmission System Operators, the Power Exchanges and the Market Parties Platform in 2009. The countries involved are the countries from the Pentalateral Forum (Belgium, France, Germany, Luxembourg and the Netherlands), plus Switzerland and Austria.

The set and objective of this forum is to analysis, design and implement a flow based market coupling between the five countries of the CWE region to achieve a future steps in the field of security of supply and support wider European integration.

RGNS is involved in this initiative and a study about the security of supply between Penta++ forum countries is going to be done in 2014. This study is based on TYNDP database and TYNDP methodology.

1.5 How to read this Regional Investment plan 2014?

The document is structured in the following way:

- Chapter 0: Executive summary.
- Chapter 1: Introduction.
- Chapter 2, “Methodology and Assumptions” describes the overall process and specific methods used to elaborate the TYNDP 2014 package.
- Chapter 3, “Scenarios and study results” gives a synthetic overview of the basic scenarios underlying the present TYNDP and presents the results.
- Chapter 4, “Investment needs” describes the evolution of the European grid capacity from the present situation, highlighting the drivers of grid development based on bulk power flows, across the key grid bottlenecks.
- Chapter 5, “Assessment of the Regional Investment Plan 2012” presents the monitoring update of the RegIP 2012 compared to earlier publications.
- Chapter 6, “Investments – Project Portfolio” presents an overview of all proposed projects of pan-European and regional significance. (The technical details of the projects are in Appendix 1)
- Chapter 7, “Transmission capacities and adequacy” sums up the effect of the proposed grid expansion in 2030 including all projects of pan-European significance, provided target capacities and also provided target capacities for the Visions considered.
- Chapter 8, “Environmental assessment” highlights the environmental impact of the proposed projects.
- Chapter 9, “Assessment of resilience” presents a high level overview of the proposed projects’ resilience.
- Chapter 10, “Conclusion” summarizes the findings.
- Appendix 1 sums up all the information regarding projects of Pan-European significance. ‘Transmission’ PCIs among them are marked and related to a specific correspondence table. ‘Storage’ PCIs are grouped in a separate list.
- Appendix 2 supplies the definition of key-concepts and definitions.
- Appendix 3 sums up the results of the NSCOGI grid study and sets it in relation to the ENTSO-E visions.

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 (EC) No 347/2013), which was enacted in 2013 and formalised the role of the TYNDP in the Project of Common Interest selection process.

Figure 2-1 provides an overview of the TYNDP 2014 process; the stars represent stakeholder workshops held during this two-year process.

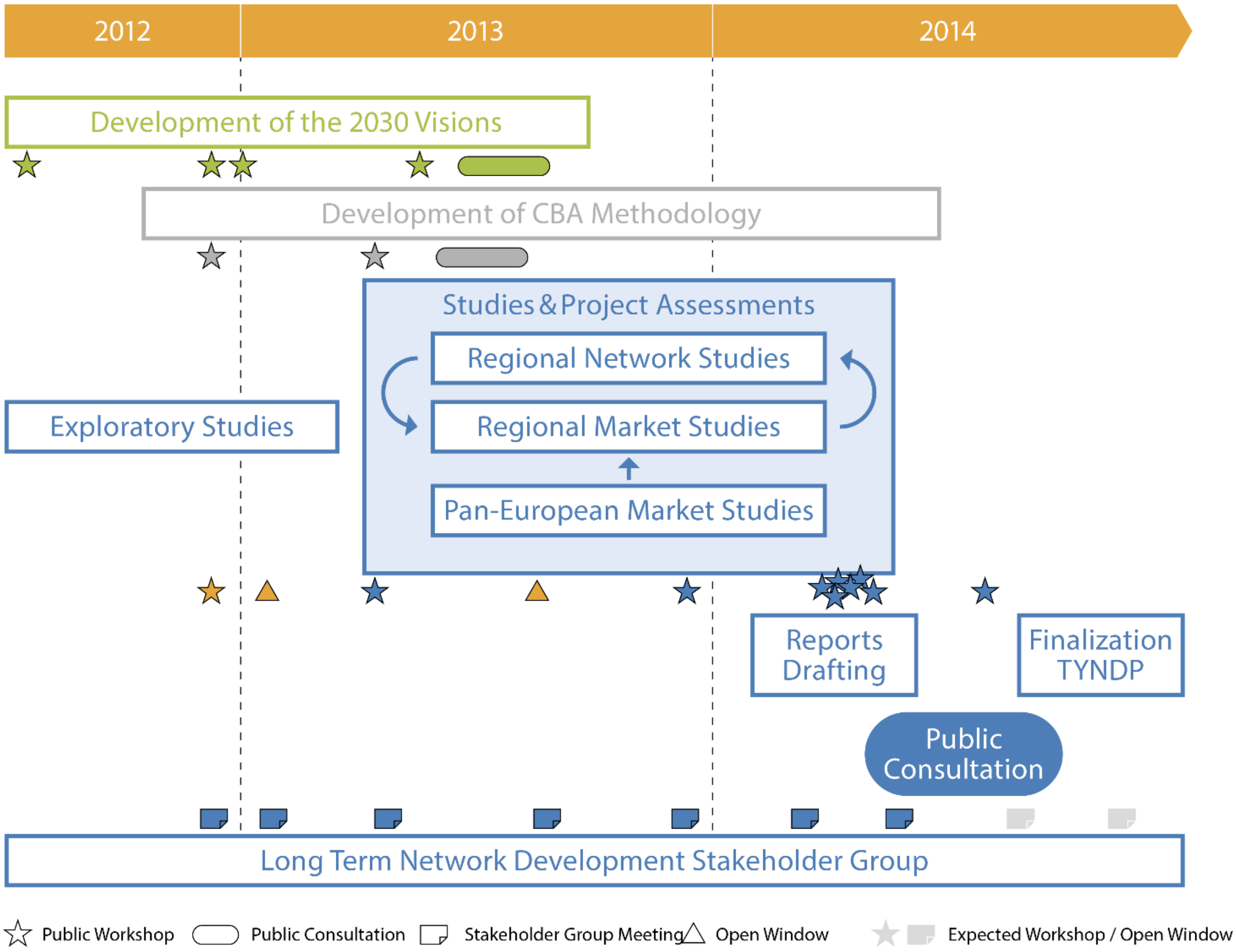

Figure 2-1 Overview of the TYNDP 2014 process

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:

- 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 CO_2 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 is described in the figure below and in the following section.

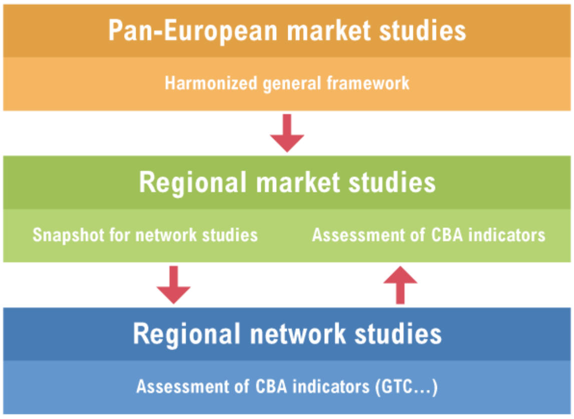

Figure 2-2 An iterative process towards the preparation of TYNDP 2014

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.
- 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 2.1 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.

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[4].

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 led 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.

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[4] Link to the report.

Figure 2-3 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 (EC) 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 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 (EC) 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 (EU) No 347/2013, in force since 15 May 2013, aims to ensure strategic energy networks[5] 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[6] with the following goals:

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

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

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

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. (EC) No 347/2013[7], 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 2.3, while others are measured through physical units such as tons or kWh (outer ring of Figure 2.3).

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.

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, CO_2).
- 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).

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

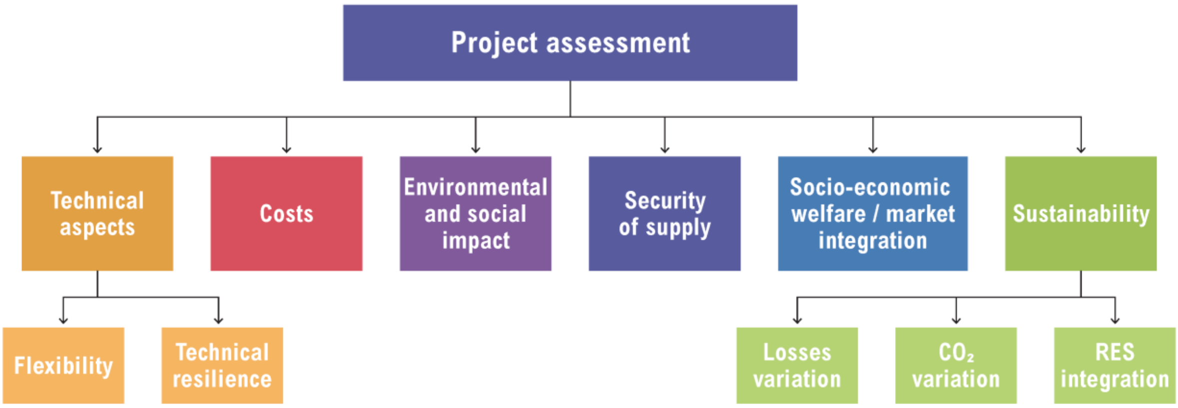

Figure 2-4 Main categories of the project assessment methodology

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[8] (SoS) is the ability of a power system to provide an adequate and secure supply of electricity under ordinary conditions[9].

B2. Socio-economic welfare (SEW)[10] 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[11].

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[12].

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[13] and is correlated with SEW.

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[8] 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.

[9] This category covers criteria 2b of Annex IV of the EU Regulation 347/2013, namely "secure system operation and interoperability".

[10] 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).

[11] 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".

[12] This category corresponds to criterion 2a of Article 4, namely "sustainability", and covers criteria 2b of Annex IV.

[13] This category contributes to criterion 6b of Annex V, namely "transmission losses over the technical lifecycle of the project".

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)[14].

B6. Technical resilience/system safety is the ability of the system to withstand increasingly extreme system conditions (exceptional contingencies)[15].

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[16].

The **project costs**[17] 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.

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 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

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[14] This category contributes to the criterion « sustainability » set out in Article 4, 2b and to criteria 6b of Annex V, namely " greenhouse gas emissions"".

[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 6b of Annex V, namely "system resilience" (EU Regulation 347/2013).

[16] 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).

[17] Project costs, as with all other monetised values, are pre-tax.

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 Studies methodology

For every scenario, a market study answers the question “which generation (location/type) is going to serve which demand (location) in any future instant?” Their outcome is market balances in every country/price zone and especially generation and exchange patterns (“bulk power flows”).

The purpose of the market studies is to investigate the impact of the new interconnection projects by comparing two different grid situations, with and without each project in turn, in terms of economic efficiency; the ability of the system to schedule plants accordingly to their intrinsic merit-order, the overall resulting variable generation costs as well as the overall amount of CO_2 emissions, and volumes of spilled (i.e. unused) renewable energy. An economic optimisation is conducted for every hour of the year taking into account several key constraints; such as flexibility and availability of thermal units, wind and solar profiles, load profiles and uncertainties, and transmission capacity between countries.

The pan-European market studies results are used as boundary conditions to ensure overall consistency of the regional market studies. The CBA assessment of TYNDP projects is then performed using regional market and network studies.

2.3.1 System Modelling

For the modelling of the electricity market in the Regional Group North Sea, the whole of Europe has been considered. The region itself has the highest level of detail, which decreases with increasing distance (see figure: blue = detailed, green less detailed, white: simplified). In this way, a balance between accuracy and efficiency was achieved. Europe has been divided into three areas in the model:

- The countries in the Regional Group itself, where the modelling of the generation is more detailed than in the Pan European Market Database (PEMDB). The Swedish electricity system has been modelled in the same level of detail in view of its participation in the **North Seas Countries' Offshore Grid Initiative** (NSCOGI).
- The Extended perimeter (first neighbours, green in Figure 2-5), where the modelling of the generation and load from the PEMDB was used
- The rest of Europe, where the flows that originate from the Pan-European Market Study are used as an input which ensures appropriate consistency across all regional groups of ENTSO-E.

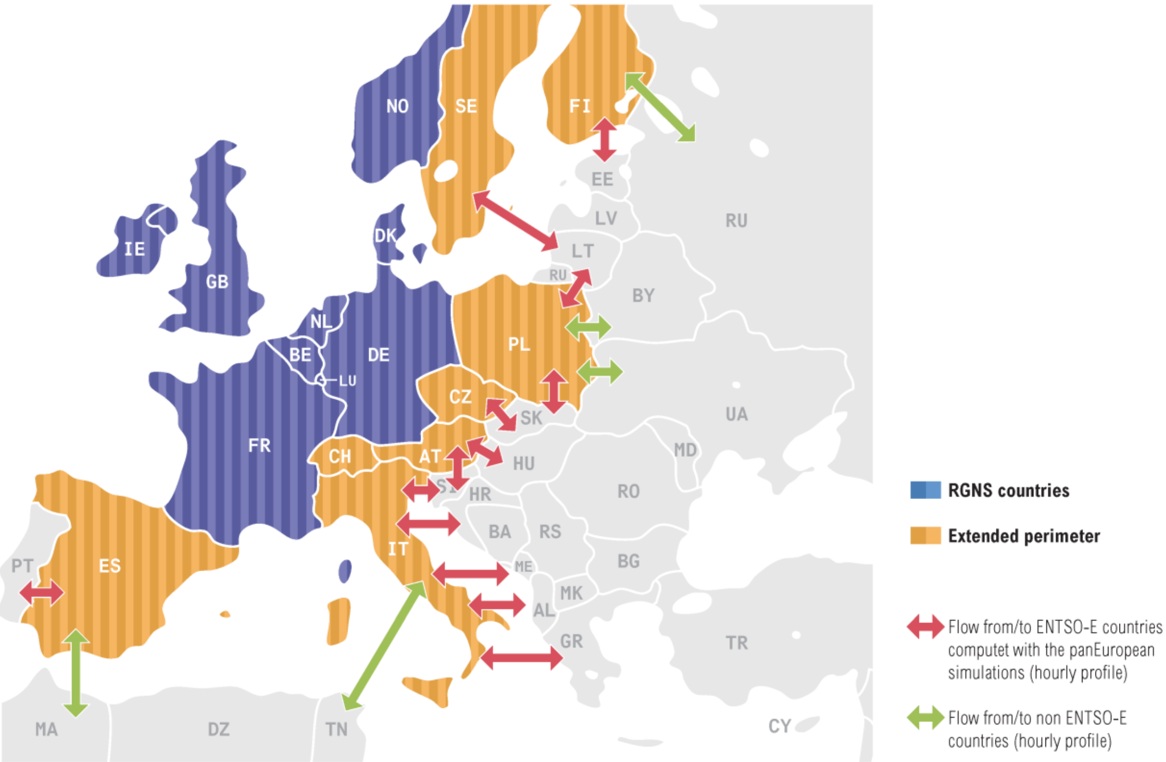

Figure 2-5 RGNS modelling perimeter

For every Vision a separate model has been built.

For the regional simulations, the model of the Pan-European Market Database (PEMDB) was enhanced for the countries in the Regional Group North Sea in the following respects:

- **A more detailed regional database** to better reflect regional specifics, including climate data (wind, solar) and temperature dependent load as well.
- Norway and Sweden were divided into **multiple market areas**, reflecting the current market areas, and hydro modelling was enhanced.
- The Pan European **meteorological data base** was used to reflect the sensitivity to various climatological years and its effect on renewable energy integration.
- A market model for Iceland was added in order to be able to assess a cable project from GB to Iceland

2.3.2 Tools Used for Market Studies

The North Sea Regional Group used four market simulation tools in parallel: Antares, BID, PowrSym4 and PROMOD. Each of the tools has its own particular strengths, which provide an opportunity to challenge the single models results, which were based on the same input data, towards each other and thus provide greater confidence in the results.

The results of these four simulation tools were compared in depth, enabling the North Sea Regional Group to verify the results and to increase the quality of the market analysis.

The pan-European meteorological database was also used to assess renewable energy integration. For this task, a stochastic method based on wind, sun and temperature probability was used.

It should be noted that all tools assume a perfect energy-only market; some of the internal congestions are simplified. Thus the models deliver the energy flows triggered by the market price differences.

2.4 Network Studies Methodology

For every scenario, network studies answer the question “will the dispatch of generation and load given in every case generated by the market study result in power flows that endanger the safe operation of the system (accounting for the N-1 criterion)?” If so, then transmission projects are designed, tested and evaluated for all relevant cases. Studied cases explore a variety of dispatch situations: those which occur frequently, or those which rarely occur but which would result in particularly extreme flow patterns.

2.4.1 Market studies as an input to the Network Studies

The power system in ENTSO-E’s Regional Group North Sea consists of four separate synchronous sub-parts:

- In Mainland Europe: Belgium, France, Germany, Luxemburg, the Netherlands and Denmark West;
- In Scandinavia (the former Nordel System): Norway and Denmark East;
- Great Britain;
- Ireland and Northern Ireland.

These sub-parts are operated in AC and are interconnected to each other by DC links. Figure 2-6 gives an overview of these synchronous regions.

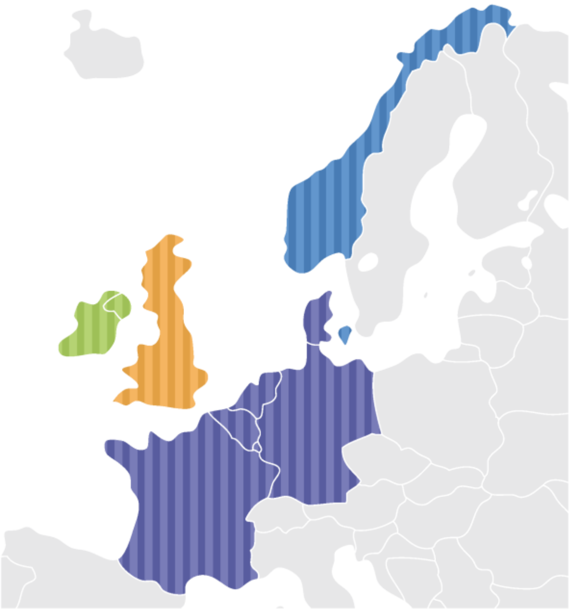

Figure 2-6 Four Separate Synchronous Areas.

The TSOs within the Regional Group North Sea have developed a Common Interface Model (CIM)-based integrated grid model of this power system, including the electrical parameters of all equipment. This grid model, coupled with the hourly nodal load and generation values provided from the market models, enables an evaluation of the physical behaviour of the power system at any hour of the year, in the normal state and in the event of contingencies. Where simulation studies identified that network security could be endangered, additional projects were identified to mitigate this risk.

This grid modelling exercise can be repeated for each of the 8760 hours of the year in order to create a view on how the network will be loaded during a full year and to identify potential bottlenecks or congestions.

However, the high voltage AC grid is modelled in great detail down to the individual busbars, transformers, phase shifter transformer (PST), and AC and DC lines and cables with their specific impedances. These results in a complex model, with thousands of lines, transformers and nodes to be managed for each of the 8760 hourly situations, as illustrated in Table 2.2. This full-year modelling has been performed to analyse the performance of the bulk power system. However, it is too complex and time consuming to perform such detailed analysis for the internal grids at lower voltage levels or for the individual project assessments.

Table 2.2. Size of the Regional Group North Sea's Grid Model

Type of Element	Number of Elements
Links	12463
Transformers	8910
Busbars / Nodes	16823
Loads	8508
Generators	11259

For these reasons, and without losing any accuracy, this integrated model has been split into five sub-models (Continental Europe, Denmark, Norway, Great Britain, and Ireland and Northern Ireland). The flows between these sub-systems can adequately be fixed according to the market flows, as given by the market simulations.

A balanced approach optimizing the number of simulated hours had been adopted: Rather than modelling all 8760 hours of the year, as it has been done for the Danish submodel, a reduced subset of planning cases was determined based on selected hours which are representative of the whole year (i.e. between 10 and 12 planning cases for the other four sub-parts).

These hours are selected carefully to provide an accurate representation of the year. To verify the accuracy, the results of the selected planning cases and the full year round run simulations have been compared on the example of the Danish sub-part and the difference between both approaches turned out to be acceptable.

Table.2.3 below gives the results of the Planning Case (PC) selection for Vision 1 for the Continental European sub-part. These cases have been used for project assessment and detailed grid analysis in the internal grids at lower voltage levels.

Table.2.3 Planning cases selected for Vision 1

Name	Number of hours represented	Actual hour of the year
PC1	526	419
PC2	341	576
PC3	343	622
PC4	1665	1851
PC5	425	2443
PC6	271	2677
PC7	402	2993
PC8	380	3533
PC9	1885	5327
PC10	1356	6229
PC11	767	6753
PC12	375	8176

Modelling of controllable grid devices

The power system within Regional Group North Sea includes increasing numbers of controllable grid devices, such as HVDC links and phase shifting transformers (PSTs). The operating rules of these devices are important information with respect to grid simulation and have been developed in the course of simulation activities. The following settings have been used in the grid modelling:

- In most of the cases, HVDC cross-border[18] links are set in a way that the physical flow equals the commercial flow between both market sides;

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[18] Market flows are not available for HVDC links embedded in internal grids

- In some specific cases e.g. concerning the regions' first neighbours (like FR-ES or FR-IT), the cross-border HVDC links are used to mimic the behaviour of the common AC grid (AC emulation);
- The settings of HVDC links which are inside a synchronous area must also be defined in the models. For example, the flow through the planned German North-South HVDC corridors will be controlled in a way that the flow will be directly proportional to the current angle difference between both ends of the links.
- The phase shifting transformers (PSTs) are as a preliminary assumption set at their central tap in the normal/healthy state. In the event of contingencies, they are available to mitigate them.

2.4.2 Network studies Tools used

A number of different network analysis tools, namely PSS/E, Powerfactory, Convergence, PSA Integral, were used for network studies in Regional Group North Sea.

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 trustworthy and comparable final results.

3 Scenarios and study results

3.1 Regional Description of Scenarios

The TYNDP 2014 uses 4 scenarios to assess the project portfolio on the Cost Benefit Analysis methodology:

- 2 bottom-up (Vision 1 and 3): result from the input received from the national correspondents based on the common European guidelines.
- 2 top-down (Vision 2 and 4): are developed at the European level. These Visions are based on data provided by the TSOs for the bottom-up Visions which is further modified in order to reflect the assumptions established for the studied Visions.

The year 2030 is used as a bridge between the European energy targets for 2020 and 2050. The aim of the "2030 Visions Approach" used for the TYNDP 2014 scenarios should be that the pathway realised in the future falls with a high level of certainty in the range described by the Visions that have been formulated taking into account the results of an extensive consultation with several workshops and a formal consultation during summer 2013.

The Visions are not forecasts and there is no probability attached to them. These Visions also have no adequacy analysis associated with them and are rather based on previous ENTSO-E and regional market studies, public economic analyses and existing European documents. This is a markedly different concept from that taken for the Scenarios up to 2020 used in the TYNDP 2012, which aim to estimate the evolution of parameters under different assumptions, whereas the 2030 Visions aim to estimate the extreme values, between which the evolution of parameters is foreseen to occur.

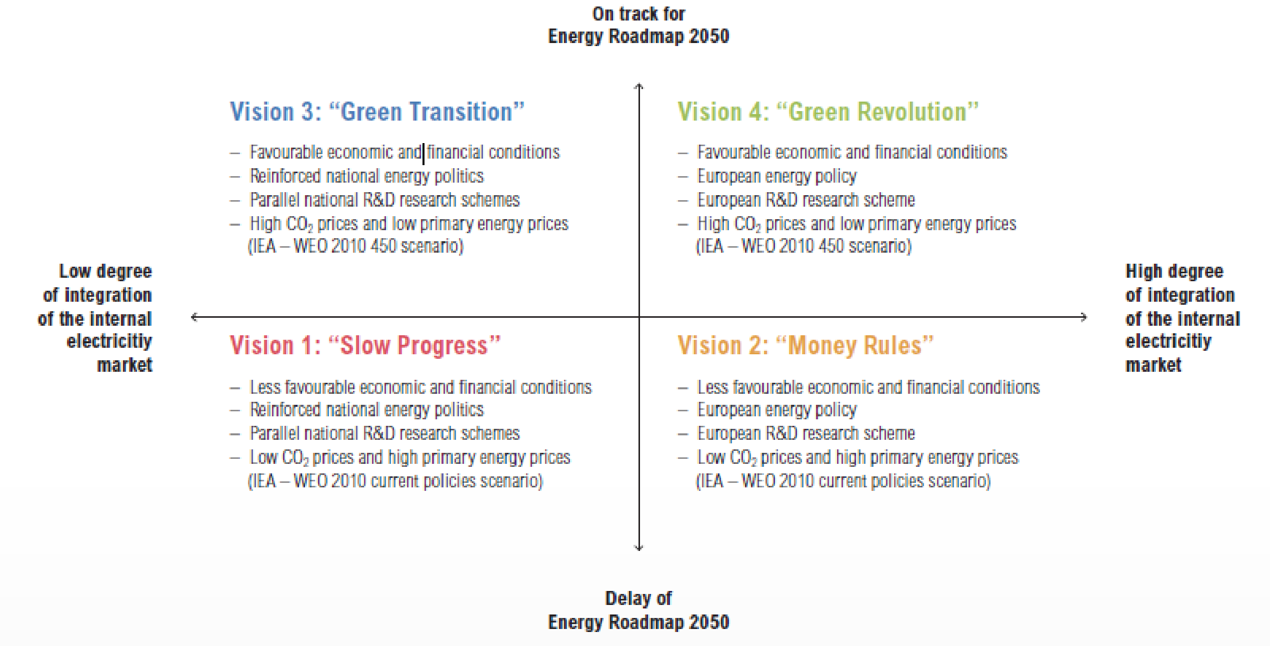


Figure 3-1 Overview of the political and economic frameworks of the four Visions

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

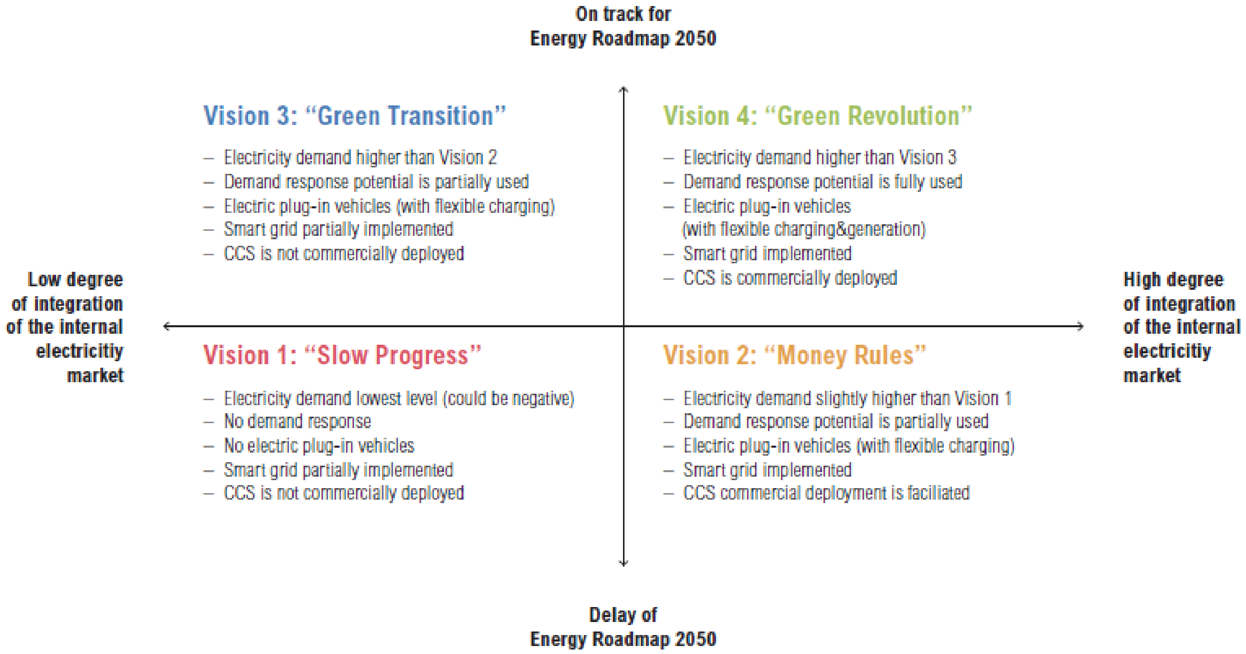


Figure 3-2 Overview of the generation and load frameworks of the four Visions

1. The Vision 1 represents a slow progress and is based on National TSO forecasts for less favourable economic and finance conditions. 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 regulated by national policies and no changes in storage facility. The CO_2 price is low and primary energy prices are high.

2. The Vision 2 is a money rules Vision with more liberalized electricity market conditions in all of Europe but still with less favourable economic and finance conditions remaining. The Vision 2 is a top-down Vision which is derived through modifications of Vision 1 by an expert team (experts of TSOs from whole EU) of ENTSO-E, WG SAMM. It is an 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 in storage facilities. The CO_2 price is low and primary energy prices are high.

3. The Vision 3 is a bottom-up Vision prepared by National TSO forecasts, therefore based on national energy policies and research and development schemes as well as favourable economic and finance conditions. Electricity demand should be higher than in Visions 1 and 3, more favourable conditions for electricity vehicles with flexible charging, NPPs developments according to national views, and planned decentralised storage. In the Vision 3 the CO_2 price is low and primary energy prices are low.

4. The Vision 4 is the most ambitious of all the four Visions and it focuses on Green revolution in which RES are expected to become base generation and fossil fuels remain as secondary generation and for keeping a balance in the power systems. The Vision 4 is prepared by the 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.

3.2 Market Study Results

Development of the demand and balances in the RGNS Region in the four Visions

The development of the demand for the fours Visions is illustrated in Figure 3.3. Due to differences in anticipated policy and economic trends the demand will vary for each Vision. The Demand (TWh) graph shows, that there is an increase in the demand forecast for each successive Vision starting with Vision 1.

Vision 1 has less favourable conditions for economic growth in all countries of the RGNS. The demand in Vision 1 is based on TSO forecasts at a national level. The expected annual demand for the Vision is around 1780 TWh, this is the lowest level for the four Visions.

In Vision 2 more liberalized market conditions are expected, as well as a common European focus on energy policies, along with EU research and development schemes. This Vision has more favourable economic and financial conditions. The result is a small increase in demand over Vision 1, equating to a total annual demand of 1840 TWh for Vision 2.

Vision 3 is based on national projections by TSOs. This Vision has favourable economic and financial conditions, a national focus on energy policies, demand response schemes, as well an increase in the usage of electric vehicles. These conditions lead to annual demand of 2000 TWh in the RGNS countries, once again an increase over the previous Vision.

The annual demand in Vision 4 is the highest of all the Visions. It is assumed that all economic and finance conditions are very favourable. In this Vision the European energy policies, along with EU research and development schemes are key drivers in delivering a “Green Revolution”. In addition to this, there are no more restrictions in charging and generation of electrical vehicles. The use of heat pumps will grow significantly. This results in an annual demand within RGNS of around 2050 TWh. The difference in annual consumption between Vision 1 and Vision 4 is around 300 TWh.

The country balances in each Vision are dependent on the national demand and the national generation portfolio in each Vision. Germany and Great Britain are highly dependent on the generation mix assumed for each Vision.

For example, in Vision 1 and 2 Germany is assumed to be “less green”, the generation shift away from fossil fuel has not fully started, due to the low CO_2-price. The low CO_2 price results in a significant proportion of the demand being met by coal fired power plant. The energy balance is slightly negative meaning that some energy is met by lower cost generation from other regions. In the greener Visions 3 and 4, the German energy balance becomes very negative. Since the CO_2 price is higher, the result is that the German coal fired plant drops down the merit order, therefore cheaper generation from neighbouring countries provide the balance to Germany. Main reason for the high German imports is the strong demand increase in these visions compared with today.

The opposite happens for the Great Britain energy balance. Vision 1 and 2 see Great Britain as a net importer. However, in Vision 3 and 4 there is significant increase in wind generation which allows Great Britain to reduce production costs and switch to becoming a net exporter of energy. This is also true for Ireland, as the Visions become “greener” the ability to harness additional wind energy enables a switch from net importer to net exporter by Vision 4.

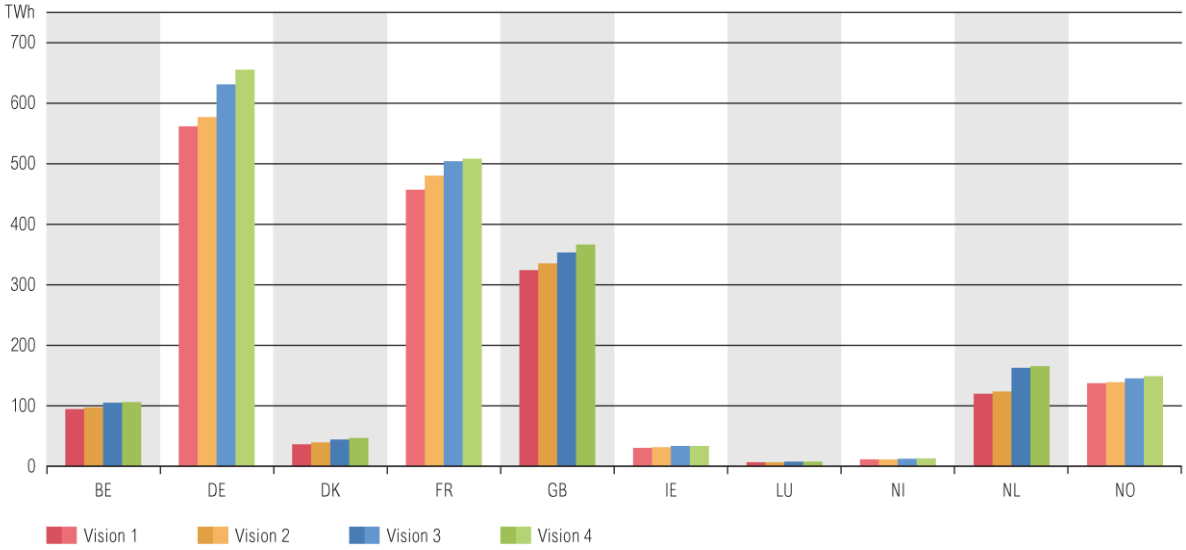


Figure 3-3 Demand for the RGNS countries for all the Visions, (TWh)

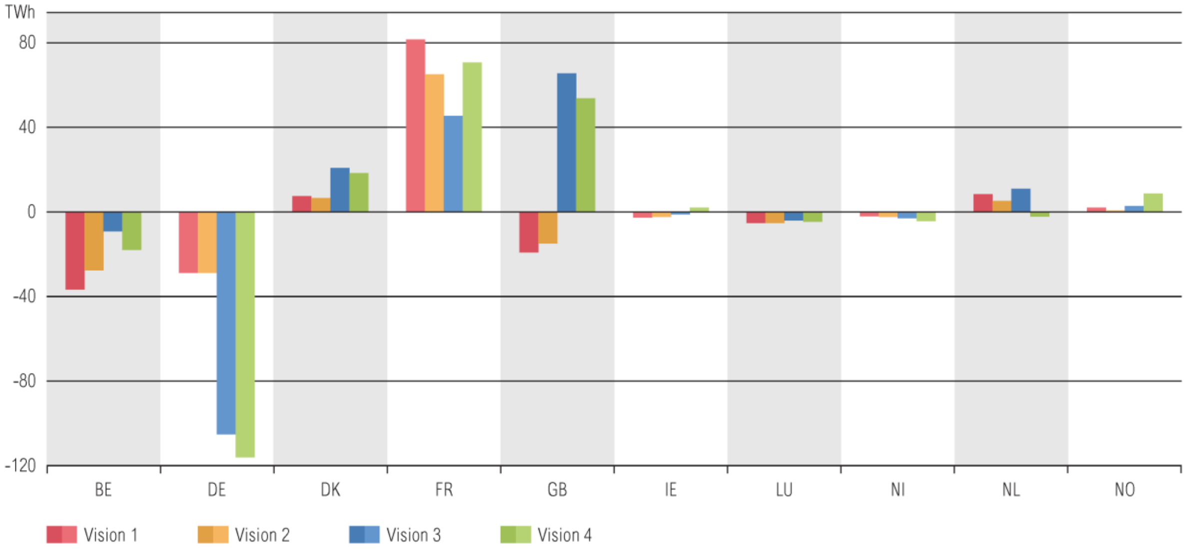


Figure 3-4 Balances for the RGNS countries for all the Visions, (TWh)

Development of the supply in the RGNS Region in the four Visions

The four Visions are made to span the possible future development of the power system and analyse the consequences of these development trends.

The pie charts in figure 3.4 show the installed capacities (GW) in the RGNS for each of the Visions. As observed with the demand forecast, the installed capacity also increases for each successive Vision 1, 2, 3 and 4. The expected increase from Vision 1 to Vision 4 is about 260 GW.

The pie charts are shown in such a way that the total installed generation capacity of Vision 4 is represented by 100%. The percentages of installed generation capacities shown in the pie charts for Visions 1, 2 and 3 are relative to this Vision 4 total. In this way, installed capacities in Visions 1, 2 and 3, are comparable to Vision 4. The white segments in the pie charts for Vision 1, 2 and 3 represent the difference in total installed generation capacity, relative to Vision 4.

In Vision 4 wind generation (both on-shore and off-shore) has the highest share (34%) in terms of installed capacity, this is more than double the amount installed in Vision 1 and 2 (16%). Solar power also shows a significant variation between Visions, showing a large increase from around 10% in Vision 1 to 17% for Vision 4. Wind farms, solar, along with hydro power, are the main energy sources towards a carbon neutral Europe of the future. The proportion of installed capacity of hydro power remains relatively constant in all the Visions. It is worthy of note that hydro resources are limited by water inflow and depend on the weather condition in any particular year.

The installed capacity of natural gas plants is increased in Visions 3 and 4 relative to Vision 1 and 2, whereas nuclear, solid fossil (hard coal and lignite) and oil capacities are slightly reduced in absolute terms.

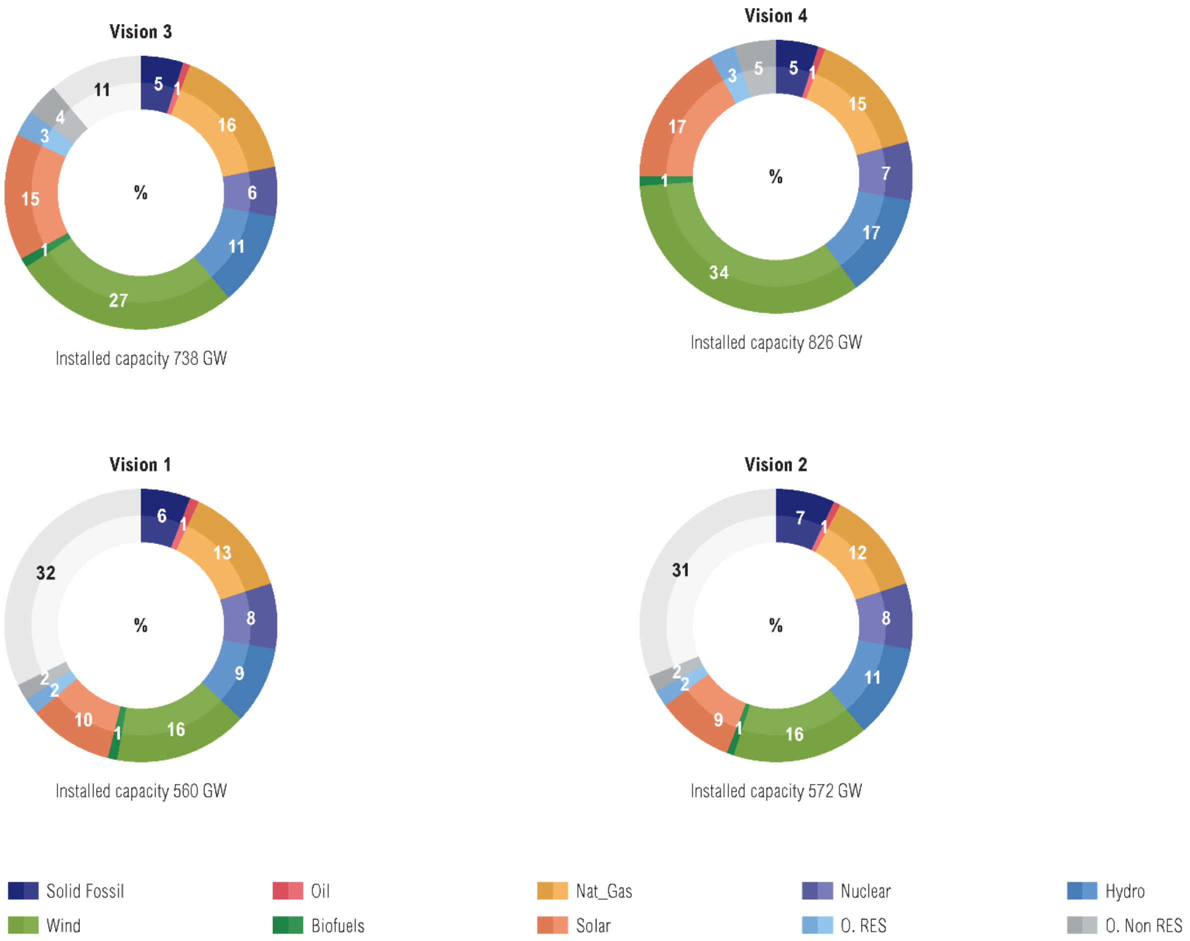


Figure 3.4 Installed generating capacity in North Sea Region in Visions 1, 2, 3 and 4, shares installed capacity by fuel types. White area represents difference in total installed capacity from Vision 4.

3.2.1 Vision 1

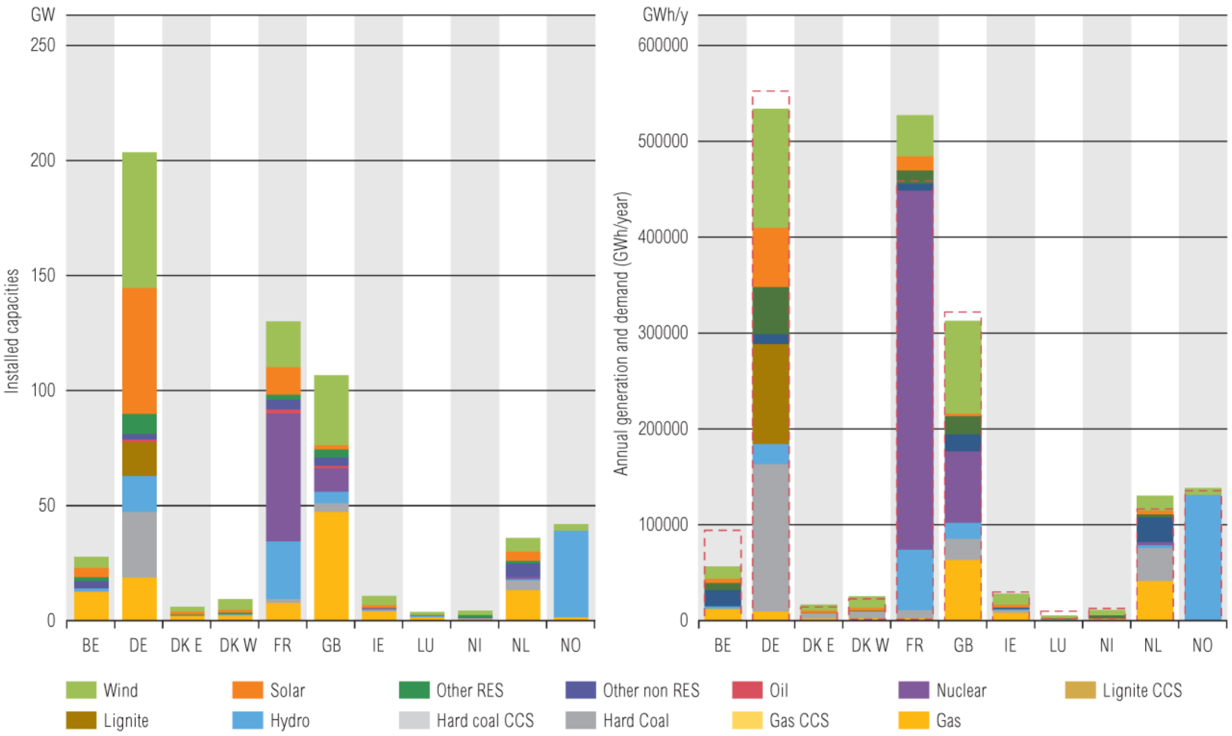


Figure 3.5 (a) Installed generating capacity and (b) annual generation and demand in the North Sea Region, Vision 1.

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.

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 Wind, Hydro, and lastly from solar.

The results show that, Norway has a considerable amount of hydropower generation, and France a substantial amount of nuclear generation. For other RGNS countries there is a mix of generation based on renewables and fossil fuel plant. The merit order between gas and coal/lignite is very important the CO_2-prices favour the coal/lignite. The annual energy contribution from solid fuel is approximately x2.4 that of natural gas power plants.

Figure 3.6 shows the simulated average price difference in the North Sea region. The figure shows the yearly average prices per country and the average price difference based on hourly absolute price difference. Figure 3.6 shows that there are large price differences between the Nordic countries and Central Europe and Great Britain.

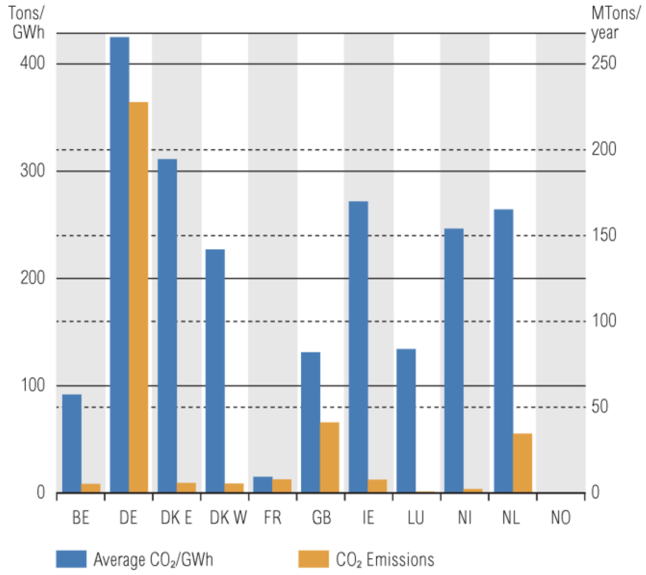


Figure 3.7 shows the expected CO_2 emissions in Vision 1, both in terms of total emissions from electricity production (Mtons/year) and in terms of emissions per GWh produced. The largest emitter is Germany due to a high installed capacity in fossil fuel thermal power plants. The Vision's merit order is favourable for this type of thermal plant due to a low CO_2 emission cost. For Germany's part, the shutdown of nuclear power generation will contribute to an increase in the emission of CO_2. Norway's emissions are almost zero, due nearly all annual demand being met by hydrological energy production.

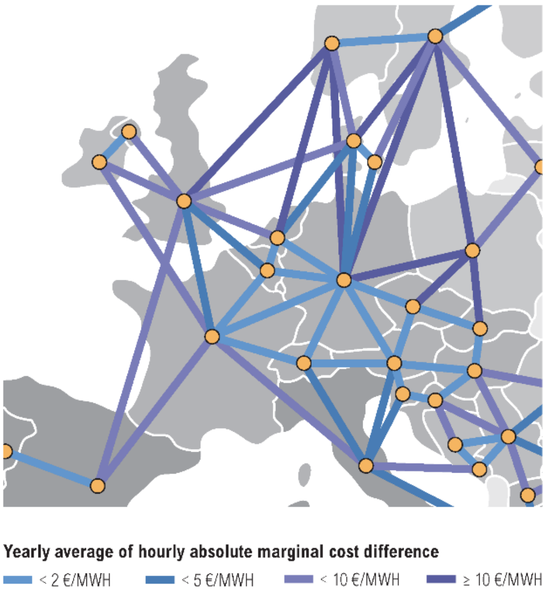


Figure 3.6 Yearly average marginal cost difference in RGNS, Vision 1.

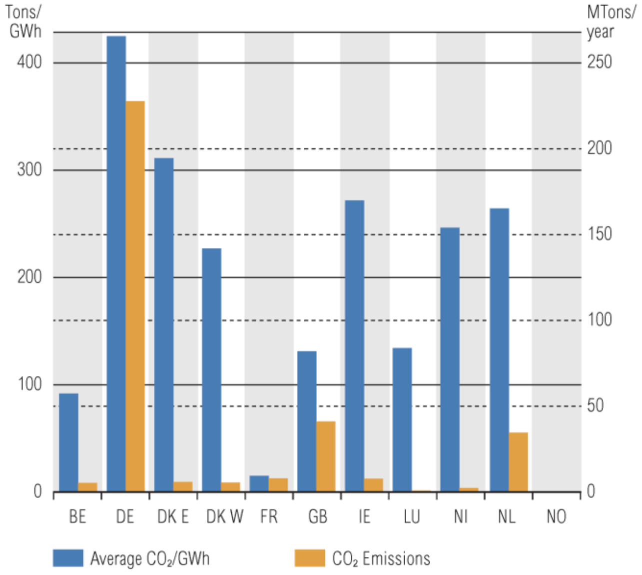


Figure 3.7 CO_2 emissions from electricity production in RGNS (MT/year), Vision 1.

3.2.2 Vision 2

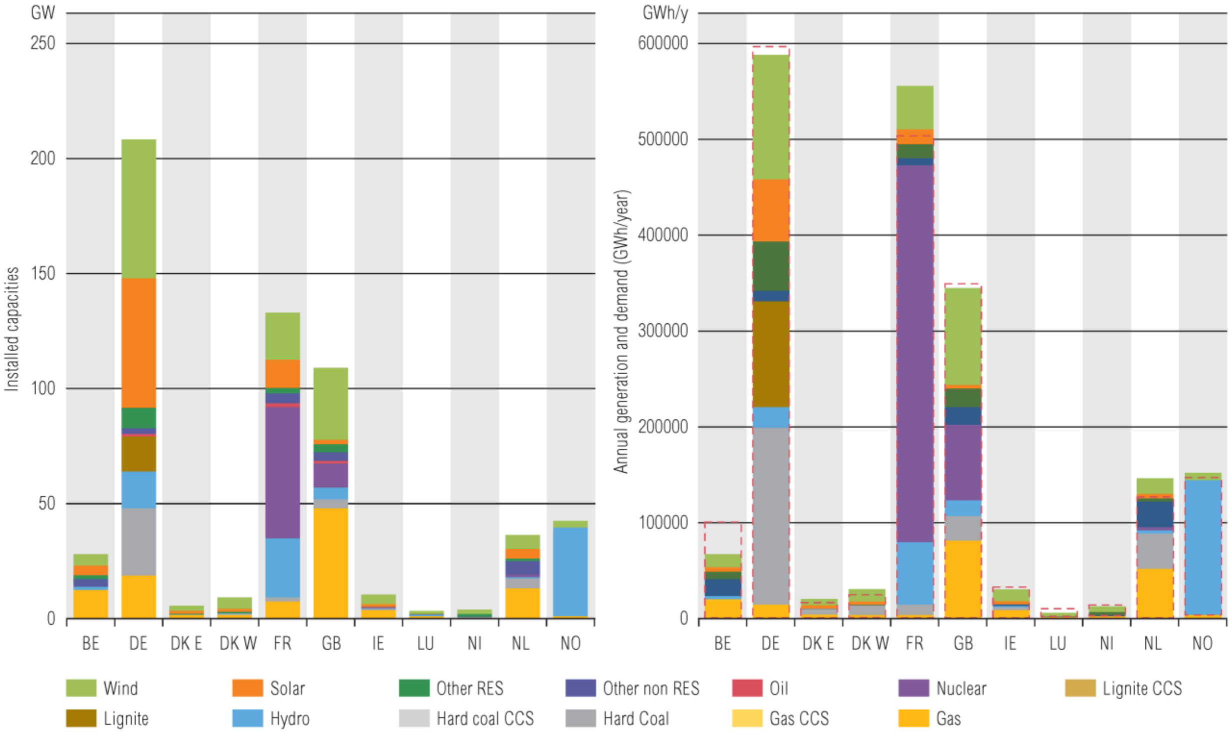
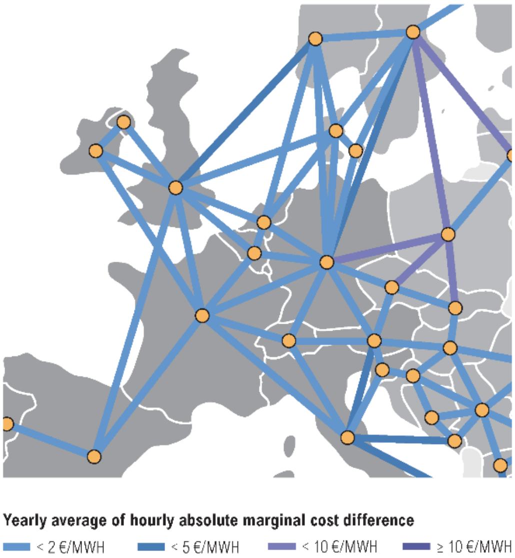


Figure 3.8 (a) Installed generating capacity and (b) annual generation and demand in the North Sea Region, Vision 2.

Energy mix by fuel type are rather similar for Visions 1 and 2 in the North Sea Region.
The increase in annual demand of Vision 2 results in a slight increase of energy supplied from fossil fuel thermal power plants.



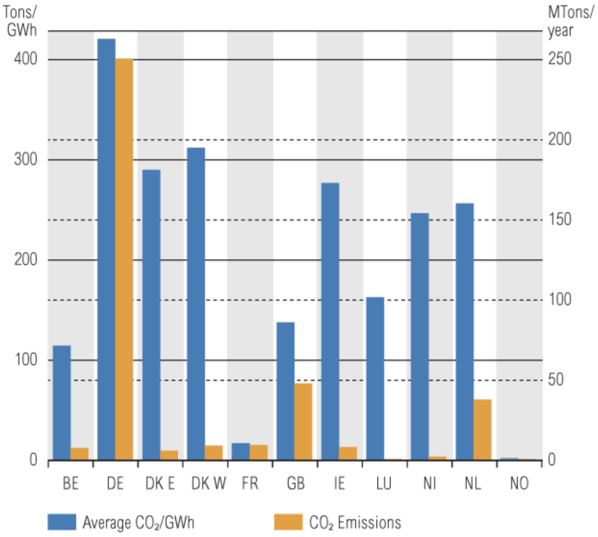


Figure 3.10 CO_2 emissions from electricity production in RGNS (MT/year), Vision 2.

Figure 3.9 Yearly average marginal cost difference in RGNS, Vision 2.

Figure 3.9 shows the simulated average price difference in the North Sea region. The figure shows the average prices per country and the average price difference based on hourly absolute price difference for 2030. There are large price differences between the Nordic countries and Central Europe and Great Britain.

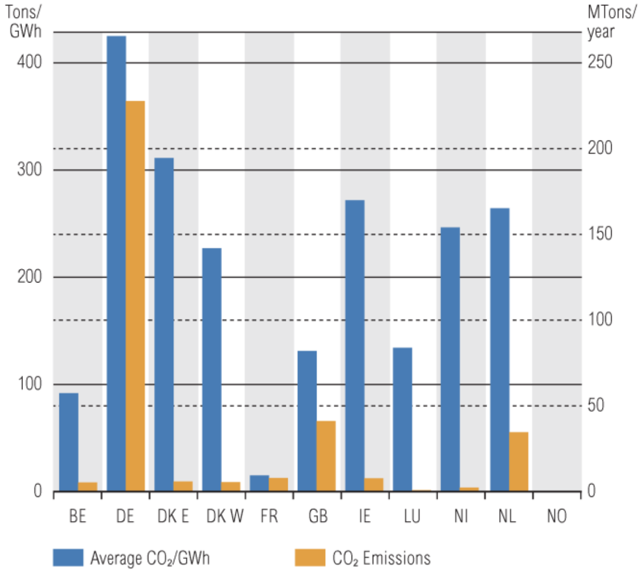


Figure 3.10 shows the expected CO_2 emissions in Vision 2, both in terms of total emissions from electricity production (Mtons/year) and in terms of emissions per GWh produced. The largest emitter is Germany due to high installed capacity in fossil fuel thermal power plants and a low CO_2 emission cost. For Germany's part, the shutdown of nuclear power generation will contribute to the high CO_2 emissions. Norway’s emissions are almost zero, due nearly all annual demand being met by hydrological energy production.

3.2.3 Vision 3

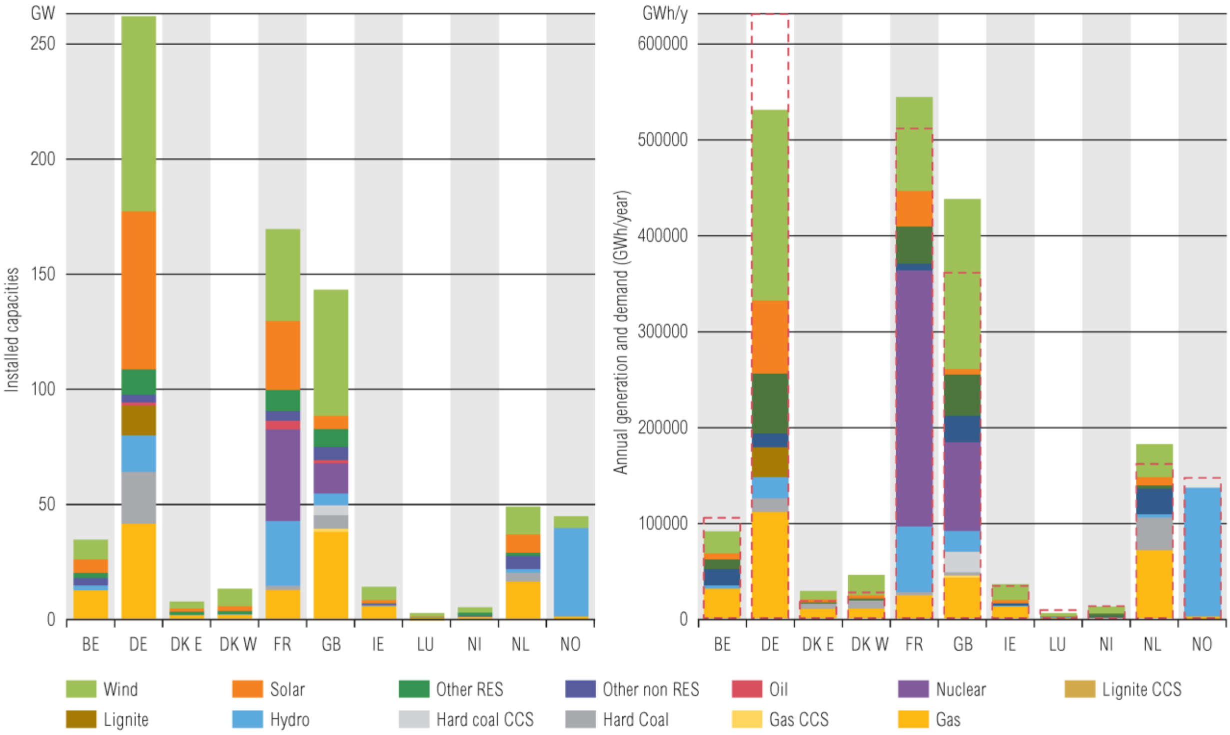


Figure 3.11 (a) Installed generating capacity and (b) annual generation and demand in the North Sea Region, Vision 3.

In comparison to Vision 1 and 2, the Vision 3 generation share from thermal power plants is reduced and there is considerable increase in RES generation. There is a switch of generation from coal to gas power plants compared to Vision 1 and 2, due to a high CO_2-price. The biggest RES contribution comes from wind, but also hydro and solar and have a large energy contribution. The biggest share of annual demand is covered by RES generation in Vision 3.

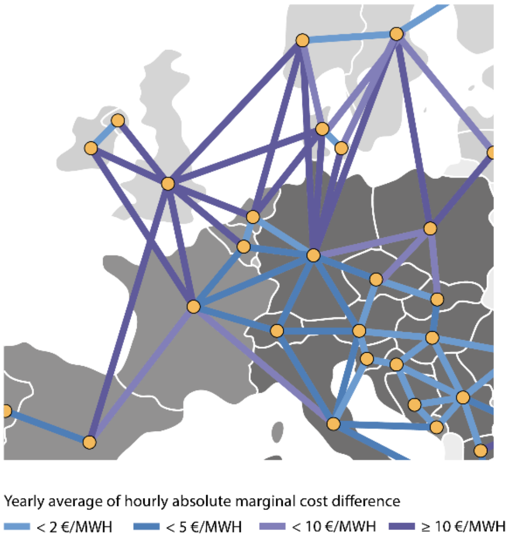


Figure 3.12 Yearly average marginal cost difference in RGNS, Vision 3.

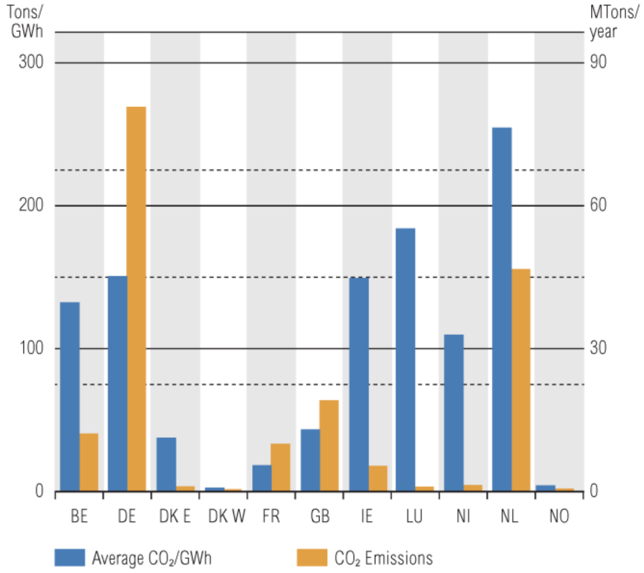
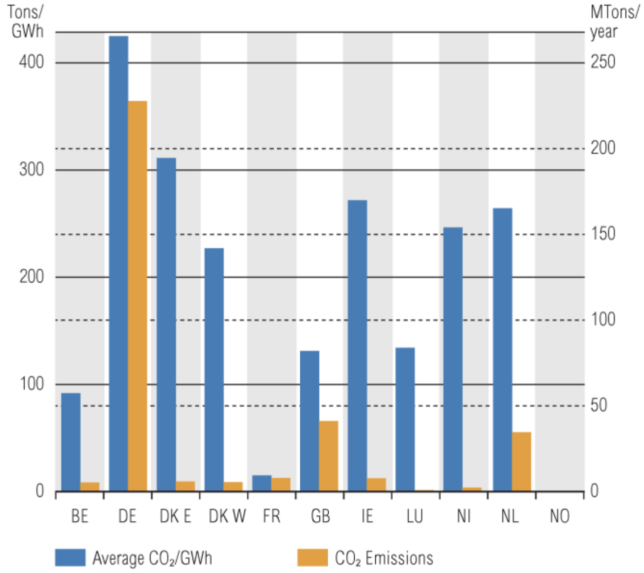


Figure 3.13 CO2 emissions from electricity production in RGNS (MT/year), Vision 3.

Figure 3.12 shows the average prices per country and the average price difference based on hourly absolute price difference for 2030. The figure shows the simulated average price difference in the North Sea region. The largest price differences for this Vision are between Nordic countries and Central Europe and between Nordic countries and Great Britain.



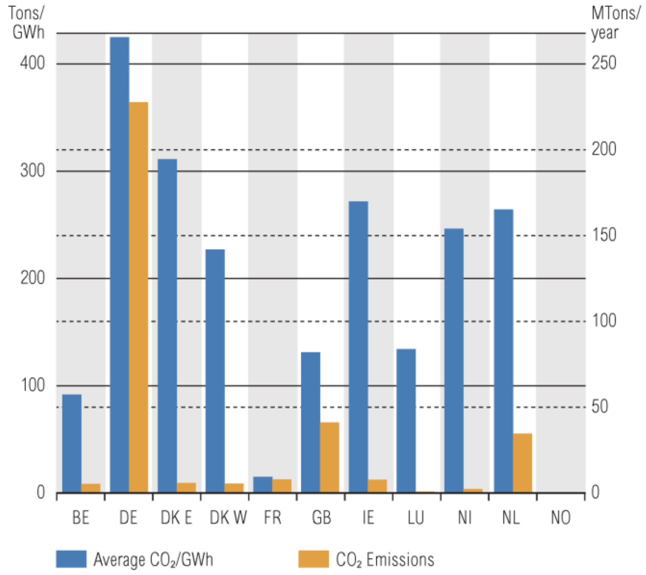


Figure 3.13 shows the expected CO2 emissions in Vision 3, both in terms of total emissions from electricity production (Mtons/year) and in terms of emissions per GWh produced. Germany is the largest emitter in terms of total emissions. However, looking at CO2 emission per GWh production, this is no longer the case. The generation shift from coal to gas in Vision 3 causes a dramatic change in the German fuel mix: there is a large decrease of the coal and lignite share and large increase of both production from RES and gas. The RGNS countries with the lowest emissions are the Nordic countries.

3.2.4 Vision 4

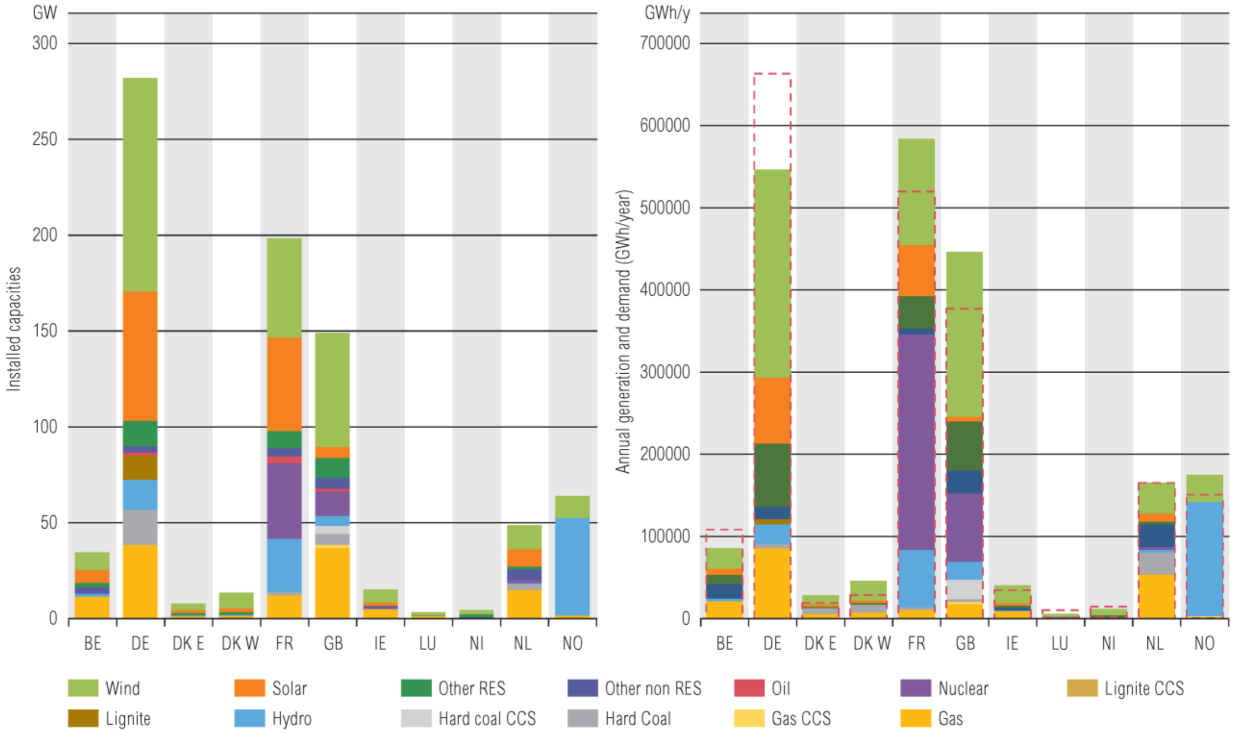


Figure 3.14 (a) Installed generating capacity and (b) annual generation and demand in the North Sea Region, Vision 4.

In Vision 4 the generation shift from coal to gas and from thermal to renewables is very strong. This switch is based on a very high CO_2-price, but also based on EU policies and the right economic climate that stimulates significant investment in renewable generation projects. In Vision 4 the installed capacity of wind generation is higher than all other Visions. Other RES generation, especially solar is also significantly higher than Vision 1 and 2.

In this vision Germany becomes a strong importer, due to nuclear phase-out, coal power stations drop out of merit and the strong demand increase. The same generation shift leads to more electricity production from British gas power plants. In this Vision Great Britain has a large increase in new wind power plants, this enables Great Britain to switch from a net importer to net exporter of electricity.

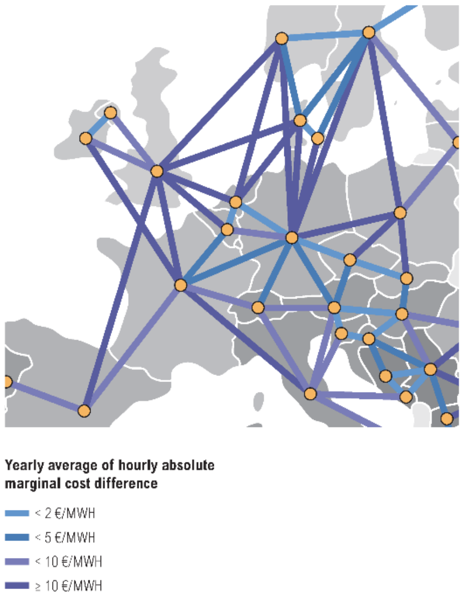


Figure 3.15 Yearly average marginal cost difference in RGNS, Vision 4.

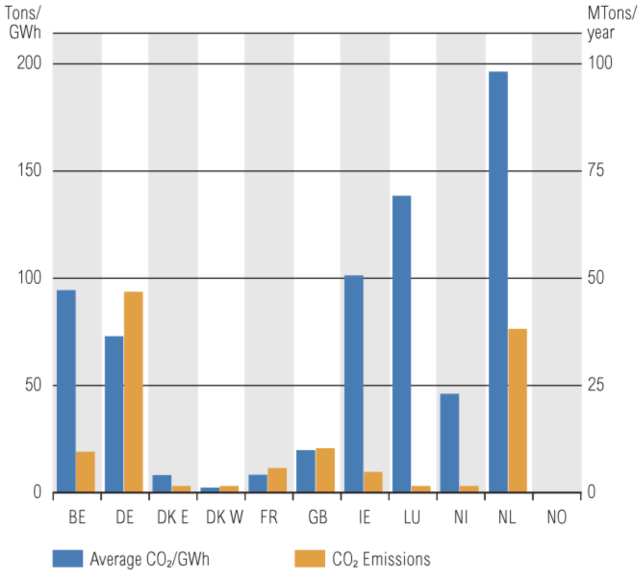
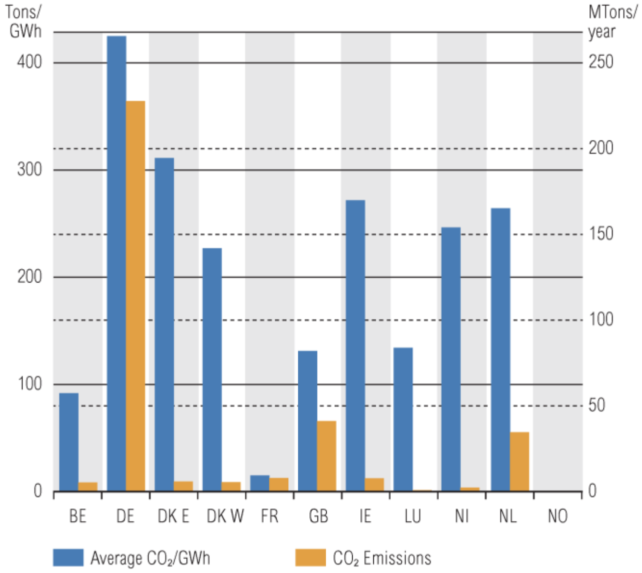


Figure 3.16 CO₂ emissions from electricity production in RGNS (MT/year), Vision 4.

Figure 3.15 shows the average prices per country and the average price difference based on hourly absolute price difference. The figure shows the simulated average price difference in the North Sea region. The largest price differences are also for this Vision between Nordic countries and Central Europe and between Great Britain and Central Europe.



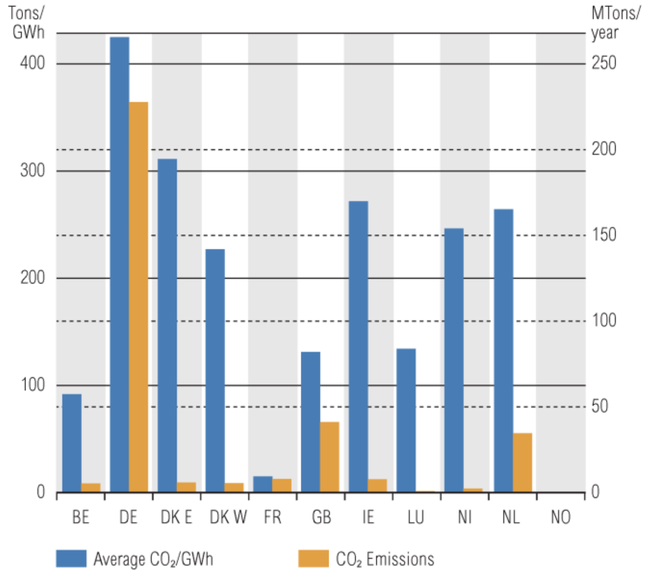


Figure 3.16 shows the expected CO_2 emissions in Vision 4, both in terms of total emissions from electricity production (Mtons/year) and in terms of emissions per GWh produced. Conclusions are broadly similar to those for Vision 3.

3.3 Network study results

The changes in generation mix in 2030 are expected to drive the need for increased power flows between the three islanded systems (Ireland, GB and Norway / Denmark East) and between each islanded system and the main continental system.

Regional Group North Sea has identified the following main flow patterns:

- The islands of Ireland and Great Britain are expected to experience significant growth in variable RES production, resulting in variable power flows depending on the prevailing wind conditions. In high wind conditions, it will be necessary to evacuate variable wind energy to other regions. Conversely, in low wind conditions, it is of crucial importance to have access to other regions for balancing. Significant flows between the islanded systems and to continental Europe are therefore expected.
- The islanded system in the Nordic region features high hydro generation capacity. The existing and new interconnectors connecting the Nordic system with the Continent and GB will be beneficial for trade and balancing flows.
- High electricity injection of wind farms in the North Sea and hydro generation in Norway will be transmitted southwards to other consumption areas. This trend is already dominant and will increase.
- The change in the energy mix will give rise to a major evolution of energy flows between France, Germany, Belgium and the Netherlands, stressing intensely the interconnections in the borders between those countries.

On the base of the methodology described before (chapter 2), grid studies have assessed whether physical flows may exceed the physical capacity of the existing grids, taking into account the power dispatches as evaluated by the market simulations. Where congestions have been identified, additional projects have been investigated to reinforce the networks in the congested areas.

3.3.1 Vision 1

The flow duration curves on each border have been calculated. The figure 3.18 gives the flow duration curve of regional AC borders. The 5% lowest and highest flows on each border are described on figure 3.17. This last picture shows that most of the DC interconnections are operating at full power for these percentiles. AC borders are heavily loaded as well.

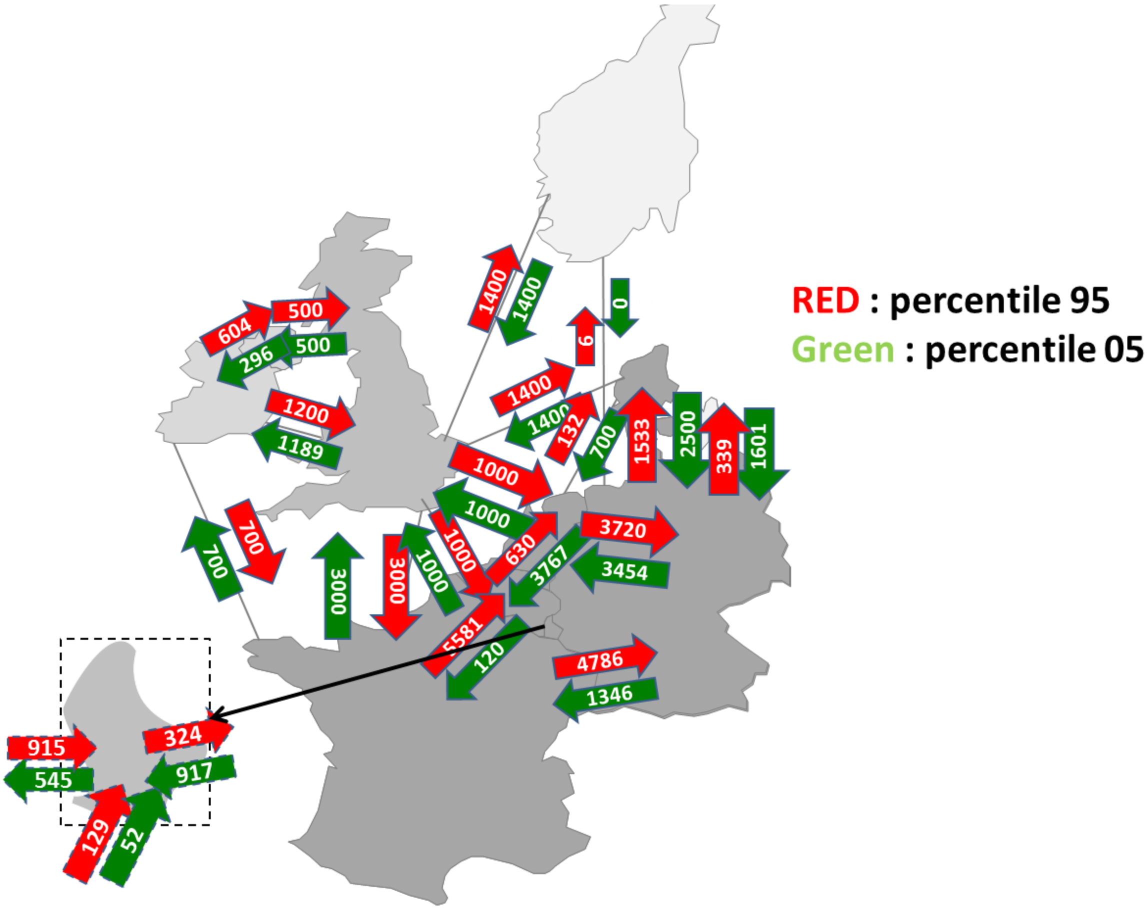


Figure 3.17: bulk power flows (5% (green) and 95 % percentiles (red)) - Vision1.

The year-round flow duration curves confirm the system loading, but a detailed contingency analysis shows the regional system is safe, given the reinforcements already foreseen in the TYNDP 2012-2022. Nevertheless, the following comments are important:

- The Belgium-The Netherlands border is secure thanks to the planned installation of an additional PST at the border. This increases the capacity at the border, and the PSTs used at half control range enable to counter flows in high flow situations (except the most extreme percentiles, i.e. 5-95%);

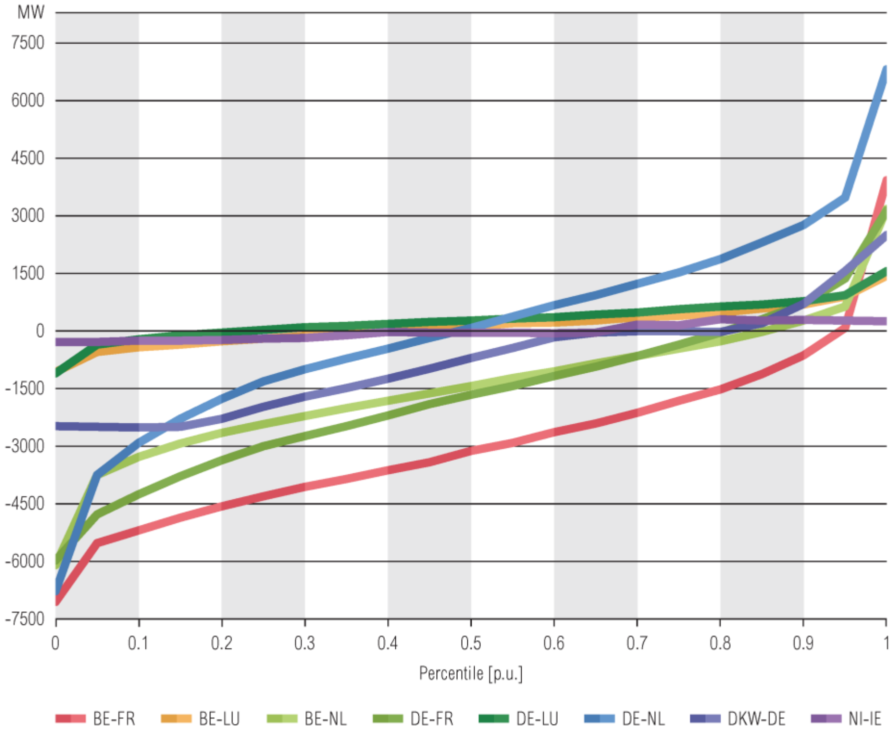


Figure 3.18: flow duration curve on the AC border within Regional Group North Sea (healthy state) – Vision 1

- The reinforced at the Belgium-Luxemburg border is safe for the expected flows except for some extreme flows. The PST installed in Schifflange only serves to balance the flows between parallel underground cables and overhead line but does not control the overall transit;
- The expected flows between Belgium and France confirm the need to reinforce that border, as already announced in the previous TYNDP;
- The Dutch-German border, the borders between Northern Ireland and Ireland and between Denmark (West) and Germany safe – some reinforcements are already planned at these borders;
- In general terms, The Benelux countries Belgium, Netherland and Luxembourg, the North part of France, and the North West region of Germany will be subject to high transit and loop flows making additional grid control counter measures necessary. The network losses will consequently increase significantly due to load increase and high RES capacity in the Sea and onshore.

The analysis has been extended to the internal grids, but only on a limited set of representative hours. The flow on each grid element has been calculated, taking into account normal conditions or contingency situations on the whole Regional Group North Sea area. The assessment results in a huge amount of quantitative results. For the sake of illustration, figure 3.19 shows a typical flow pattern. It focusses on the Benelux, Western Germany and Northern France during two representative hours, but the same pictures are available for the whole North Sea area.

Provided the already planned investments in both the TYNDP and RGIP[19] are delivered, the assessment concludes that no additional significant internal constraints are required to accommodate the Vision 1 generation mix in the North Sea Region.

Some additional investments can be needed to manage the flows throughout the Danish system in Vision 1. Additional assessed connectors, which go beyond the Danish national grid plan, have been identified. These investments are shown on figure 3.21 and may include:

- a 400kV 1.94 kA cable system Endrup-Idomlund.
- a 400kV 1.94 kA cable system Ferslev-V.Hassing.
- a 400kV 1.08 kA cable system Tjele-Trige.
- upgrading OHL Ferslev-Tjele 400 kV.
- a 400kV 1.37 kA cable system Asnaes-Kyndby.
- Reinforced cable, i.e. one more 0.9 kA 400 kV cable, system of the Roskilde Fjord FSP and impedance correction (a series reactor).
- a 400kV 1.08 kA cable no. 2, Tjele-Trige

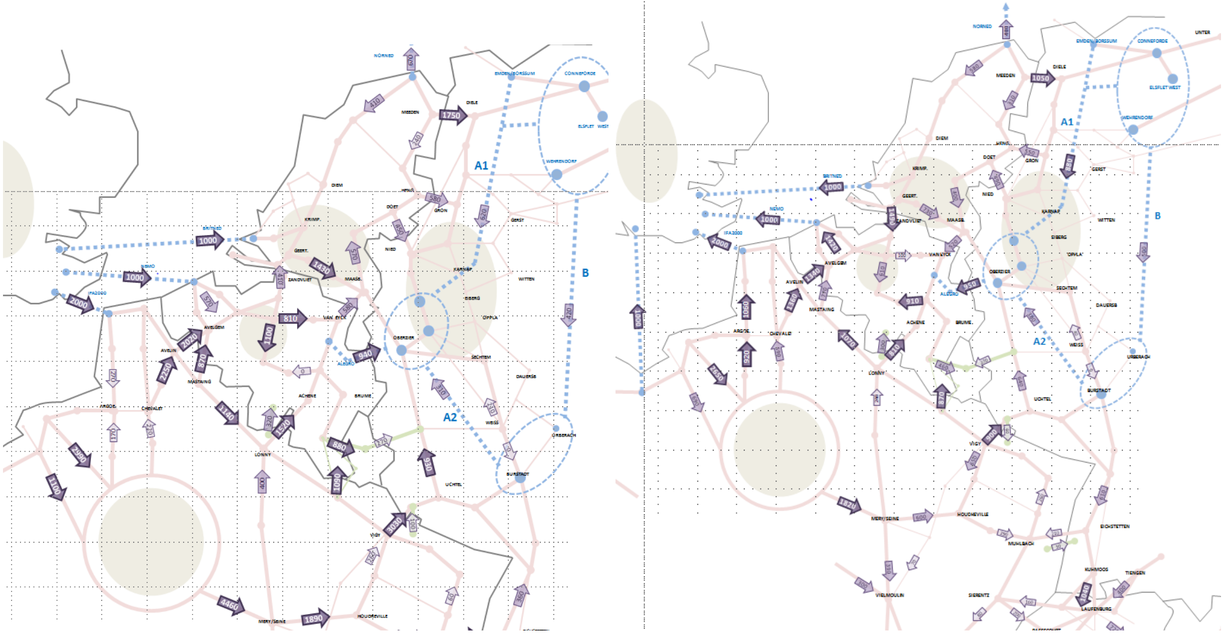


Figure 3.19: two typical flow patterns in the Continental part of Regional Group North Sea, same kind of analysis and picture have been performed in each area with the group– Vision 1.

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[19] Regional Group Investment Plan (RGIP)

3.3.2 Vision 4

The same modelling exercise has been performed for Vision 4, for both cross-border and internal grids. The figure 3.20 gives the flow duration curve of regional AC borders. It emphasizes an increase of flow intensity in Vision 4 in comparison with Vision 1.

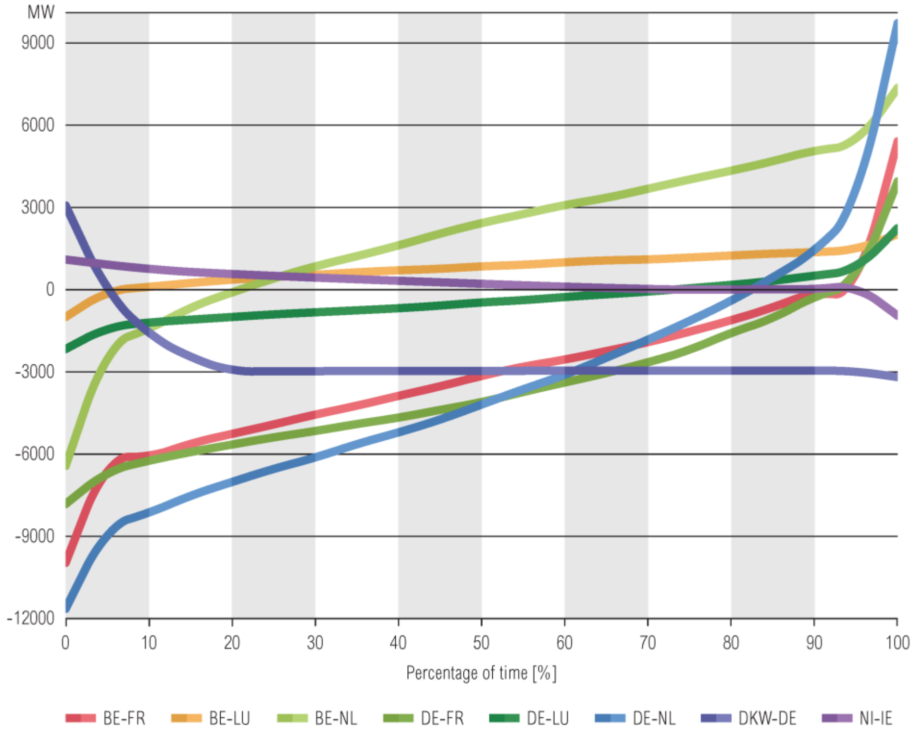
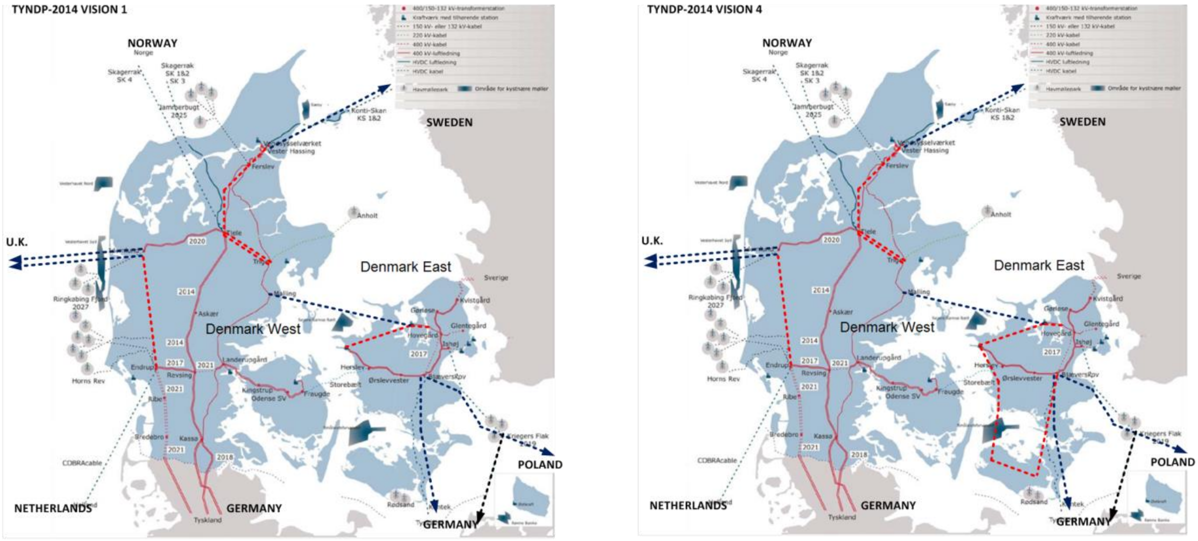


Figure 3.20 load duration curve on the AC border (healthy state) – Vision 4

As for **Denmark**, Vision 4 has introduced congestions in the Danish 132 kV, 150 kV and to some extent in the 400 kV grids in conduction with power transmission from a significantly increased amount of wind power and other RES sources.

The following maps illustrate how the Danish transmission grid expansion may look like when going from Vision 1 to Vision 4. Specifically, the 150 kV grids in Denmark-West (not shown in the maps) have been doubled in order to evacuate all wind power without any curtailment. In Denmark-East, the wind power evacuation could not been efficiently solved by only expansion of the 132 kV grid and, then, the 400 kV grid expansion has been proposed to south of Denmark-East - in this work. by using almost 200 km 400 kV cables.

With those reinforcements, there would be no contingencies in the Danish transmission system in Vision 4. The mentioned reinforcements are not part of the Danish national grid plan or TYNDP-2014 projects. However, the mentioned reinforcements could gradually or fully be initiated in case such a significant increase in the Danish variable RES would be decided for commissioning.



Danish Grid Vision 1 with moderate new internal reinforcements	Danish Grid Vision 4 introducing a lot of new internal reinforcements especially in Denmark East

Figure 3.21: Identified reinforcements inside the Danish system

As for the **Benelux and France**, Vision 4 shows significantly increased flows from France to Belgium. The reinforcement of 2 overhead lines 380 kV Mastaing (FR)-Avelgem-Horta-Mercator and Avelin (FR)-Avelgem-Horta-Mercator with High Temperature Low Sag conductors (HTLS) as planned for Vision 1 can be confirmed. However, a further reinforcement becomes necessary and is being studied. Options include reinforcement with HTLS of the 3rd 380 kV overhead line between France and Belgium, Lonny-Achêne-Gramme, or HVDC connections (these options are not cumulative).

The increased offshore wind power requires a reinforcement of the connections from the coast to a load centre with less production (e.g. Brussels or Antwerp), next to the planned corridor from the coast to Horta. Several technological options and locations are being considered.

The main internal bottleneck from Horta to Mercator (located between Antwerp and Brussels) is stressed by the combination of flows France-Belgium, UK-Belgium and offshore wind power. For this reason, the second interconnector UK-Belgium present in Vision 4 would be connected not at the coast, but e.g. in the Antwerp area. The reinforcement from the coast to inlands load centres further serves to alleviate the stress on Horta-Mercator.

The border Belgium-The Netherlands is more highly stressed in Vision 4, and especially in the direction from Belgium to The Netherlands. The 4 phase shifters used up to half the control range allows to secure the situation for all situations except the most extreme.

Vision 4 leads to an increase of flows through the 220 grid in Luxembourg. Two additional PSTs might be needed on the planned 220 kV cables between Belgium and Germany.

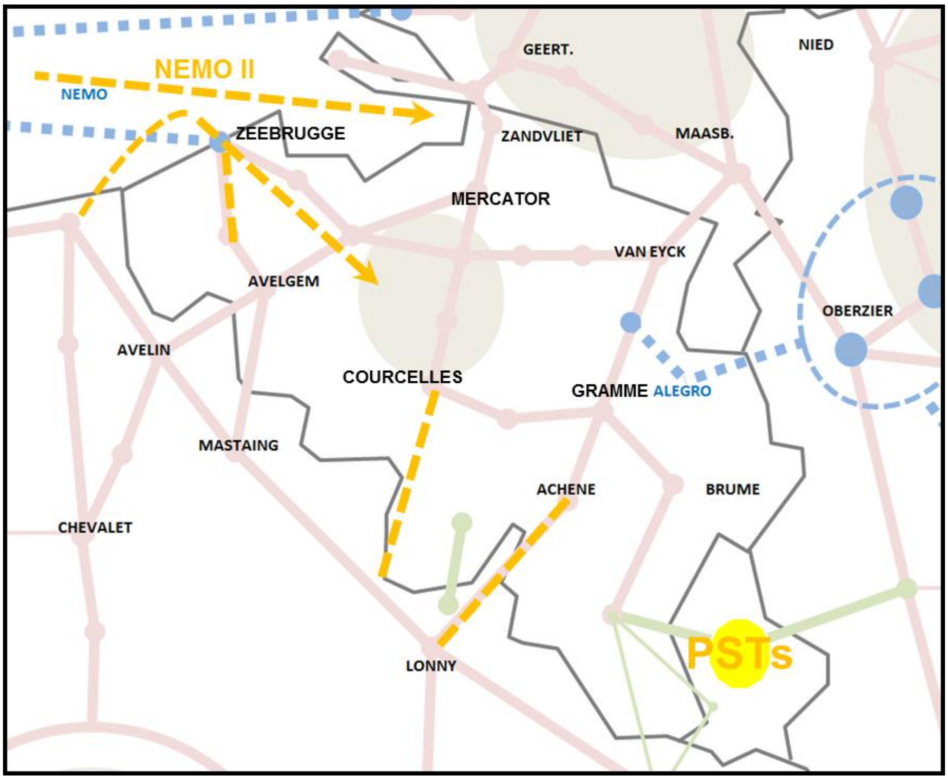


Figure 3.22: considered options in Benelux – Vision 4

As for **Germany**, the high amount of renewables in Vision 4 compared to Vision 1 leads to additional bottlenecks due to high North-South power flows. Therefore additional HVDC connections are needed in comparison with Vision 1, in line the German National Development Plan.

As for **Ireland and Northern Ireland**, the grid analysis of N-1 contingencies for Vision 1 showed that the planned 2030 transmission network is adequate for most of the time. However, it should be noted that the wind generation has been dispatched pro rata across the country in the analysis and so they do not capture inter area or local stresses.

There is a significant increase in renewable penetration between Vision 1 (Ireland 40% and Northern Ireland 40%) and Vision 4 (Ireland 76% and Northern Ireland 60%). A large portion of this increase is in the form of offshore wind and biomass. Offshore wind is expected to connect in the East of the Island into strong transmission nodes. Biomass is expected to replace existing peat burning stations and some additional new plant which are also connecting in relatively strong parts of the network. This accompanied with averaged simulated situations shows that for Vision 4 the 2030 network model is adequate from a capacity perspective. However serious deficiencies in reactive power were observed and a significant roll out of reactive power support will be required to accommodate Vision 4.

As for ***Great Britain***, based upon the market studies output and grid studies, Vision 4 shows a higher level of internal constraints within the National Grid network in Great Britain. The reinforcements identified for Vision 1 play a pivotal role in minimising the constraints for Vision 4, however due to the level of renewable power and interconnector operation, constraints in the form of bottlenecks in and around London, South Coast & Upper North are identified. Additional internal constraints identified in East Anglia & North Wales are a product of the scenario to carry the power into these regions. The South Coast constraint is driven by a number of interconnectors in the South of England, while London experiences large penetrations of wind power and thru flows into the largest demand centre of the UK. The Upper North is driven by flows from Scottish flows and wind Power in the North East & East Coast. These internal constraints fall out the remit of this work, and will be addressed within our own planning regime.

As **Norway** is in the Nordic synchronous area network studies and description of the Norwegian grid is commented in the Regional Investment Plan Baltic Sea.

3.3.3 Visions 2&3

The Visions 2 and 3 have not been assessed in a quantitative way as preliminary results have shown that Vision 2 is very similar to Vision 1 and that Vision 3 is relatively close to Vision 4. In some case, the Visions 2 and 3 flows are mostly calculated via a qualitative interpolation between the Visions 1 and 4 flow values.

3.4 Comparison of the Visions

This chapter is giving an overview of generation, CO_2-emissions and RES-integration in different Visions at regional level. The results are based on regional analyses performed by Regional Group North Sea.

The analysis of the grid capacities shows that the investments already planned in the previous TYNDP 2012-2020 are sufficient to cope with the Vision 1 ***(“slow progress”*)** scenario. Denmark is the exception where internal reinforcements are necessary to accommodate new interconnections.

More significantly, structural reinforcements are needed to accommodate Vision 4 and thus to support the ***“green revolution”***. Major additional reinforcements are necessary in Belgium, Germany, Great-Britain and Denmark. The France-Belgium border needs to be reinforced again as well.

The North Sea region has an interesting generation mix that makes it favourable to build interconnectors. 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 it is important to have enough transmission capacity between the areas.

The three main drivers for system evolution in the North Sea region are market integration, integration of renewables and security of supply. Large amounts of renewable production in countries like Germany and Great Britain, combined with the possible generation shift from coal-fired power plants, makes the generation mix totally different from recent years. In Germany the decision of a nuclear phase-out by 2022 makes even stronger structural changes in generation necessary.

3.4.1 Generation – a shift from fossils to renewables

There is huge potential for change of generation mix across the Visions. There is a potential to phase-out of more flexible generation like coal/oil and integration of less flexible renewable generation like wind and sun. Changes in generation mix will lead to a need for more flexibility between the different areas.

For example some areas may experience low wind production whilst other areas within the North Sea region might experience higher wind production. And in periods of low sun and wind production there might be a need for using the hydro-reservoir flexibility in the Nordic countries. Conversely in periods with very high sun and wind production the hydro-reservoir might be used for storage of energy.

With potentially new generation mixes, in a European context there will be a need to improve flows between areas. For the North Sea region this leads to a need for more interconnectors between the areas and the power systems around the North Sea.

Installed generation capacity by type is presented in the Figure 3.4. The charts in Figure 3.23 below illustrate the energy volumes from different generation types for the different Visions.

In general there is a generation shift from coal to gas, and a higher penetration of renewables when moving from Visions 1 and 2 to Visions 3 and 4. This can also be observed by looking at the emissions (see Figure 3.24). The emissions are reduced dramatically when moving from Vision 1 and 2 towards Vision 3 and 4. The switch from coal to Gas in Visions 3 and 4 leads to a dramatic reduction in the total emissions from electricity production, especially in Germany and Great Britain.

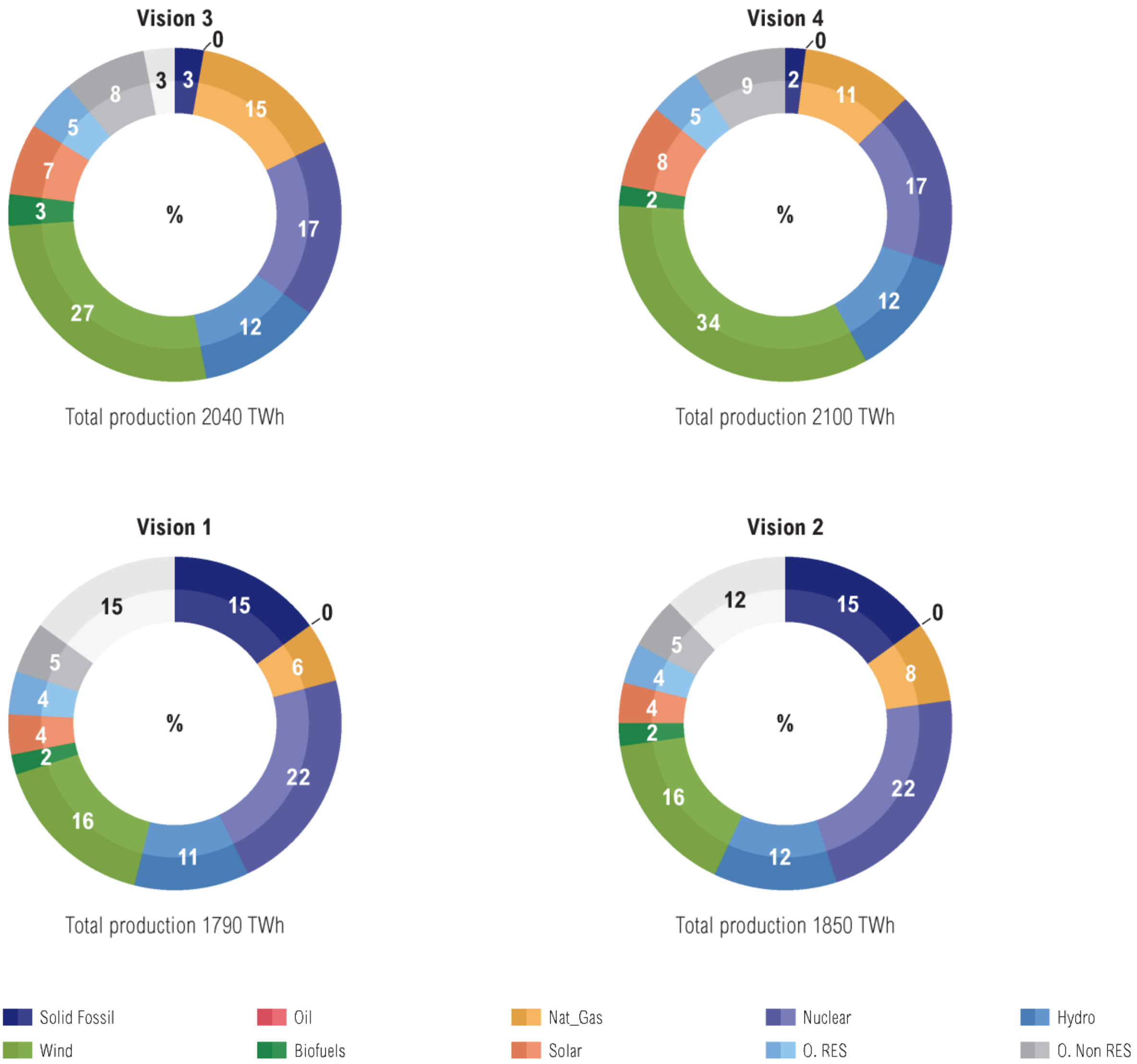


Figure 3.23 Generation portfolio mixture in North Sea Region in Visions 1, 2, 3 and 4 in terms of shares of produced energy. White area represents difference in total generation from Vision 4.

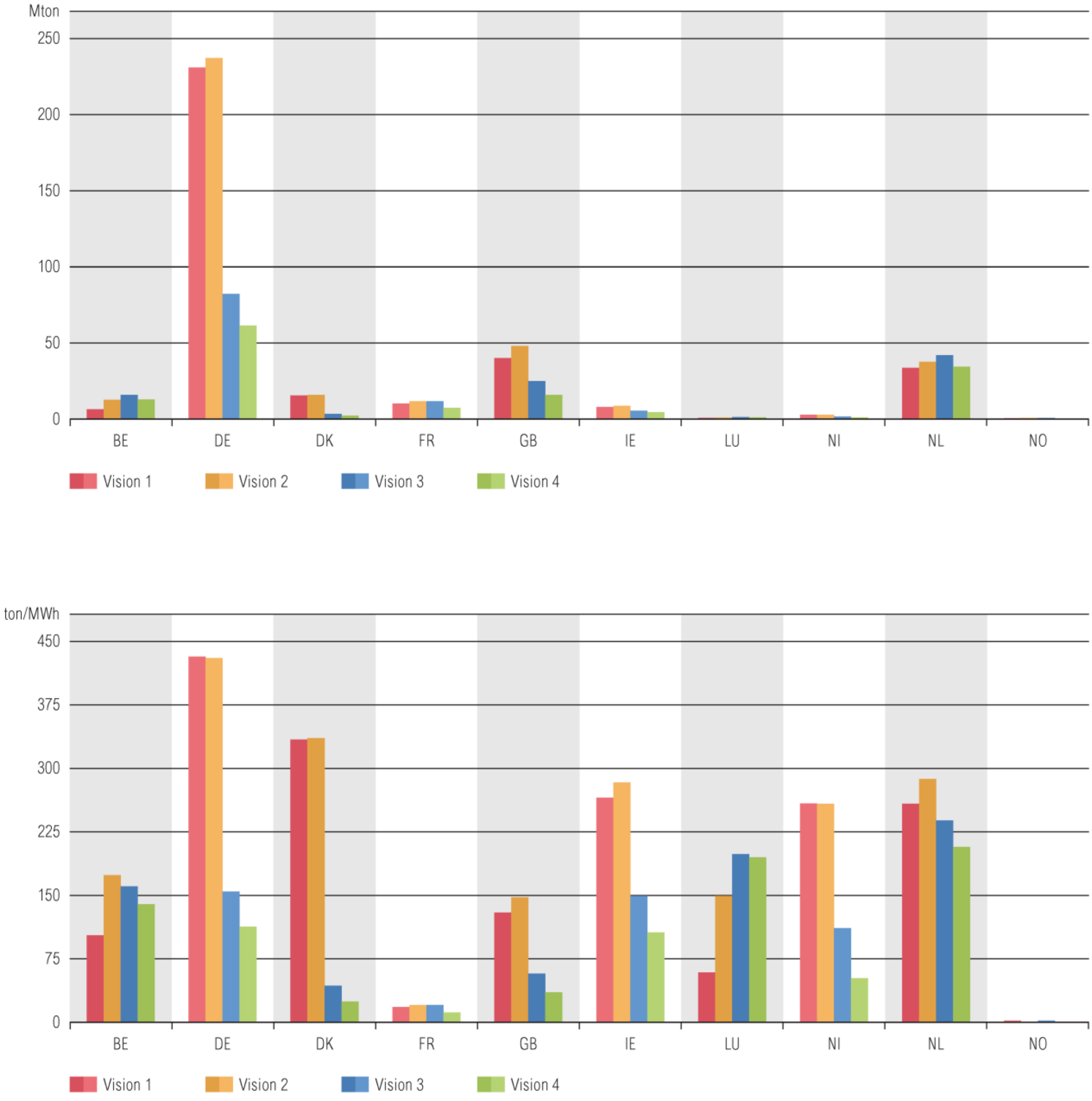


Figure 3.24 CO_2 emissions from electricity production in RGNS (MT/year and emissions per MWh), for the 4 Visions.

3.4.2 Interconnectors - necessary for the RES-integration

To enable the generation shift from thermal conventional plant to renewable technologies, a more flexible power system is necessary. New bulk flow patterns will occur, but as the generation shift enables additional renewable generation there is proportionally less flexible plant portfolio available for despatch. In this context interconnectors between the countries around the North Sea are very important.

Interconnection enables greater flexibility in the system to despatch generation optimally both during peak/off-peak periods and in windy/non-windy periods. The figure hereunder show how potential interconnectors in the North Sea Region influence the curtailment of energy production. Curtailment is expected to occur on less renewables. The figures 3.25 and 3.26 show the influence of interconnectors on increased European renewable productions in (a) Vision 1 and (b) Visions 4.

RES-integration is low in Vision 1 in comparison to Vision 4. In Vision 1 the CO_2-prices are low. It is assumed percentage wise, that there will be no more renewables than stated by the 20-20-20-goals. This means that the generation shift to renewable technologies has not started significantly in this Vision. However, interconnectors from the hydrological parts of the Nordics, especially going to Great Britain, lead to a large increase in total European renewable production.

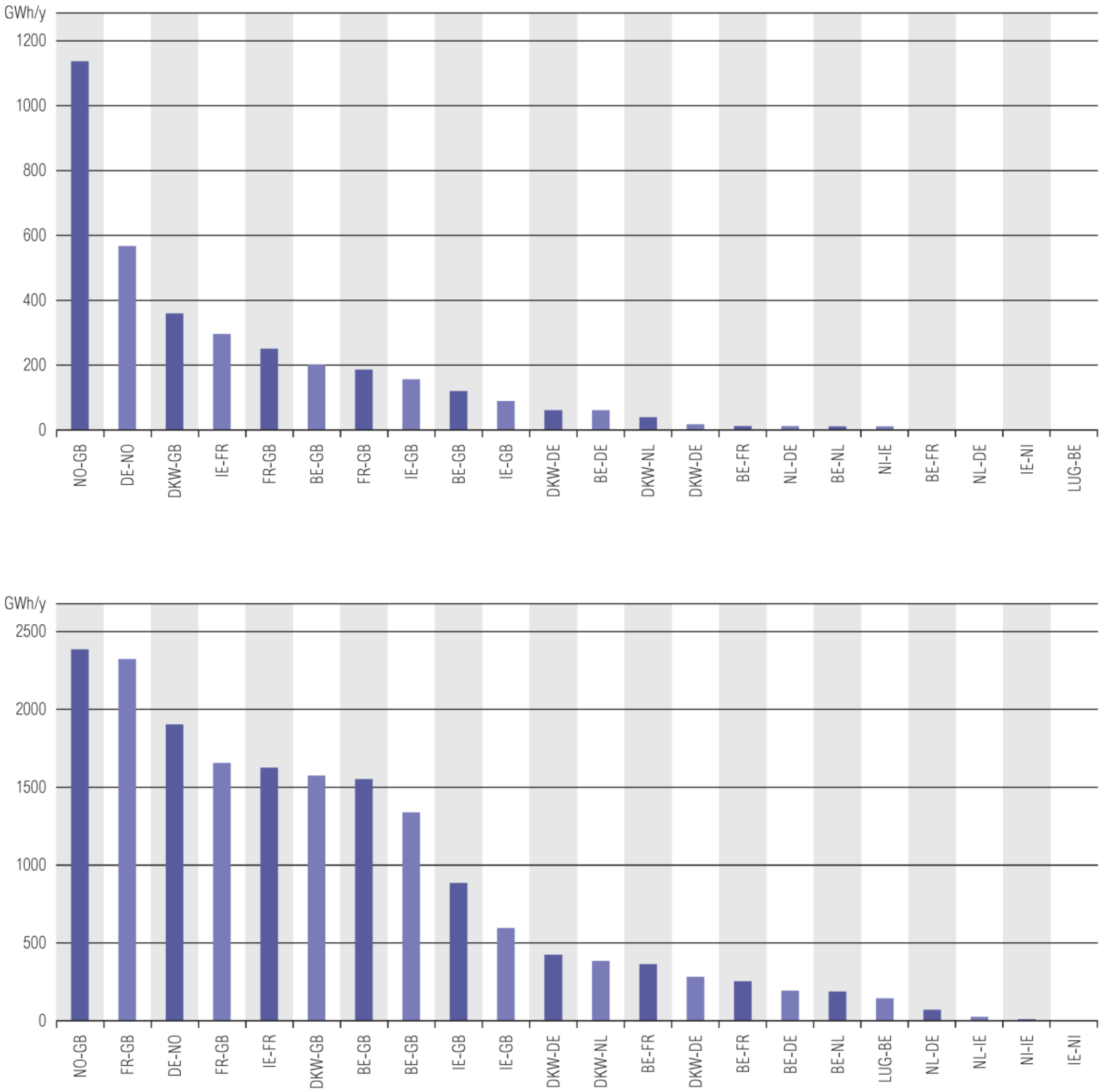


Figure 3.25 Interconnector's influence on European RES-integration in (first) Vision 1 and (second) Visions 4.

In Vision 4, RES-integration has significantly increase as the GWh/year in each country as shown in Figure 3.25. In this Vision the CO_2-prices are very high. The percentage of renewables has significantly increased.

In this Vision the generation shift towards the Roadmap 2050-goals are gaining substantial momentum. Interconnectors are highly necessary, and the influence on helping to reduce CO_2-emissions on an EU basis through RES integration is important. The interconnectors from the hydro-rich parts of the Nordics going to Continental Europe are significant in reducing the total European CO_2-emissions. With improved interconnection coal-fired power production on the continent can be replaced by renewable production; this is also true with the interconnectors going to Great Britain

3.4.3 Interconnectors – leads to decreased CO_2-emissions

In order to be able to enable the generation shift, both from coal to gas and from thermal to renewables, a more flexible power system is necessary. In such a flexible power system, interconnectors between the countries around the North Sea are very important. Interconnection assists in the replacement of thermal production with renewable generation, but also adds flexibility to the system by optimization of the system generation despatch during peak/off-peak periods and in windy/non-windy periods.

The following figure 3.26 shows the potential that interconnectors in the North Sea Region have on reducing the total European CO_2-emissions from power productions in (a) Vision 1 and (b) Visions 4. In Vision 1 the influence is low. In this Vision the CO_2-prices are low and it is not assumed more renewables than stated through the 20-20-20 goals. This means that the generation shift has not gained any significant momentum in this Vision. One exception is interconnectors from the hydrological parts of the Nordics, especially going to Continental Europe, which leads to a reduction in total European CO_2-emissions.

In Vision 4 the influence of additional interconnection capacity in reducing CO_2 emission is high in comparison to Vision 1. In Vision 4, the CO_2-price is very high and there is a large amount of renewables. The result is that the generation shift has gained momentum toward achieving the EU Roadmap 2050-goals. In this Vision interconnectors are highly necessary and their influence on reducing CO_2-emissions is important. For this Vision interconnectors from the hydrological parts of the Nordics going to Continental Europe, leads to a noteworthy reduction in total European CO_2-emissions. One reason for this is that continental coal-fired power production is replaced by renewable generation production. Interconnection with Great Britain also has an important role in helping to reduce the total European CO_2-emissions.

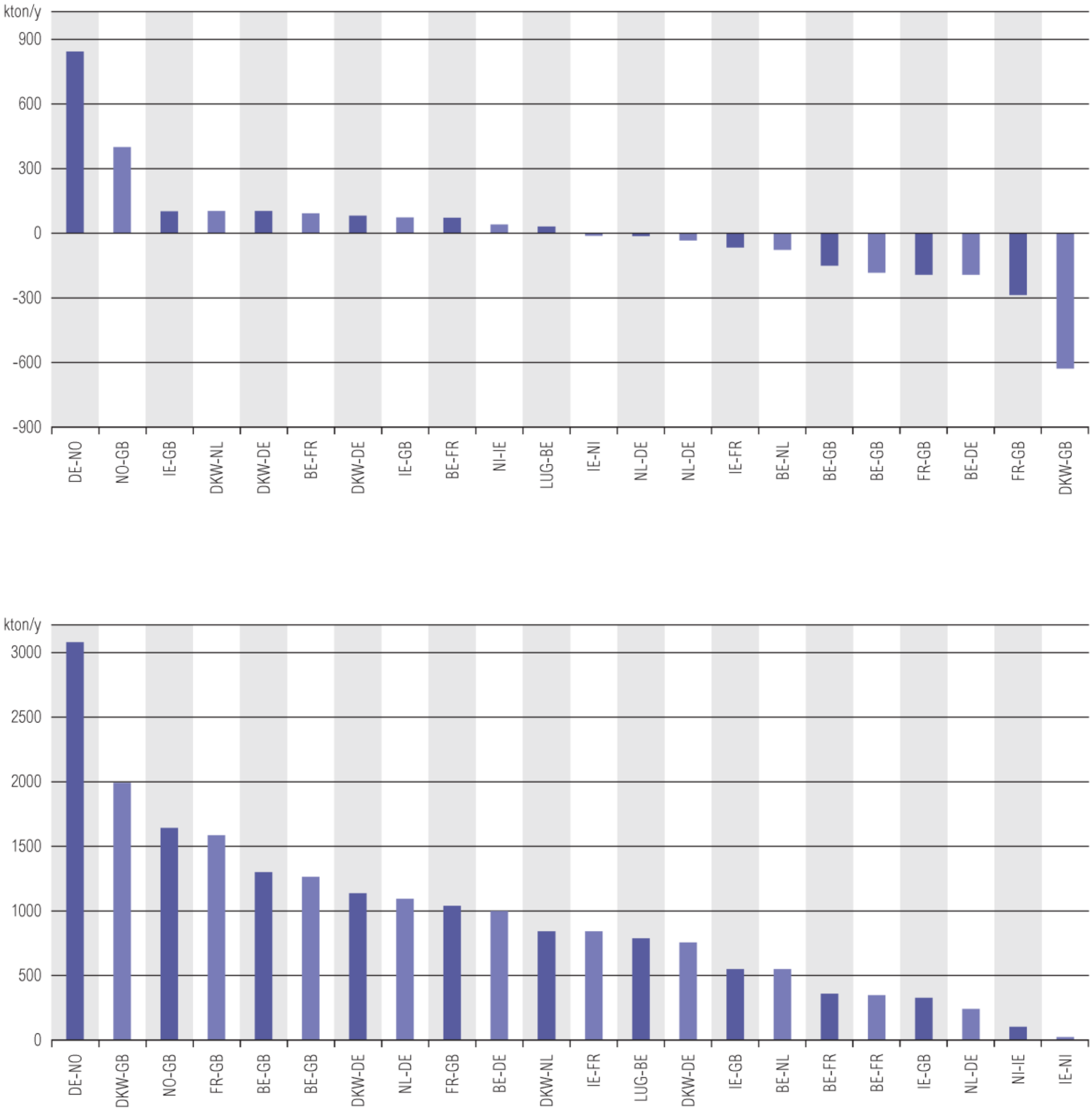
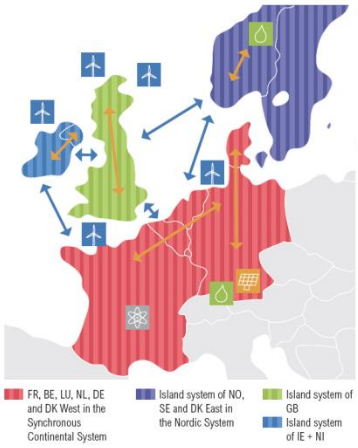


Figure 3.26 Interconnector's influence on CO_2-emissions from European power productions in (first) Vision 1 and (second) Visions 4.

4 Investment needs

In this chapter, investment needs are specified. Those investments are impacted by the specific geography of the region:

- A high renewable energy potential especially in the Channel, in the North Sea and in the north of the region
- four synchronous systems separated by sea.



The North Sea Region comprises four synchronous systems around the North Seas. The synchronous systems themselves are heavily meshed. Between the four synchronous systems within the region, the relatively low level of interconnection limits the ability to rely on neighbouring systems for system security and trading.

One of the aims of governments is to de-carbonise the electricity network and in some cases to reduce the dependency on nuclear power. Those drivers have a significant impact on the development of the transmission network. The change in generation mix will result in the need to transfer power over greater distances and require interconnectors between member states. The ability to provide this additional transmission capacity is impacted by this political orientation.

4.1 Present Situation

The map in figure 4.1 shows diverse levels of Net Transfer Capacities (NTC) in Europe. The NTC is the maximum total commercial exchange capability between two adjacent control areas that is compatible with security standards.

NTC values change under different conditions, for example the topology of the network, the load pattern or time of year.

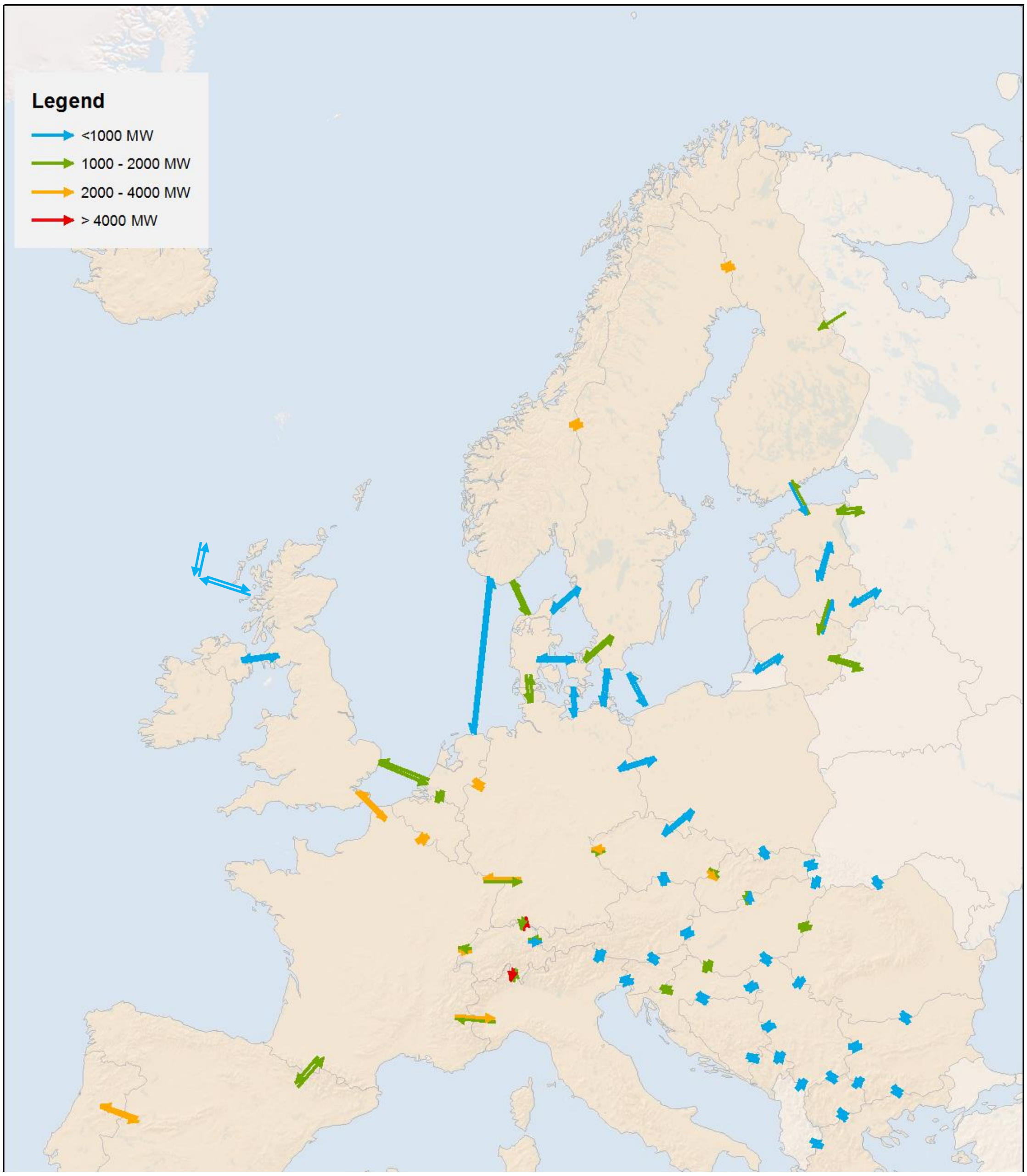


Figure 4.1 Illustration of Net Transfer Capacities in NS region (2013)

4.2 Drivers of Grid development

Regarding grid development and planning the North Sea Region faces major challenges over the plan period on the way towards an efficient European Energy market and secure European Network and a deep penetration of renewable energy sources. These challenges lead the TSOs within the Region to plan and conduct projects aiming at:

- Security of supply, for example challenges due to German and Belgian nuclear phase-out and French nuclear reduction.

- Increased integration of the European energy market;

- Large scale connection and increased integration of renewable energy sources (wind, solar and hydro).

The generation shift identified in the Vision requires a more flexible power system and causes new transport patterns. The key changes are as follows:

- A shift from thermal to renewables.
  Adding interconnectors to the system provides 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 North Sea Region, leads to large reduction of the regional CO_2-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 CO_2-emissions. The assumption of the CO_2 price is the main driver for the generation shift from coal to gas.

In order to avoid heavy curtailment of RES generation more interconnectors are needed. Adding interconnectors is also a means to create more flexibility in the power system, required due to the increase of RES generation.

Transmission lengths have to be increased to deal with the location of wind power generation often at distance from load centres.

This renewal of the generation mix is a major challenge for the transmission grid of the future.

4.3 Main Bottlenecks

The market and network study processes have identified bottlenecks in the European electricity system that will persist or emerge in the coming decade, unless new transmission assets are developed. Figure 4.2 shows the location of these grid bottlenecks (or "boundaries") in the North Sea Region, where the transfer capability may not be large enough to accommodate the likely power flows unless new transmission assets are developed.

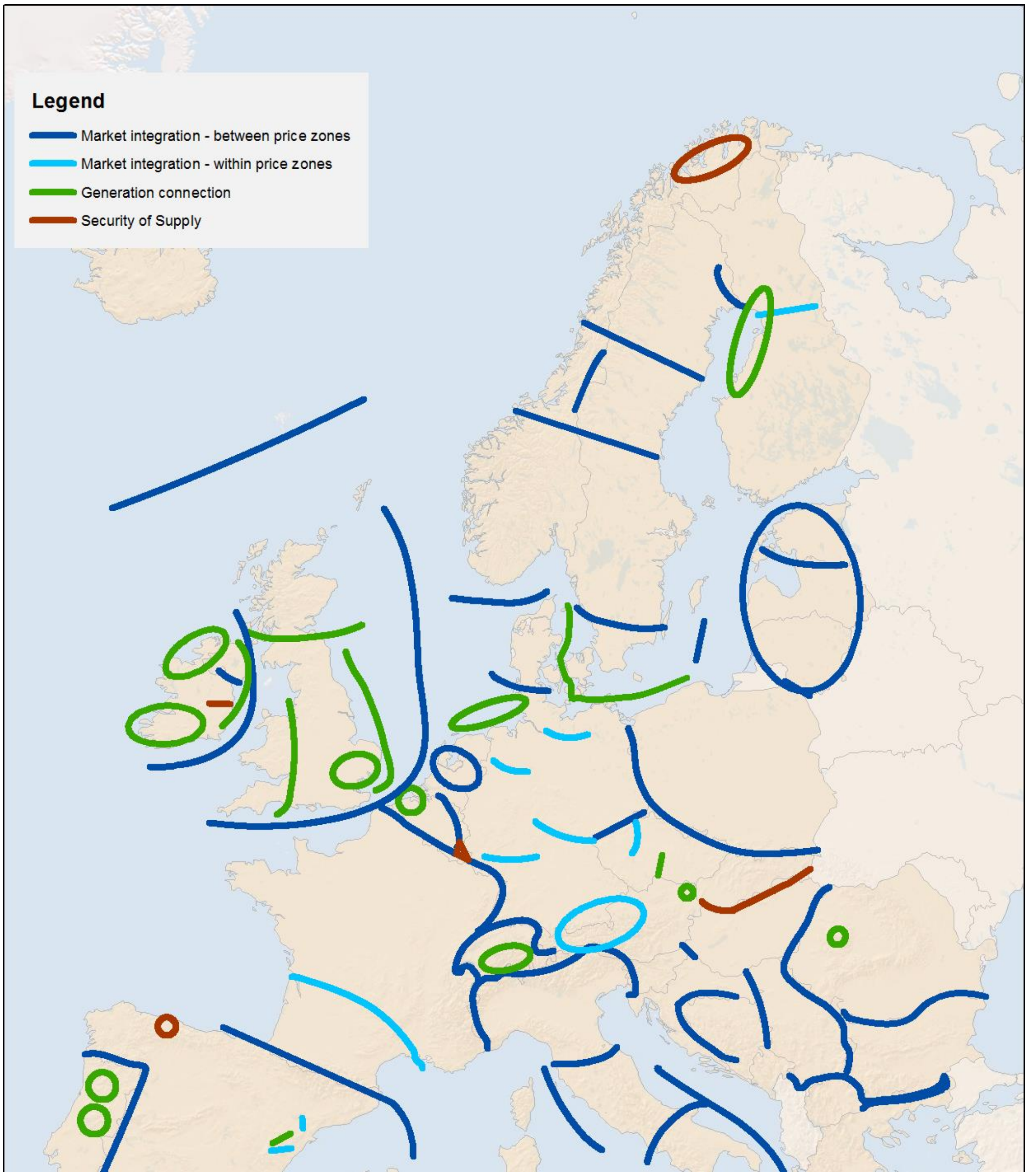


Figure 4.2 Map with the main bottlenecks in the North Sea region in 2030

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In order to assist with the understanding, the probable bottlenecks are presented in the map according to the main areas of concern:

- ***Security of Supply:*** The level of interconnection capacity between the countries within the synchronous areas is high in relation to the peak load of the individual countries. This ensures a high level of system stability and resilience. This means that the security of supply in the region is at a high level. However, there are still a small number of cases where *Security of Supply* is the main justification for an investment in the North Seas regional investment plan.
- ***Direct Connection of Generation:*** The transition towards higher levels of renewable generation is a key driver of the identified bottlenecks in the North Sea region. In the North of the region hydro energy and hydro storage is the dominant driver, while in Great Britain and Ireland the increase of wind generation is dominant. On the continent, the increase of wind, especially in the North Sea itself and Germany plays a major role in the new transport patterns.
- ***Market Integration- between Price Zones:*** Price differences can be observed **between the four synchronous areas**, giving an indication that market bottlenecks exists. Price differences and network congestions can also reveal bottlenecks **inside the synchronously coupled parts of the grid**. These price differences vary from hour to hour as the type of electricity generation can change very fast, especially renewable generation. The average price spread across borders can give an indication on the level of congestion. Within the synchronous areas, specific new load and generation patterns might cause overloads in the AC grids. Additionally, the physical flows within the meshed synchronous areas do not necessarily follow commercial flows and thus part of the AC interconnection capacity may be absorbed by **loop flows** and **transit flows**. This effect can lead to additional bottlenecks within a country or between countries. Further analyses may lead to proposals for interconnection projects, if cost effective.
- ***Market Integration – within Price Zones:*** Bottlenecks **within a price area** can restrict the ability to use the most economic generation sources, causing inefficiencies in the integrated market.

4.4 Bulk Power Flows in 2030

The Region's market and grid studies have identified potential Bulk Power Flows for 2030 across the major boundaries in the North Sea Region that could trigger grid developments. These are the typical power flows that are expected to be reached at least 80% of the time.

Figure 4.3 shows annual cross border flows in Vision 1 and Vision 4 for some selected borders. The region's bulk power flows are mainly asymmetrical, i.e. interconnectors across boundaries are loaded more in one direction than the other. The flow on the DC connections between Norway and the other areas are predominantly towards the Continent and GB showing higher export of hydro power from Norway compared to imports of thermal power.

Another phenomenon that is observed in Vision 1 is a dominant direction of flow towards Great Britain from Norway and the Continent, and dominant flows to Ireland and Northern Ireland from GB and the Continent. In Vision 4 this trend is opposite on most borders, because of the large increase of installed wind capacity in Great Britain and Ireland.

The 2030 Bulk Power Flows calculated for each of the four Visions range from approximately 500 MW to more than 10,000 MW, and are presented in the following sections.

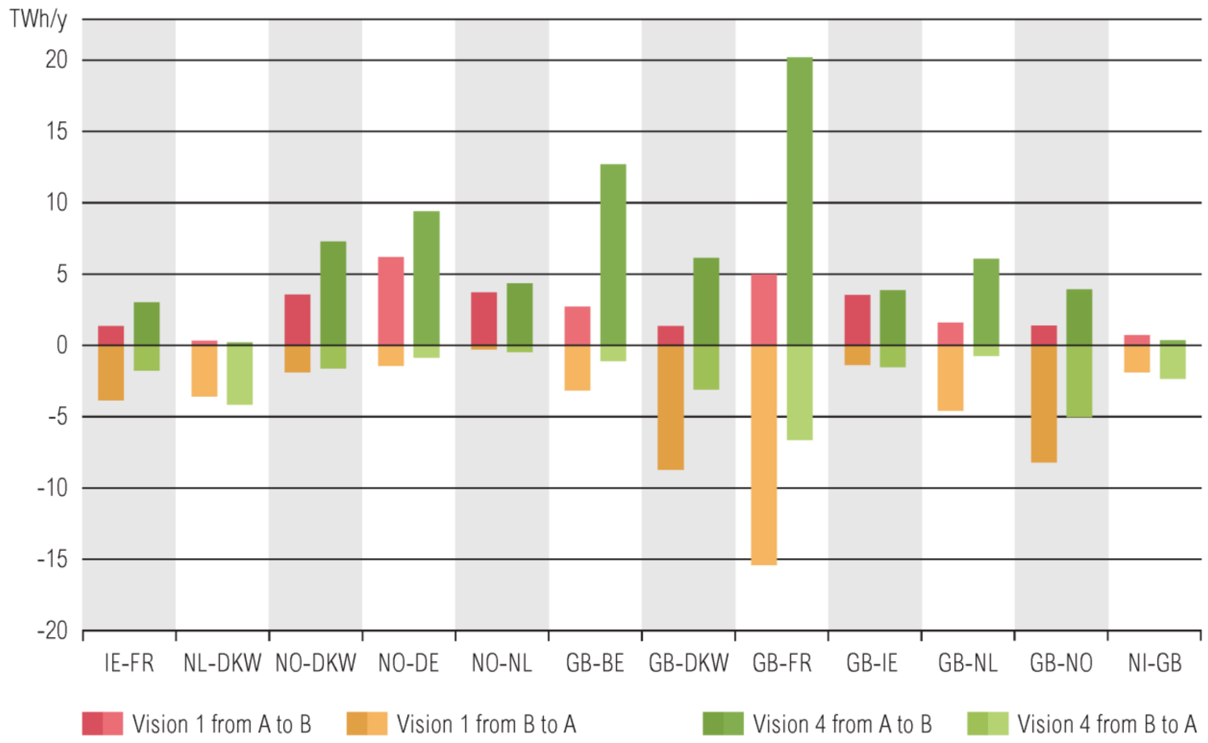

Figure 4.3 Annual Cross border energy flows for Vision 1 and Vision 4 on some selected borders

4.4.1 Generation Connections

Figure 4.4 below shows the expected bottlenecks or boundaries arising as a result of the connection of new generating facilities; the colours relate to the expected power flows across the boundaries, as indicated in the legend.

Bulk power flows could be greater in Vision 4 than in Vision 1 because of the different allocation of generation power plants assumed.

The main changes for power generation between Visions for our studies are detailed in chapter 3.4.

In summary, the greatest differences in generation between Vision 1 and Vision 4 are in Germany, France and Great Britain as a result of:

- The decrease of solid fuel energy production especially in Germany for Visions 3 and 4.
- The phase out of nuclear generation in Germany and Belgium and the reduction of nuclear in France.
- The increased number of wind power plants in the whole region.

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

New generating facilities (mainly wind power plants) are planned to be built in the coastal areas of the North Sea Region, especially in the north of Germany (North Sea and Baltic Sea). They are one of the main drivers for the necessity of grid expansion.

In the coastal areas of France up to 2 GW of new offshore wind power plants and 3 GW of tidal power plant are expected. Also in France several old power plants which are located close to load centres will be decommissioned and replaced by new power plants in the north east of France, located far from load centres.

In the Belgian part of the North Sea, additional offshore wind parks are also expected to reach more than 2 GW in 2020.

Northern Ireland, Ireland and Great Britain as well face the connection of a high volume of offshore wind parks. In Ireland and Northern Ireland, the onshore wind power is mainly connected in locations that are remote from the main load centres in the east giving rise to the need to reinforce the grid to accommodate high west to east flows. In Great Britain, onshore wind power is connected mainly in Scotland, causing the need for strengthening of the north-south axis between England and Scotland. Additionally in Great Britain a number of nuclear power stations are planned to be connected.

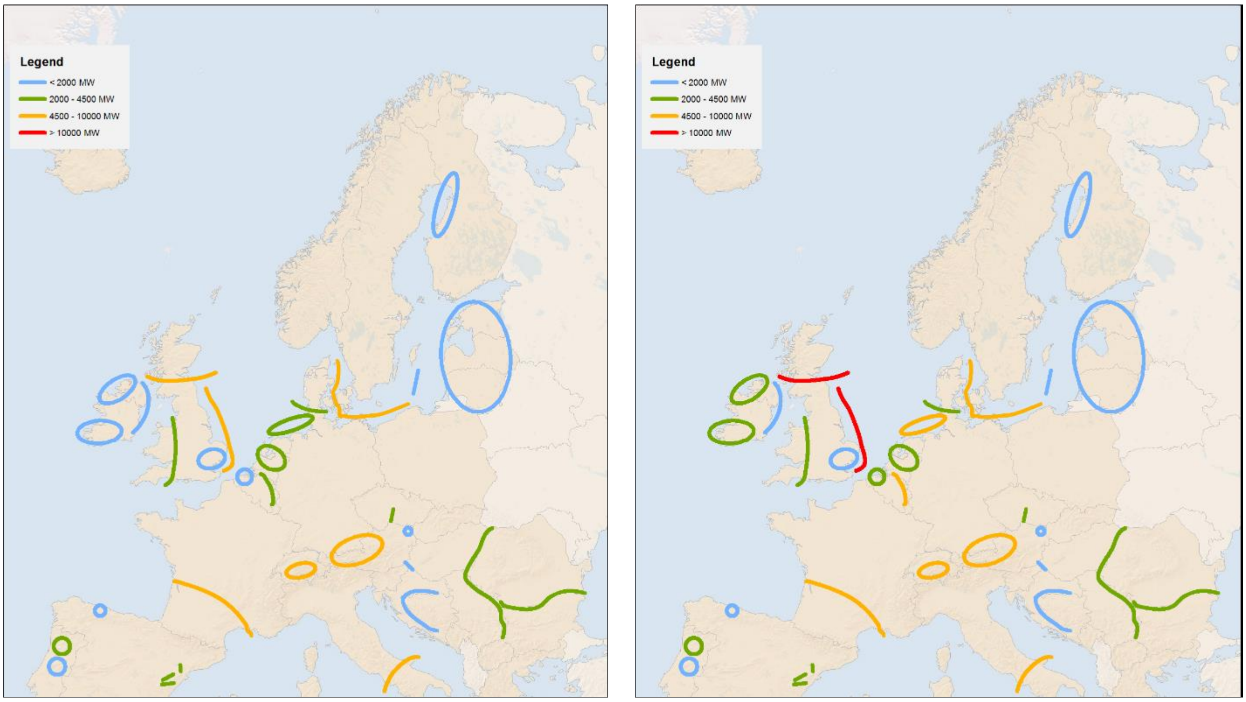

Figure 4.4 Maps of bulk power flows across boundaries related to generation connections - Vision 1 (left) and Vision 4 (right)

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, and is therefore a driver of grid development. Figure 4.5 shows the boundaries related to market integration and the bulk power flows (BFPs) that trigger grid development in 2030, under Visions 1 and 4.

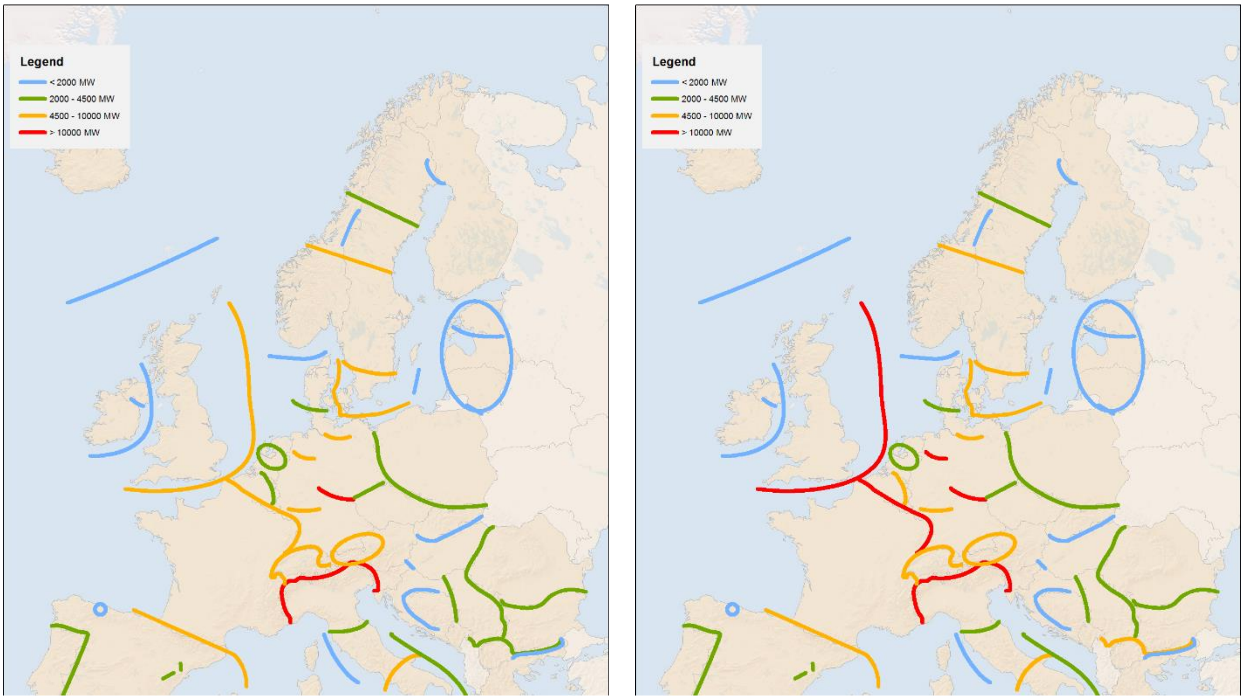

Figure 4.5 Maps of bulk power flows across boundaries related to market integration - Vision 1 (left) and Vision 4 (right)

More capacity is needed between the island of Ireland, Great Britain and the continental and Nordic energy markets. While strong connections already exist between the Nordic countries, further market integration is required in order to fully utilise the benefits of the countries' diverse generation portfolios, triggering increased energy flows. Bottlenecks currently still exist between the hydropower dominated areas of Norway and Northern Sweden and the thermal / wind power based production of the northern part of the continent. Because hydro-power plants in Nordic are flexible and can act as energy storage, more transmission between the Nordic countries and Continental Europe is crucial to serve the expected change in transmission patterns resulting from the expected increase of RES in the Continent. Internal north-south flows within Germany are a consequence of market integration of wind farms and nuclear phase out.

Some new small scale hydro is planned to be constructed 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 Norway.

In the long-term the connections of Great Britain and Ireland to Central and Northern Europe via new connections are also drivers for investments in GB and Ireland.

4.4.3 Security of Supply

Today, electricity is at the core of each European society, serving as an engine for any social and economic activity of its everyday life. Preventing a disruption of the electricity supply is naturally a crucial matter. Therefore and in accordance to Directive 2009/72/EC the security of supply in the North Sea Region is of vital importance. There are two aspects of Security of Supply:

- Inadequate production capacity;
- Inadequate transmission capacity.

In most cases Security of Supply concerns, due to transmission capacity limitation, are limited to relatively small areas and are therefore often efficiently mitigated by investments with local/national importance. However, there is a small number of significant security of supply issues present today or emerging over the next ten years in the North Sea Region.

Figure 4.6 below shows the expected bottlenecks or boundaries related to the security of supply concerns; the colours relate to the expected power flows across the boundaries, as indicated in the legend.

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

The transition of the German power system leads to increased requirements for the transmission grid to facilitate higher north-south power flows. In order to ensure security of supply and to improve system stability not only new DC and AC grid expansion measures are needed, but also additional reinforcements such as reactive power compensation.

In addition to the requirement to address system stability issues, there is a need to increase cross-border capacities between European countries in order to avoid a supply shortfall. In particular, the reinforcement of existing interconnections and the addition of new interconnections between France and Germany and reinforcements inside France itself will provide additional market capacity and also improve the security of supply in both countries.

The strengthening of the interconnection between Northern Ireland and Ireland will help to alleviate an emerging security of supply issue in Northern Ireland, and improve the efficiency and functioning of the all island market.

Additionally, some grid reinforcements are needed in the London area to deal with security of supply.

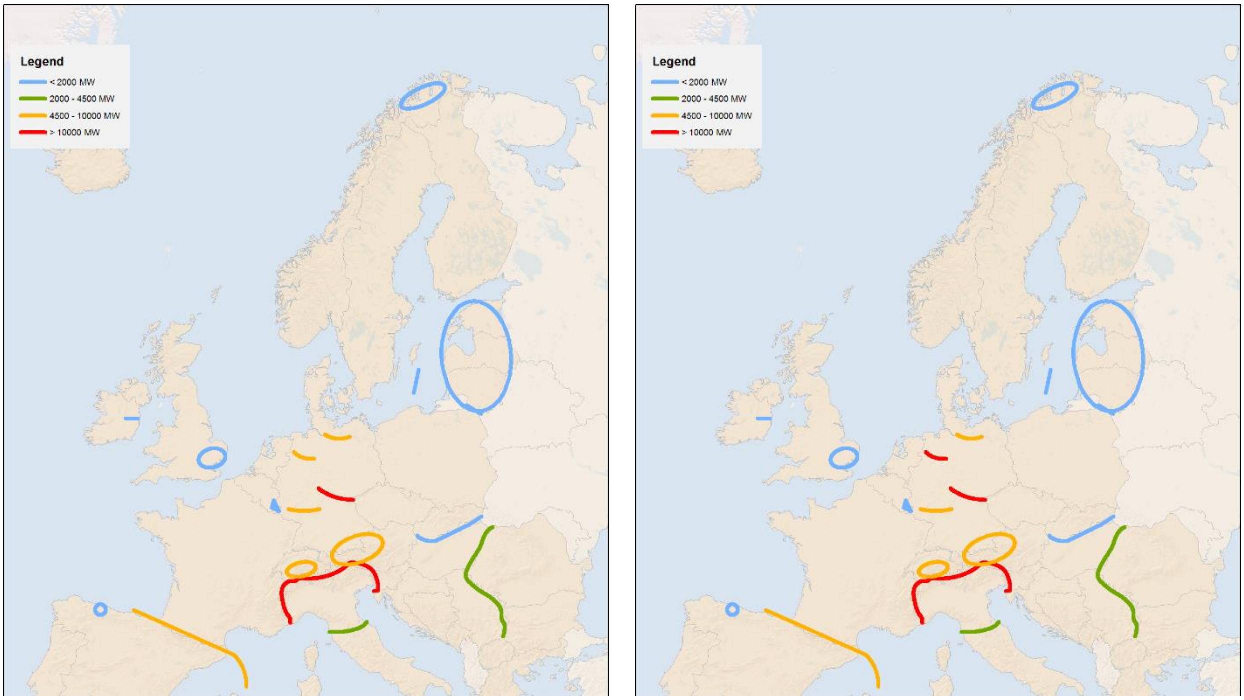

Figure 4.6 Maps of bulk power flows across boundaries related to security of supply - Vision 1 (left) and Vision 4 (right)

5 Assessment of the regional Investment Plan 2012

This chapter presents an overview of the evolution of the investments identified in the TYNDP 2012, including statistics, as well as an updated table of projects focused on the status, date of commissioning and additional monitoring information (see 13.1 Table and map of Pan-European Projects).

5.1 Developments since 2012 (portfolio)

The Investment plan of Regional Group North Sea includes a schedule of projects representing grid reinforcements which are either European or Regional significance. Each TYNDP project consists of one or multiple investments, dealing with one or more particular European targets identified in the four Visions. The RGNS Regional Investment Plan 2012 presented 248 investments. The portfolio in this RGNS Regional Investment Plan represents 348 investment items. A total of 106 new investments were identified during the TYNDP 2014 process as required to cope with future possible developments in the electricity sector as it evolves towards 2030. These are in addition to the projects and investments listed in the TYNDP 2012 document, which only considered needs up to 2022.

The following figures present the evolution of the investments since the publication of the TYNDP 2012; Figure 5.1 presents the situation for all 348 investments in TYNDP 2014, Figure 5.2 deals specifically with the 248 investments included in TYNDP 2012 only.

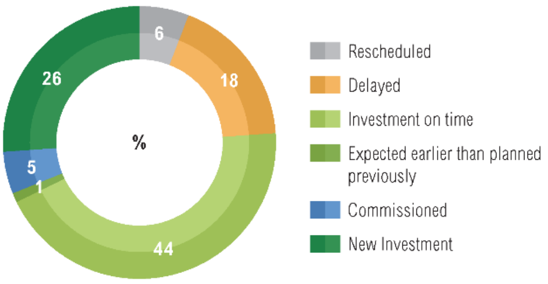

Figure 5.1 Status of the RGNS region investments portfolio 2014 (including pan-EU and regional significance investments)

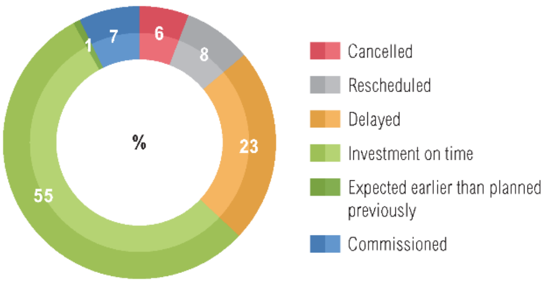

Figure 5.2 Evolution of the TYNDP2012 portfolio for the North Sea Region from 2012 to 2014 (including pan-EU and regional significance investments)

The majority investments that were presented in the RGNS Regional Investment Plan 2012 are expected to be commissioned on time (55%) or ahead of time (1 %). Since 2012, 7% of investments have been completed. In total, about a quarter of the investment items face a potential delay in commissioning. The effectiveness of the proposed investments is constantly being reviewed in response to changes investment drivers. This is especially the case for the longer-term projects, because of the significant uncertainties with respect to volume and timing of future generation which may drive individual projects. In that regard, the schedule for 8% of the investments has been updated to reflect the revised case of need in response to new developments in the project drivers.

The majority of the projects in the North Sea Region consist of subsea cable projects between countries that have a commissioning date in or beyond 2020. This explains why the number of commissioned projects in the period 2012 - 2014is relatively low.

5.2 Delayed investments

From the overview of the major changes of the investments in respect to TYNDP 2012 it can be concluded that the largest category of change is with respect to delays in the commissioning date. For investments which are delayed, the average delay is approximately two years. The completion of a new grid infrastructure is a complex task, which involves many stakeholders who often have conflicting interests.

The main cause for delay in the RGNS investments is the **permitting procedures that take longer than anticipated**, often due to opposition to the new infrastructure. The second largest cause for delay is a postponement of **the developments that drive the need for projects**; in most cases the change in schedule is directly attributable to delays in the development of new generation that is to be connected to the grid (both renewable and conventional generation may have difficulties in obtaining appropriate permits).

TSOs have an obligation to optimise their investments to achieve efficiencies. Therefore, the TSOs need to monitor the development of external factors which are driving their projects, and where appropriate, delay or cancel the commissioning of directly impacted projects, provided there are no negative consequences with respect to meeting the TSOs' obligations.

The TSOs welcome the Regulation EC 347/2013 which has been established to help facilitate permitting of projects which are of significant European interest.

5.3 Rescheduled investments

A new category "rescheduled" has been introduced 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 evolution of investments in relation to their maturity. Indeed, the status "rescheduled" corresponds to long term, or conceptual investments, at the early stage of the planning process, for which further studies have provided more accurate commissioning dates, 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) are also reported into this category.

The majority of the rescheduled investments have been triggered by changes in both timing and volumes of renewable generation connection. Delays in generation connections may result in the rescheduling of the long term grid reinforcements that are triggered by these developments. However when the generation connection plans become concrete at a later stage, TSOs need to gear up to realise the appropriate grid reinforcements, as the completion time of generation plants is generally less than the completion time of new grid projects. A project that has already started to be developed but is then rescheduled can be delivered more quickly than a project which has not been initiated.

5.4 Commissioned Investments

In the RGNS a total of 18 projects have been commissioned since the TYNDP 2012. The total length of route of these projects is well above 1300 km. These include two projects that connect wind directly from an offshore location to the shore (BorWin1 and Riffgat in Germany). In the next few years, more offshore connections of wind farms are expected in the North Sea region.

One HVDC subsea interconnector between Ireland and Great Britain has been completed.

6 Investments - Project Portfolio

6.1 Criteria for Projects Inclusion

6.1.1 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

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.

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.

6.1.2 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, entered into force on 15 May 2013, 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[20]", 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 with TSO promoted projects 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).

6.1.3 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 generally included in the TYNDP, but some of these investments support TYNDP projects when regional grid reinforcements are needed for the commissioning of a pan-European project. They are therefore included in this regional investment plan.

6.2 Projects portfolio

The next two maps 6.1.and 6.2 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 indicates where the investment is likely to occur.

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

Figure 6.1 Map of for mid Term Projects

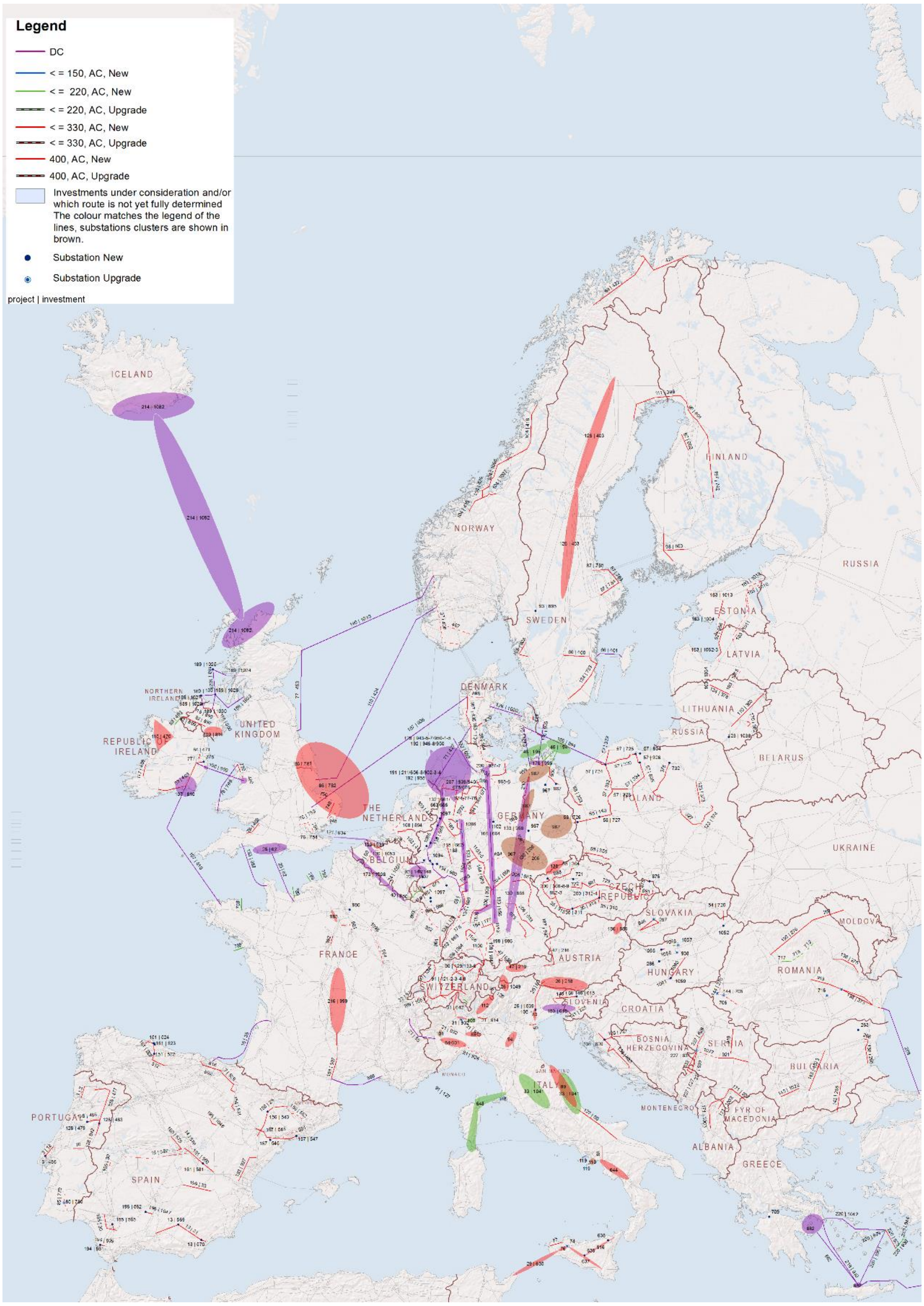


Figure 6.2 Map of long term projects

6.2.1 Projects of common interest

44 project of common interest are identified in the North Sea area

These projects improve two priority corridors defined by the EU:

- “Electricity northern seas offshore grid”
- “Electricity WEST”

There is a number of PCI projects under consideration which provide interconnection between two countries via HVDC links utilising subsea cables, this includes:

- Ireland and Great Britain (6 projects applied for this cluster including a project of electricity storage);
- Ireland and France;
- Great Britain and France (4 projects);
- Belgium and Great Britain (an interconnection project and the construction of two off-shore hubs);
- Norway and, Great Britain;
- Norway and Germany;
- The Netherlands and Denmark;
- Great Britain and Iceland;
- Great Britain and Denmark.

There is also a number of PCI projects which are designed to provide increased transmission capacity via onshore developments, including:

- The North and the South of Germany
- Belgium and Germany
- Luxembourg Belgium and Luxembourg Germany
- Ireland and North Ireland.
- The Netherlands and Germany.

The primary objective of these PCI projects is support increased market integration and/or integration of increased volumes of renewable energy.

6.2.2 Projects of Pan-European Significance

A significant proportion of the North Sea portfolio is composed of subsea cable projects. These projects are designed to further facilitate market integration. There are 65 projects defined as pan-European significance (without PCI projects which are also pan European Significant). A number of projects seek to provide additional interconnection capacity between UK, Iceland, Ireland and the continental part and Northway.

The offshore PCI projects, which are presently planned or under construction, will utilise almost 14.000 km of cables and will incorporate the latest HVDC technology. HVDC technology is also been incorporated into the onshore network utilising new DC overhead lines to reinforce the German grid in integrating large volumes of renewable power.

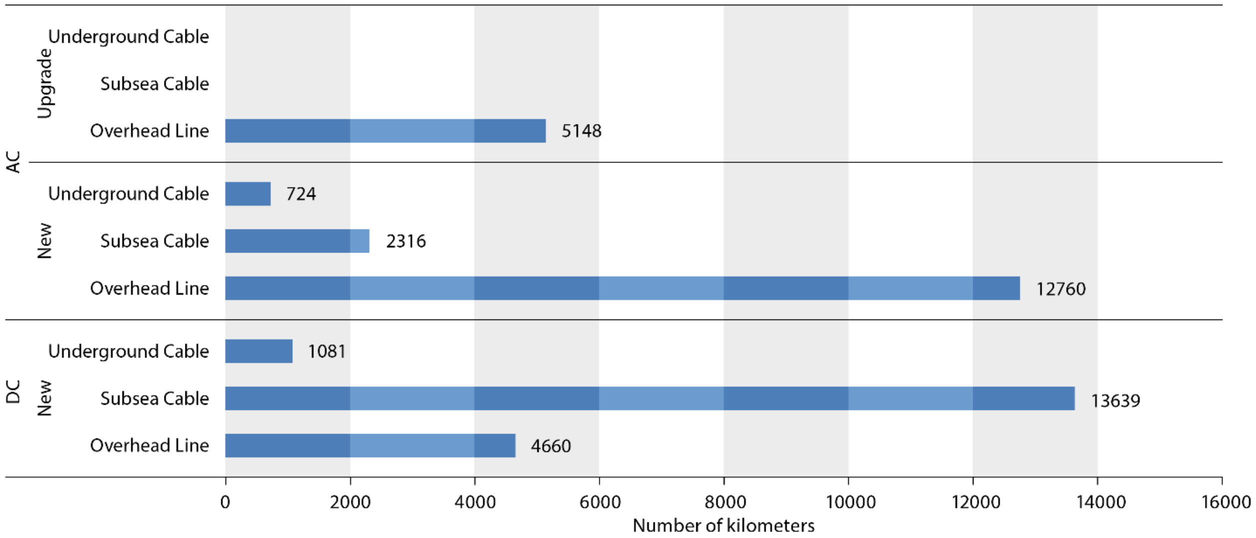
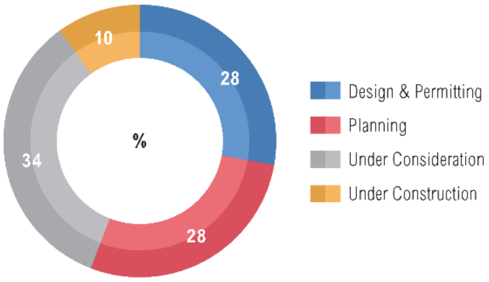


Figure 6.3 Project of pan-EU significance in RGNS region - breakdown per technology

In analysing the status of the investments, it can be noted that the percentage of projects under consideration and project under construction are approximately equal. Most of the RGNS projects which are under consideration represent significant investments.



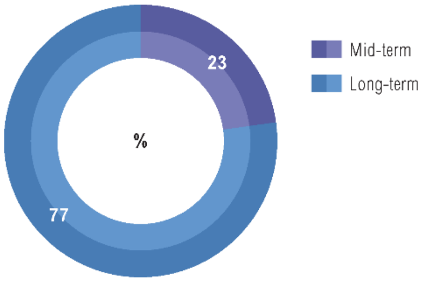


Figure 6.4- Status of the RGNS-investments

Figure 6.5- Commissioning Horizon, RGNS.

The projects can be allocated into six main clusters:

- The OWP (off shore wind projects) TenneT North Sea
- The wind integration North South corridor in Germany and the long term RES integration
- The Anglo Scottish Cluster
- Belgium north border
- The London cluster
- The Wales cluster

The main objective of these of pan-European clusters is accommodating RES integration and to relieve bottleneck.

6.2.3 Investments of Regional Importance

Only 6 projects are in this category. They are projects which are useful for pan European projects.

6.2.4 Investments of National Importance

There are investments of national importance in every country of the Regional Group North Sea. A number of these projects and investments 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. They are included in the National Development Plans.

There are two storage projects in Ireland:

- A hydro-pumped (1.300 MW of capacity) associated with a connection between Ireland and Great Britain. This storage will be connected with the wind generation and storage facility in Glinsk.
- A compressed air energy Storage in Larne with an annual capacity of 550 GWh.

6.3 Assessment of the portfolio

6.3.1 Social and Economic Welfare

Social and 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. 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. Additional transmission capacity can reduces the total cost of electricity supply and in these cases will general increase social and economic welfare.

In general, two approaches can be used for calculating the increased benefit from social and economic welfare:

- The generation cost approach, which compares the generation costs with and without the project for the different bidding areas.
- The total surplus approach, which compares the producer and consumer surpluses for both bidding areas, as well as the congestion rent between them, with and without the project.

If demand is considered inelastic to price, both methods will yield the same result. In the analysis for North Sea Region the generation cost approach has been used.

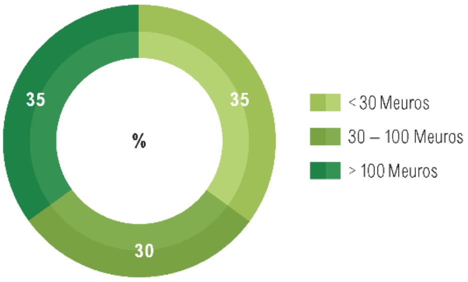


Figure 6.6 RGNS-projects influence on Social and Economic Welfare increase, Vision 1

The North Sea Region calculation for Vision 1 shows that the analysed investments in general have positive SEW-values. However, more than one third of the projects are on the lower indicator-scale with a SEW-value lower than 30 M euros/year. The reason for this is partly related to the fact that in Vision 1 only a relatively small amount of renewables has been introduced. The assumption of a low CO_2-price in Vision 1 should be noted. In Vision 1 about 30 % of the investments have medium SEW-values, while 35 % of the investments show high positive SEW-values (more than 100 M euros/year). The highest values are shown for projects connecting Scandinavia to Continental Europe and Great Britain.

The North Sea Region calculation for Vision 4 shows that the analysed investments in general have very positive SEW-values. In Vision 4 as much as 69 % of the investments are showing high SEW-values (more than 100 M euros/year, The reason for the positive SEW-values is related to the fact that in Vision 4 more renewables are assumed and a high CO_2-price is assumed. As a consequence of this the congestions are getting larger with the result of higher price-differences and therefore higher SEW-values. The highest values are shown for projects connecting Scandinavia to Continental Europe and Great Britain and for projects between Great Britain and other countries.

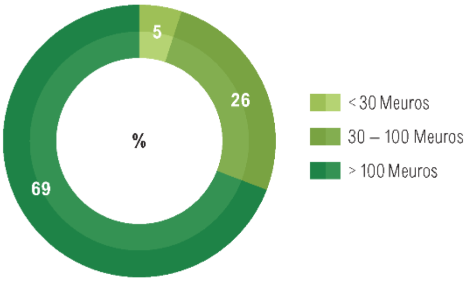


Figure 6.7 RGNS-projects influence on Social and Economic Welfare increase, Vision 4

6.3.2 CO_2 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 CO_2 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 CO_2 impact.

The North Sea Region calculation for Vision 1 shows that the analysed investments in general have a positive effect on the CO_2-indicator, showing decreased CO_2-emissions. However, as much as 49 % of the investments do not have any positive effect at all on the CO_2-emissions. The reason for this is partly related to the fact that in Vision 1 relatively small volumes of renewables have been introduced. The assumption of a low CO_2-price in Vision 1 should be noted. This leads to a high generation of thermal power plants, and which leads to that the CO_2-emissions not directly impacted by new investments. As many of the RGNS-investments are interconnectors, bringing different markets closer together, this leads to a possibility of lower CO_2-emissions. In Vision 1, 21 % of the investments have medium influence on the emissions, while 30 % of the investments show high positive influence (more than 500 ktons/year) on the emission. The highest values are shown for projects connecting Scandinavia to Continental Europe and Great Britain.

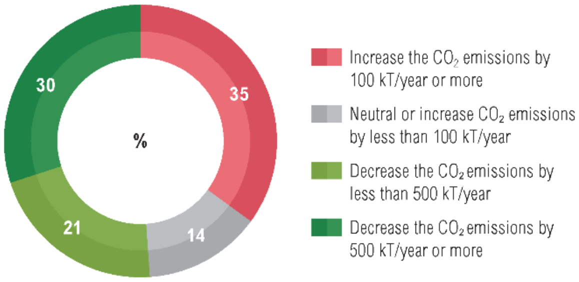


Figure 6.8 RGNS-projects influence on CO2-emissions, Vision 1

The North Sea Region calculation for Vision 4 shows that the analysed investments in general have a very positive effect on the CO_2-indicator, showing decreased CO_2-emissions. In Vision 4 as much as 80% of the investments have a significant influence (more than 500 ktons/year) on the emissions, while 17% of the investments show medium influence on the emission. The reason for this very positive effect is related to the fact that in Vision 4 more renewables are assumed. Additional to this a high CO_2-price is assumed, which brings forward a generation-shift from thermal production towards renewable production. As many of the RGNS-investments are interconnectors, bringing different markets closer together, this leads to possibility to do the generation-shift enabling low-carbon generation to generate more electricity with the result of lower CO_2-emissions. Therefore in Vision 4 the results in general show a very positive effect on CO_2-emissions. The highest values are shown for projects connecting Scandinavia to Continental Europe and Great Britain.

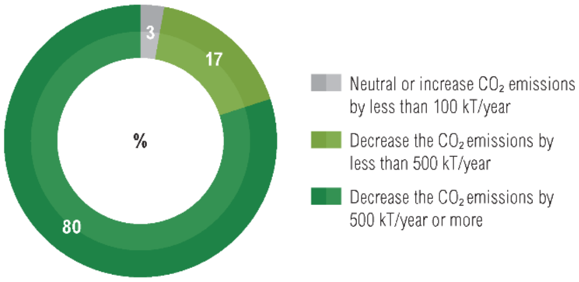


Figure 6.9 RGNS-projects influence on CO_2-emissions, Vision 4.

6.3.3 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 curtailments. The RES-indicator is both calculating the RES-effect for:

- Direct connection of RES generation to a power system and
- 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.

The North Sea Region calculation for Vision 1 shows that the analysed investments in general have a positive effect on the RES-indicator. However, approximately 37 % of the projects are not contributing RES generation directly or they have a neutral effect on RES integration. The reason for this is partly related to the fact that in Vision 1 only a limited volume of renewables have been introduced. As many of the RGNS-investments are interconnectors, bringing different markets closer together, this leads to a possibility of higher RES-integration. Therefore even in Vision 1 around 30% of the investments have a medium influence on RES-integration, while 33 % of the investments show high positive influence (more than 300 GWh/year) on the RES-integration. The highest values are shown for projects connecting Scandinavia to Continental Europe and Great Britain.

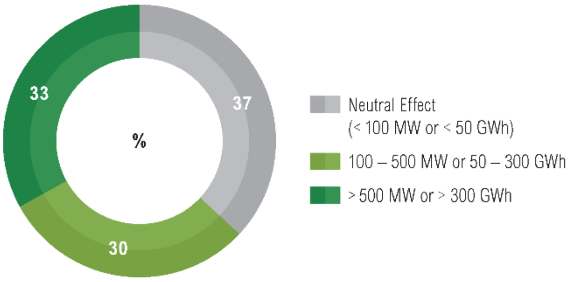


Figure 6.10 RGNS-projects influence on RES-integration, Vision 1

The North Sea Region calculation for Vision 4 shows that the analysed investments in general have a very positive effect on the RES-integration. In Vision 4 as much as 72 % of the investments have a high influence (more than 300 GWh/year) on the RES-integration, while 22 % of the investments show medium influence on the RES-integration. Only 6 % of the projects have a neutral effect on RES-integration. The reason for these very positive values for RES-integration is related to the fact that in Vision 4 more renewables are assumed. In addition, a high CO_2-price is assumed, which brings forward a generation-shift from thermal production towards renewable production. As many of the RGNS-investments are interconnectors bringing different markets closer together, greater production from low-carbon generation is enabled with the result of higher RES-integration. Therefore in Vision 4 the results in general show a very positive effect on RES-integration in North Sea Region. The highest values are shown for projects connecting Scandinavia to Continental Europe and Great Britain.

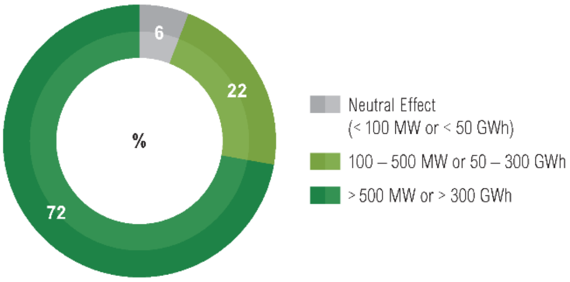


Figure 6.11 RGNS-projects influence on RES-integration, Vision 4

6.3.4 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 has in the TYNDP 2014 in general only been calculated by using ordinary market models. The indicator is more demanding than in the TYNDP 2012, leading to value equal to zero for most of the projects.

In general the security of supply of the North Sea Region countries may become more challenging for the coming decades. This can be related to:

- Commissioning of renewable production (less flexible) and decommissioning of thermal production (more flexible), leads to a potential stressed power system. Such a stressed power system is because of the new generation mix having less flexibility.
- Decommissioning of nuclear production, like in Germany or Belgium, might lead to a stressed power and energy balance for some areas.
- Closure of existing units because they reach the end of their technical lifetime or because they are not economically viable in the current market conditions.
- The climate change could lead to more extreme weather situations:
    - More often stormy weather, with large amount of unregulated production.
    - More often dry years, which in the hydro-dominated (Scandinavia) countries might be challenging.

6.3.5 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 when they decrease the 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 over long distances, which often can be a driver for increased losses.

Variation in losses can be calculated by a combination of market and network simulation tools. This is done both with and without the project, and the variation in losses is then calculated as the difference between both values.

The North Sea Region calculation for Vision 1 shows that about half of the analysed investments have a negative effect on the total losses. The reason for this is as mentioned above that the main driver for transmission projects is often a higher need for transit over long distances, which often can be a driver for increased total losses. However, approximately 32% of the projects have a positive effect, decreasing the total losses.

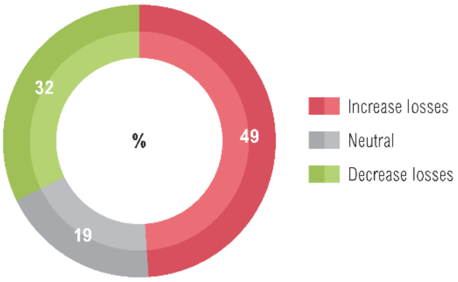


Figure 6.12 RGNS-projects influence on Losses, Vision 1

The North Sea Region calculation for Vision 4 shows that more than half of the analysed investments have a negative effect on the total losses. The reason for this is as mentioned above that the main driver for transmission projects is often a higher need for transit over long distances, which often can be a driver for increased total losses. However, approximately 28 % of the projects have a positive effect, decreasing the total losses.

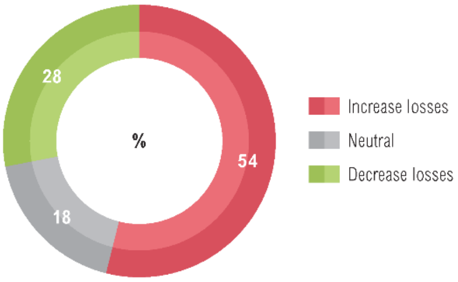


Figure 6.13 RGNS-projects influence on Losses, Vision 4

6.3.6 GTC increases

The Grid Transfer Capability (GTC) among price-areas is calculated by considering stressed network situations. A common grid model is used to assess the future grid transfer capability and behaviour with and without the planned projects, and the resilience in stressed grid situations. The delta GTC value (allowed by the reinforcement) takes into account congestions on the grid (observed in grid studies), both inside and between bidding areas.

The challenge for coming decades is to facilitate large and more power flows across Europe. The new projects are increasing the Grid Transfer Capacity (GTC) among main generation areas and consumption areas. The GTC increase is required on many boundaries within Europe and promotes market integration in Europe. The values of gained GTC are oriented by needs and cover a huge range of transmission capacity increase efforts: projects of Pan-European significance are very diverse, adapting to the very specific geography they are inserted in. The GTC has been developed from a few hundreds of MW to more some GW.

Many of the analysed investments in the North Sea Region are subsea interconnectors. As these projects are standard HVDC-projects, the typical values for these projects are between 700 MW and 1400 MW.

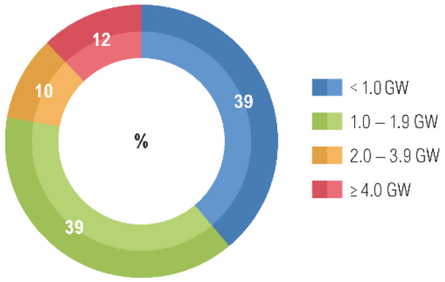


Figure 6.14 RGNS-projects influence on Grid Transfer Capability.

6.3.7 Technical 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. Almost all the RGNS-projects are scoring good related to the indicator Technical resilience.

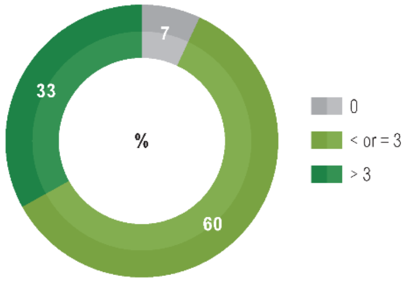


Figure 6.15 RGNS-projects influence on Technical Resilience.

6.3.8 Flexibility

The indicator B7, called "Robustness and flexibility" shows the ability of the system to meet these 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 states. 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. All the RGNS-projects score well with respect to the indicator Flexibility.

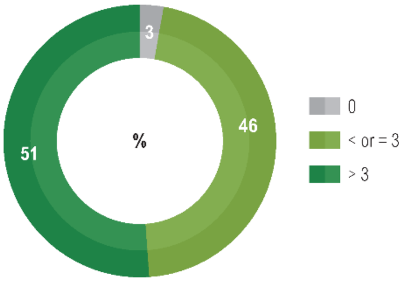


Figure 6.16 RGNS-projects influence on Flexibility.

6.3.9 S1 and S2 indicators, etc.

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[18]).

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.

As a significant proportion of the RGNS-projects are subsea interconnectors, this means that the environmental impact on protected areas is low for RGNS.

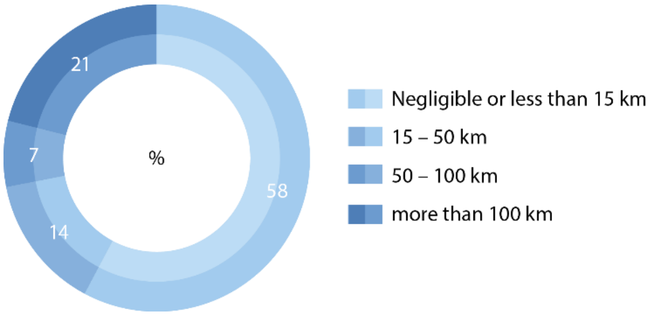


Figure 6.17 RGNS-projects Environmental impact, Protected areas.

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. Considering the RGNS observed projects the highest part (79%) of projects cross urban areas in range of 0-15 km. The second part of projects (10%) crosses urban areas from 15-25 km on route. The projects, which are crossing relatively long distance of urban areas, can also delay the expected commissioning dates due to the potential strong opposition of population.

As most of the RGNS-projects are subsea interconnectors, this means that the environmental impact regarding urban areas are low for RGNS.

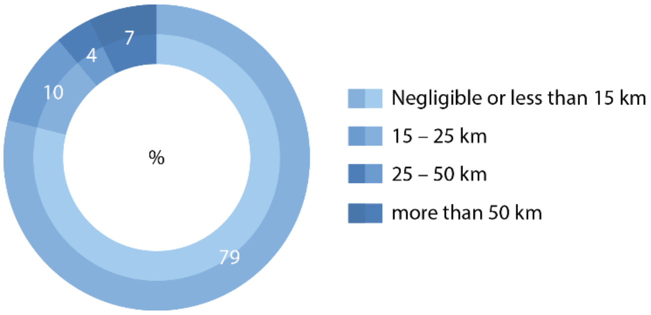


Figure 6.18 RGNS-projects Environmental impact, Urban areas.

6.4 Cost of the portfolio

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 /or 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 makes this a large financial challenge, both for TSO-projects and for third party projects. Programs like the PCI and CEF are therefore very beneficial for the project promoters.

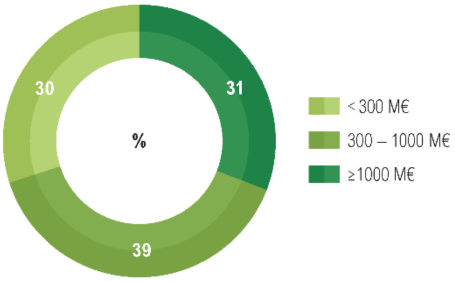


Figure 6.19 RGNS-projects, Cost of the portfolio.

The major part of the RGNS-projects have very high expenditures that exceed 300 million Euros. More than a quarter of the RGNS-projects costs more than 1000 million Euros. The reason for this is the number of subsea interconnectors, with high investment costs. Based on this, the RGNS-projects in general are larger than the average TYNDP-project.

Except by Luxembourg, all the listed RGNS-countries have total expenditures on the TYNDP-projects of more than 1bn Euros. Germany has the highest total project costs, followed by Great Britain, France and Norway. The costs per country are given in the table below.

Country	Total cost (bn Euros)
BE	2.0 - 4.0
DE	34.8 - 54.2
DK	3.7
FR	8.4
GB	15.9-16.2
IE	2.0
LU	0.2
NL	3.3
NO	7.9

Table 6.1 Total project cost by country.

7 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.

7.1 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 from the considered Vision. Thus, big changes in the generation mix may result in very different target capacities across the same boundary.
- The assumptions to be made concerning the costs of an additional project on a boundary are – also due to the time horizon, subject to uncertainty. ..

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.

ENTSO-E checked whether the interconnection capacity of every country meets the criterion set by the European Council[21] for interconnection development, asking from every Member States a minimum import capacity level equivalent to 10% of its installed production. Meeting this criterion led to lift up the target capacity between some of the European Countries, (e.g. between Spain on the one hand and France and UK on the other hand)..

The outcome of such an evaluation must hence be considered carefully. Thus, target capacities are displayed as ranges in the figures below, because accurate values can only be misleading. Globally, the maps displayed in this section should be considered rather as illustrative.

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

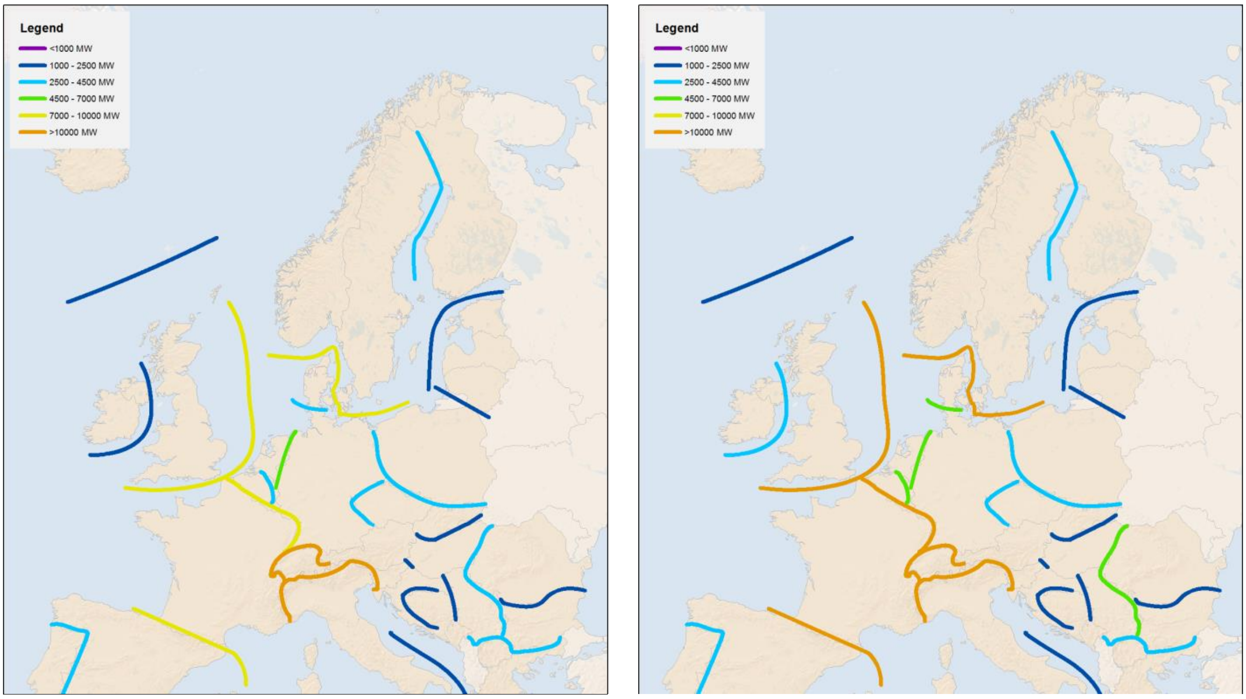


Figure 7.7-1 Target capacities by 2030 in Vision 1 (left) and in Vision 4 (right)

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 the relatively higher RES development and higher CO_2 price particularly for the boundary between Scandinavia and Continental Europe; between Ireland and Great Britain, between Great Britain and the Continent between Denmark West and Germany and the Netherlands and Belgium.

Target capacities fall in the same range of magnitude in both Visions between the Netherlands and Germany, between Germany and Poland.

7.2 Transmission adequacy by 2030

Transmission Adequacy shows how adequate the future transmission system will be referring to the analysed Visions, assuming, the proposed projects are 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.

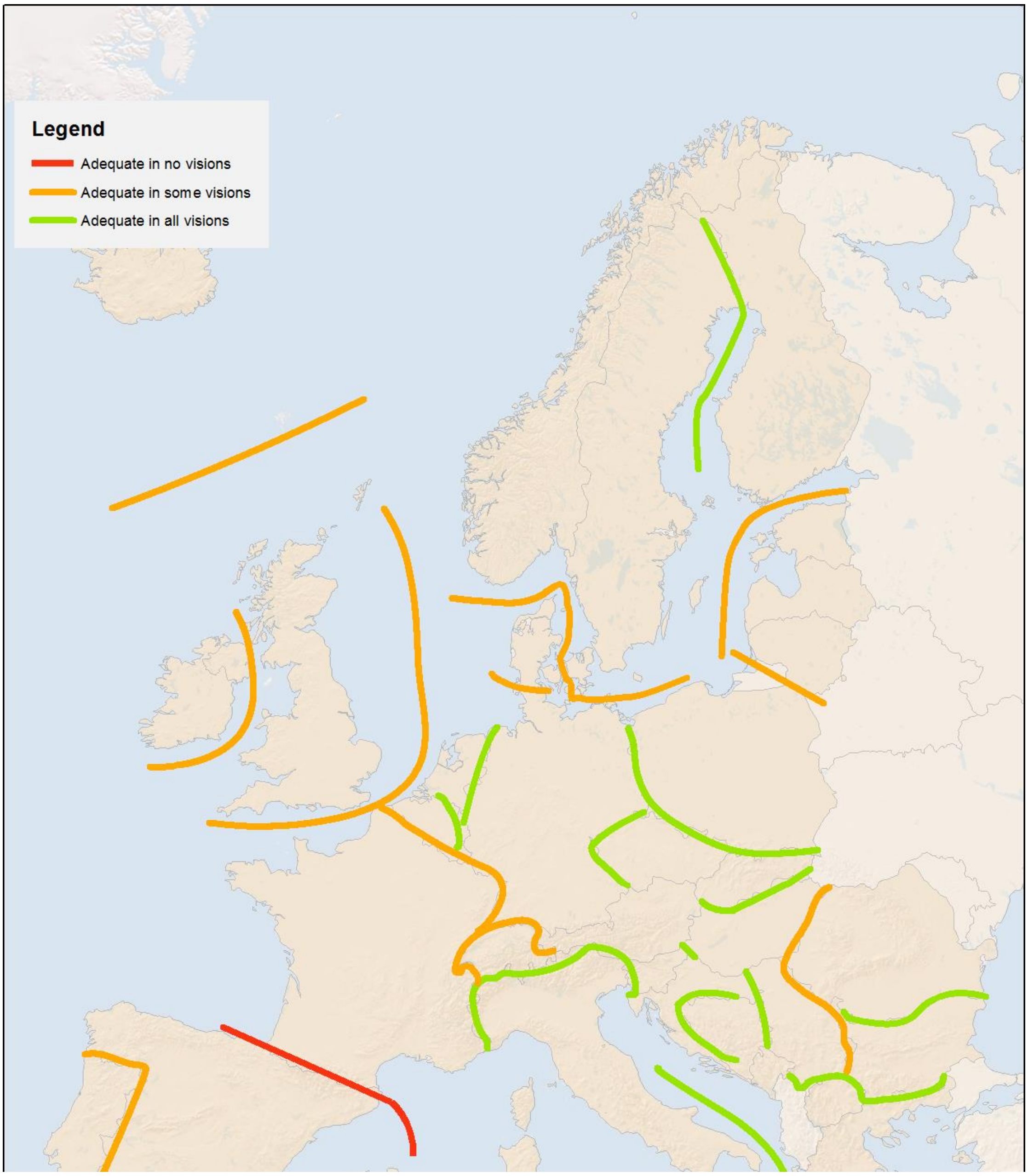


Figure 7.2 Transmission adequacy by 2030

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 had been screened, but were finally not included into the development plan content as they were considered as immature and unrealistic to be constructed together with all the rest of the projects at the same time. They might go into the next edition of the TYNDP investigating their opportunities.

These options are indicated by the map above it should not be forgotten, that increasing cross border capacities might trigger investments in internal grids. 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.

8 Environmental assessment

This chapter supplies an overview of the environmental assessment of the grid development depicted in the Regional Investment Plan.

Transmission System Operators (TSOs) are developing many projects considering the overall environmental welfare whilst giving due consideration to environmental impact. In this chapter environmental key indicators are highlighted.

In the first subchapter, the benefit of the project is stressed, especially according to the integration of renewable energy, thus reducing the CO_2 emissions. The second subchapter considers the impact of the project portfolio on the environment. Two indicators were used to assess the environmental impact of projects. The last subchapter is focused on the mitigation measures to limit the environmental impact.

8.1 Scenarios' main drivers and environmental benefits of projects.

One of the most important drivers for the 2030 Visions is RES development. Wind energy potential in the Northern Seas, Great Britain and Ireland is very significant. Considering the different Visions, **a total wind capacity of 281 GW** could directly be connected in the North Sea region by 2030. 132 GW installed wind capacity is connected to the grid in Vision 1, and an additional 149 GW is considered to be connected in Vision 4.

The environmental impact of integrating high volume of wind energy in Great Britain, Ireland and the North Seas has a significant impact on the reduction of CO_2 emissions. CO_2 reduction is also used to quantify the environmental impact of the project portfolio.

The decrease of CO_2 emissions through the Visions is expected due to the replacement of CO_2 rich fossil fuel generation sources by RES and in Visions 3 and 4 by natural gas.

As illustrated in chapter 3.4.3, in Vision 4 the influence of additional interconnection capacity in reducing CO_2 emission is very high in comparison to Vision 1. In Vision 4, the CO_2-price is very high and there is a large amount of renewables. Those CO_2 savings will be realised if the production from low-carbon power plants replaces production from high-carbon power plants, implying an increase of the CO_2 price from 31 EURO/t in Visions 1&2 to 93 EURO/t in Visions 3&4 and assuming that necessary grid reinforcements are achieved to give low-carbon power plants adequate grid access.

However there are many barriers to their deliverability, with limited on and offshore cable routes, landing points, onshore grid capacity and a constrained supply chain.

Also in connecting additional RES to the grid, consideration needs to be given to potential RES curtailment. Thus, the network should be designed to make use of this additional energy avoiding any spillage where it is economical to provide additional transmission capacity.

Grid reinforcement can minimize the spillage of energy but it's not always economic to completely eliminate it. The spilled energy for Vision 1 amounts 15,5 TWh/year. However, the spillage calculated for Vision 4 could amount a total of 70,5 TWh/year. This significant amount of spilled energy for Vision 4 is mainly due to the possible curtailment of the high possible in feed of wind energy planned around Great Britain and Ireland. Further projects could be developed to further reduce this level of spillage.

It is therefore essential that these resources are best managed by a **coordinated offshore grid development plan** (NSCOGI) to connect the offshore wind parks and to interconnect the neighbouring countries in a market trade and security of supply perspective.

8.2 Global impact of the portfolio

The upgrading of existing lines, referring either to the voltage level increase or to the capacity increment, is considered for about one third of the AC grid projects in this Regional Investment Plan.

If new AC links are inevitable they are mostly foreseen as overhead lines, since for very high voltage (> 225 kV) the solutions based on underground cables are often not possible over long distance, due to technical and economic reasons.

All direct current (DC) projects are new links; a few DC overhead lines are currently foreseen in the region, but most planned DC links are either underground or subsea cables.

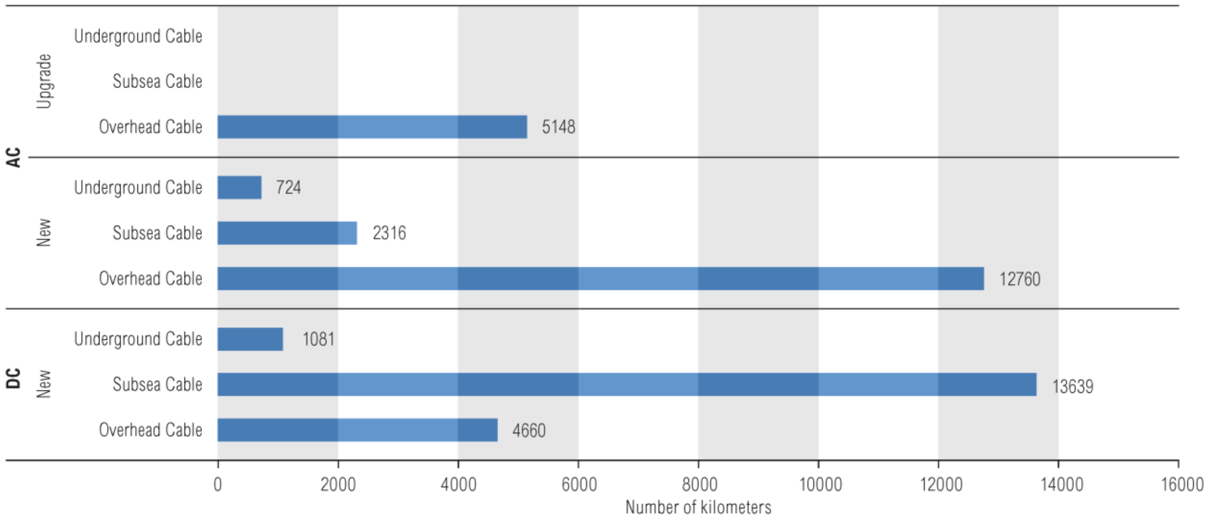


Figure 8.1 Global impact of RGNS project portfolio

<u>Subsea cables:</u>

Wind energy integration needs more interconnection capacity between the four synchronous areas of the North Sea area. Wind energy is a volatile source of energy; there is no correlation between the production of electricity from the wind and the load.

To minimize the spillage of energy and to store the extra electricity which can be produced (in the Nordic countries and the Alps), many subsea cables are under consideration (more than 13.000km). These subsea cable projects are considered to have a low environmental impact.

The HVDC technology use for these projects is generally the optimum solution when seeking to connect the four synchronous grids of the RGNS area. The losses for HVDC systems are typically around 3-5% of the transported flow. But the environmental benefit from the integration of wind energy and the increase of interconnection capacities prevails over the level of losses.

<u>HVDC lines.</u>

The main HVDC on-shore projects are planned in Germany to build three corridors to integrate renewable energy produced in the North Sea.

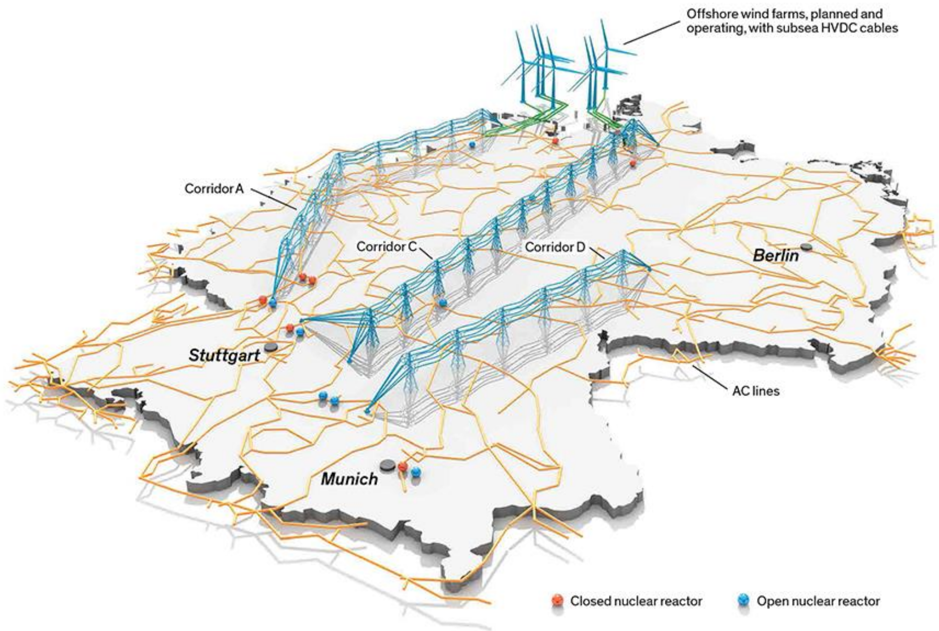


Figure 8.2 HVDC Corridors in Germany

Those projects minimize the social and environmental impact which is a major concern in the grid development process. Thus an update of existing power lines is used. The HVDC technology is chosen because of the length of the corridors. HVDC lines are also useful to control power flows through the grid.

8.3 Mitigation measures taken.

Unfortunately it is not possible to completely avoid intrusions on nature and the landscape when constructing power lines, cables and substations. Nevertheless the environmental impact of the RGNS projects is limited. As illustrated in the following table, only 6 projects have more than 15 km interaction with protected areas (S1 indicator) and more than 15 km interaction with urban areas.

The objective is to optimize the routes in consideration of all protection and conservation issues and minimize negative effects for humans and the environment. New routes try to make use of optimal technical systems, OHL or cable, by avoiding urban and protected environmental areas and/or limiting the impact to a strict minimum.

		S2 indicator		
		< 15 km	15-25 km	NA
S1 indicator	< 15 km	13	2	25
	>100 km	3		
	15-50 km	4	4	8
	50-100 km	2		1
	NA	1		71

Table 8.1 Summary of Environmental Impact of RGNS Projects

A number of projects under consideration are not being assessed at this stage as further analysis is required to determine their routes.

The following considerations are taken into account in the planning phase of a new necessary route:

- The route should be as straight as possible to minimize the effects on nature and the environment.
- Focussing routing on areas of opportunity (for example bundling with other linear infrastructures such as roads, rail road tracks, lines).
- Inclusion of line route into the appearance of the landscape in consideration of the topographical situation.
- Positioning of masts at the most ecologically compatible and economical locations possible while taking up the least possible arable land, e.g. primarily along roads and plot boundaries.
- Consideration of present and planned housing development areas including development land and areas reserved for special construction.
- Consideration of nature sanctuaries, landscape preservation areas, and protected sections of the landscape, natural and cultural monuments.
- Consideration of avifauna.
- Consideration of other protected areas, such as areas where significant quantities of natural resources are present close to the surface.
- Consideration of locations with rare or endangered types of flora in the area of masts.

All these consideration are considered during the environmental impact assessment in the authorisation phase of the different projects.

9 Assessment of resilience

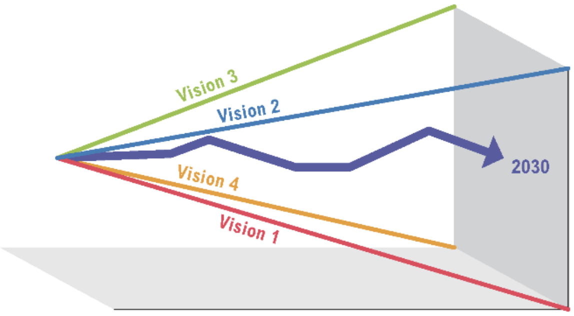
High voltage grid projects are generally costly infrastructure investments, with a long lifetime (more than 40 years) requiring a number of years for planning and delivery (some projects can take in excess of 10 years from concept to delivery). Given the interactive nature of transmission networks, the development and delivery of one project can greatly influence the design and timing of subsequent investments. It is also important that the new infrastructure that is planned should fit in with the existing infrastructure, whilst facilitating future potential development

In order to avoid stranded costs and to meet grid users' expectations in a timely manner with appropriate solutions, TSOs assess the resilience of their investment projects. This assessment is generally performed in 4 major areas:

- **Sustainable, safe operation**: investments should contribute to an improved quality of service and not put the reliability of the system at risk;
- **Economic performance**: investments should prove useful and profitable in as many future situations as possible, bringing greater benefits to the consumer than they cost;
- **Technical sustainability**: investments should take advantage of technological evolution so as to optimise their performance and ensure they do not become obsolete in the course of their expected lifetime;
- **Compatibility with longer run challenges looking ahead**: investments should be appropriate steps to meet the future challenges, while fitting into broader and longer-term perspectives.

TSOs have developed methodologies and criteria for carrying out risk assessments in relation to system performance and in developing mitigation strategies. They assess the resilience of the system in meeting whatever situation which may realistically have to faced, such as: high/low demand growth, different generation dispatch and exchange patterns, adverse climatic conditions, severe contingencies etc.

9.1 Use of scenarios and planning cases to test the robustness



The planning process begins with the definition of scenarios, depicting uncertainties in future developments in generation and demand, as well as a number of alternative grid operational conditions and development states that have to be addressed to ensure the secure and efficient operation of the transmission grid in the future. These scenarios are regularly updated in the course of the planning process and adapted in case of sudden change (e.g. Nuclear Phase Out in Germany).

The Transmission grid is designed to meet future requirements, as well as existing conditions. To meet these aims, several future scenarios or sensitivity cases are required to underpin the analysis undertaken in the production of Ten Year Network Development Plan. To this end, ENTSO-E has developed four Visions, the aim of these Visions being to test the resilience of potential future investments against different future developments. In the different Visions the future development of the power system are assessed utilising different factors such as the economy, CO_2-prices, consumption, production-mix, market integration etc. which are adapted to test the robustness of the different investment projects.

For the market studies the four Visions previously described have been the basis for testing the robustness of the investments analysed in Regional Group North Sea.

For the network studies, in addition to the four Visions, 12 different planning cases have been created. In order to assess the behaviour of the planned grid against a large number of plausible and credible conditions, a number of cases have been built taking into account forecast future demand, mix of generating units and cross-border power exchange patterns.

9.2 Resilience and robustness indicators in the CBA.

Making proVision for resilience while planning transmission systems, contributes to system security during contingencies and ensuring that robust projects are developed. 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 (KPIs) 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. Most of the projects are showing very good technical resilience, see figure 9.2.

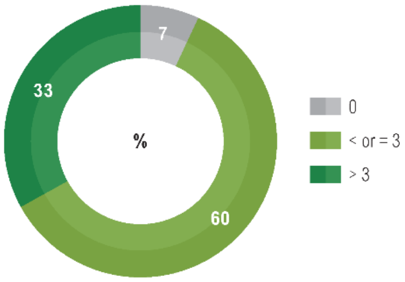


Figure 9.2 RGNS-projects influence on Technical Resilience

Another benefit indicator calculated through the CBA-methodology is the indicator B7, called "Robustness and flexibility". This indicator shows the ability of the proposed reinforcement to be adequate in different possible future development paths or scenarios, including trade of balancing services. This indicator measures the different projects ability to comply with (1) important sensitivities, (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). The scale is divided from 0 to 6 whereas 0 is the worst value and 6 is the best value. Most of the projects are showing very good robustness and flexibility, see figure 9.3.

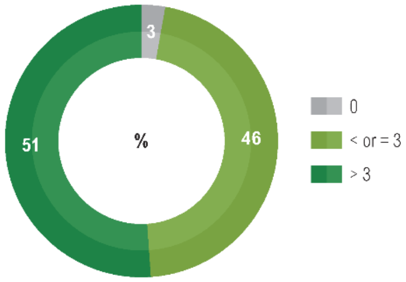


Figure 9.3 RGNS-projects influence on Robustness/flexibility

9.3 Cooperation with Regional initiatives

The Regional Group North Sea is cooperating with Regional initiatives, which have their own scenarios for future development. The following sections and the Appendix give a brief overview of the work being done there.

9.3.1 North Seas Countries' Offshore Grid Initiative (NSCOGI)

In December 2010 the energy related Ministries of the ten countries around the Northern Seas signed a Memorandum of Understanding, forming the North Seas Countries' Offshore Grid Initiative (NSCOGI). The countries involved are the Regional Group North Sea countries plus Sweden – thus, a close cooperation between the ENTSO-E Regional Group North Sea and the NSCOGI is quite natural.

Within this framework, the region's key stakeholders (Ministries, TSOs and National Regulators, together with the European Commission) are seeking to achieve a common regional basis for offshore infrastructure development. The initiative is based on the insight that without cooperation, both internationally and between the very different actors, the offshore grid issues cannot be resolved.

The NSCOGI is divided into three work streams: one focusing on grid development, the second on market and regulatory arrangements and the third on permit and authorization issues. RGNS cooperation mostly focuses on grid development issues, but is also involved in the other streams and the Programme Board as well.

During the first two years, the RGNS especially served the grid development work stream, where a comprehensive Offshore-Grid study was executed, analysing two contrasting designs, radial versus meshed (Figure 9.4).

In this study, investment costs, savings in electricity production costs, effects on CO_2 emissions and countrywide changes for electricity imports and exports have been evaluated and compared. The whole study can be downloaded from the internet (http://www.benelux.int/NSCOGI/), but the main results are presented in the Appendix 11.4 together with a comparison between the NSCOGI scenarios and the ENTSO-E Visions.

9.3.2 Penta ++ Forum

The Penta plus forum consists of the following countries: The Netherlands, Germany, Belgium, Luxemburg, France, Switzerland and Austria. In this Forum Regulators, policy makers and TSOs are working together on topics of special interest. In the past this forum has been very successful in creating progress in the field of market coupling between the countries involved. Recently system adequacy and market design have been the topics that the forum and the participants want to pay attention to. Regarding system adequacy, experts from the regional group North Sea have been heavily involved in developing a new methodology for the monitoring of system adequacy for the Penta countries. The RGNS will make sure that the improved monitoring strategy will be introduced within ENTSO-E as well.

10 North Seas Offshore Grid Infrastructure

10.1 Introduction

The TYNDP and Regional investment plans 2014 show an important step forward in the identification and assessments of required projects facilitating future on- and offshore grid developments.

This chapter gives consideration to incorporating comments received during the consultation process in summer 2014, especially asking for highlighting the offshore grid infrastructure development into the final version of the TYNDP 2014. Further in-depth improvements, based on the received stakeholder comments on the TYNDP 2014 package, will be taken into account when preparing the next TYNDP 2016.

The strategic importance of coordinated North Seas grid development have been demonstrated in the Second Strategic Energy Review, the NSCOGI objectives and the initiation of a North Sea priority corridor in context of the TEN-E Regulation.. In ENTSO-E's system development activities, the need to coordinate future energy demand and changing energy mixes in the North Sea countries, large volumes of potential offshore generation (wind, wave, tidal) and the regulatory/technical challenge of interconnecting four synchronous areas by means of a sub-sea network, resulted in the creation of a dedicated Regional Group North Sea within ENTSO-E to ensure adequate focus in identifying optimum solutions.

This chapter gathers the information initially spread across the consulting version of this report in order to facilitate a better overview on the projects – and the combination of these projects - building up to become the offshore grid infrastructure which is an important brick towards fulfilling the European Energy targets.

10.2 Reference to NSCOGI Grid study 2012

The Regional Group North Seas (RGNS) provided significant input to the NSCOGI work, where a comprehensive Offshore-Grid study was executed from 2011 to 2012. Two contrasting designs had been analysed: radial versus meshed.

The interconnection level between the countries was kept constant, so the effect of using hybrid projects, i.e. combining connection of offshore wind farms and interconnections) was investigated.

Radial – implying continuation with primarily uni- and bilateral solutions	**Offshore Grid** – implying close international cooperation between North Seas' countries.

Figure 10-1 General Design Concepts

In this study, investment costs, savings in electricity production costs, effects on CO_2 emissions and countrywide changes for electricity imports and exports have been evaluated and compared. The designs result from an optimization process aiming at least regional electricity production cost and minimum infrastructure investment and maintenance costs.

Both, the radial and meshed approach result in a similar levels of interconnection, with similar associated production cost savings, although there are significant differences in how they were achieved, e.g. the routing of some major flows across the region shifted between both designs, resulting in different levels of investment for the countries. The results summed up to roughly 9,000 km of new lines to be built at the cost in the order of 30bn€ on top of the 77bn€ already spent in the period 2012 - 2020 to reach the TYNDP 2020 “start grid” identified in the TYNDP2012 edition.

Also market benefits, import/ export positions and CO2 emissions were similar for the reference scenario. The similarity in results can be explained by the relatively small volume of offshore renewable energy assumed to be installed between by 2030 in this scenario (55 GW), based on the 10 governments’ best available input data in summer 2011.

A sensitivity analysis (“RES$^+$ scenario”), roughly doubling the offshore wind volume up to 117 GW demonstrated increased benefits for a meshed design (i.e. increasing the use of hybrid projects and point-to-point interconnections). “Benefits” is here used in terms of saved investment costs only, as the socio-economic welfare had not been evaluated in the NSCOGI grid study due to lack of time.

Additionally, the study noted that high volumes of offshore wind capacity are not expected before 2020, and that there remains significant uncertainty on potential volumes for 2030.

NSCOGI concluded that at this stage a new and comprehensive offshore grid study like the one published in winter 2012 would not lead to fundamental new findings, but only lead to a variant of what already has been found during the last study. The precedent “Offshore Transmission Technology Report[22]”, evaluating the technology assumptions for the 2030 grid study concluded that assets will be available in the market when needed. Therefore, since 2013 the primary focus of NSCOGI shifted to the regulatory/ market and to the permit work stream.

The TSOs of the ENTSO-E Regional Group North sea agree on this conclusion, which further is confirmed by the comparison of both studies’ input data, see below.

The whole NSCOGI grid study, the Offshore Transmission Technology Report as well as other NSCOGI documents can be downloaded from the internet (http://www.benelux.int/NSCOGI/). The main results of the grid study are also summarized in the Appendix of this report.

10.2.1 Comparaison between NSCOGI- RES+ vs. ENTSO-E visions

After finalising the NSCOGI Grid study in December 2012, work continued in the ENTSO-E regional group North Seas (RGNS) in the context of this Regional Investment Plan comparing the ENTSO-E Visions to the NSCOGI scenarios (the Reference scenario (“NSCOGI-R”) and sensitivity analysis, (“NSCOGI-RES+”)) in order to evaluate the relation between both studies.

Both studies were based on a time-horizon up to 2030, exploring several levels of offshore wind capacity (from a NSCOGI-Reference: 55 GW governmental figure up to 117 GW in an up-scaled vision for NSCOGI-RES+ scenario)) but of course comprising the whole regional production portfolio including all types of fuels.

Price differences between countries are triggered by different kinds of electricity generation units and fuel types used. Among others, these differences trigger the need for interconnections between countries. Offshore wind is just one part of a bigger picture, which always has to be considered as a whole. The level of offshore wind farms materializing in each country and thus in the region depends on various factors and national political decisions.

Comparing both studies’ installed capacities and fuel types, there is a difference in nuclear, coal and gas in the NSCOGI scenarios, where these are higher compared to the ENTSO-E Visions (Figure 10-2).

In Visions 3 and 4, ENTSO-E proposes more solar compared to NSCOGI, Vision 4 more wind than NSCOGI RES+, which is nearly at the level of Vision 3.

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[22] The study can be downloaded from http://www.benelux.int/NSCOGI/

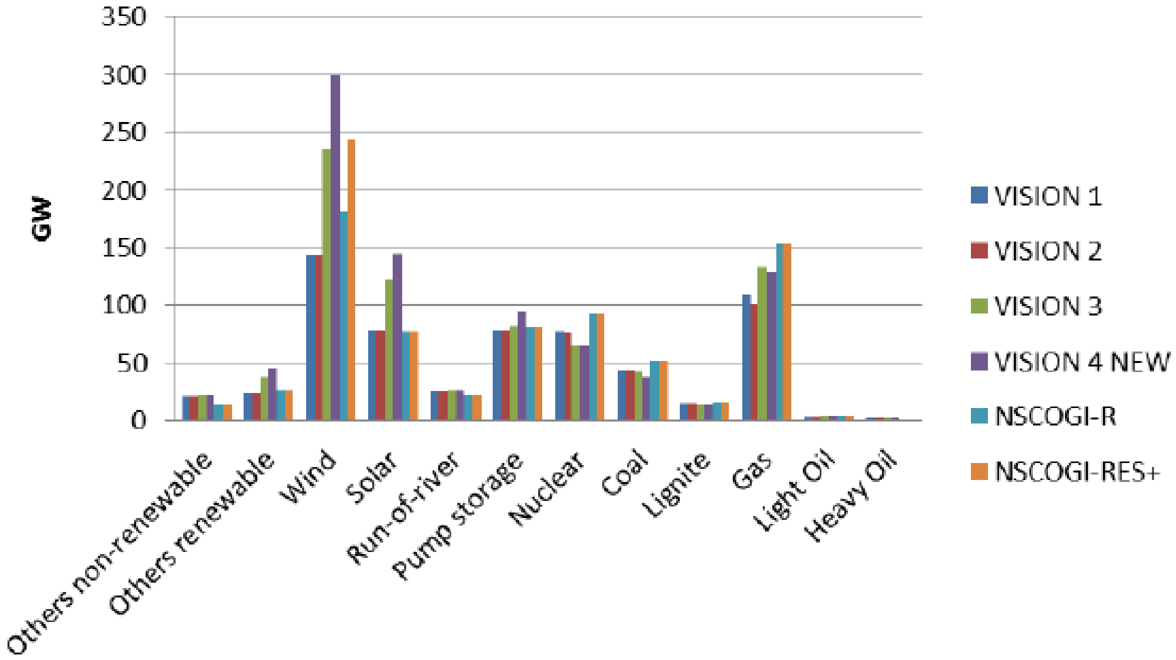


Figure 10-2 Comparison of Visions/ scenarios: installed capacity in NSCOGI countries 2030

A difference can be seen for thermal units – the national governments' expectations of the future were higher compared to the ENTSO-E Visions.

The ENTSO-E visions took the low amount of running hours for thermal units into account which will result in a smaller amount of thermal units in the European energy system. This development has already started with power plants not being able to cover their operational and capital expenditures due to decreasing market prices for electricity, thus they start to close. Hereby the ENTSO-E visions reflect valuable stakeholder comments received during the TYNDP workshops on the visions.

Comparing the demand of both studies, it can be concluded that the NSCOGI scenarios lies between Vision 1, Vision 2 and Vision 3, Vision 4, but this can look different for each single country, see Figure 10-3 and Figure 10-4.

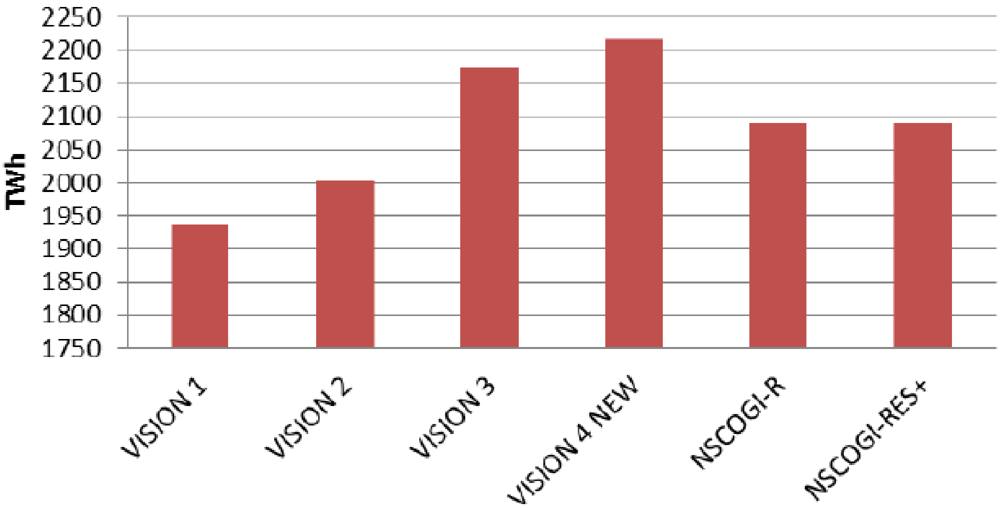


Figure 10-3 Comparison of visions/ scenarios: Demand in NSCOGI countries 2030

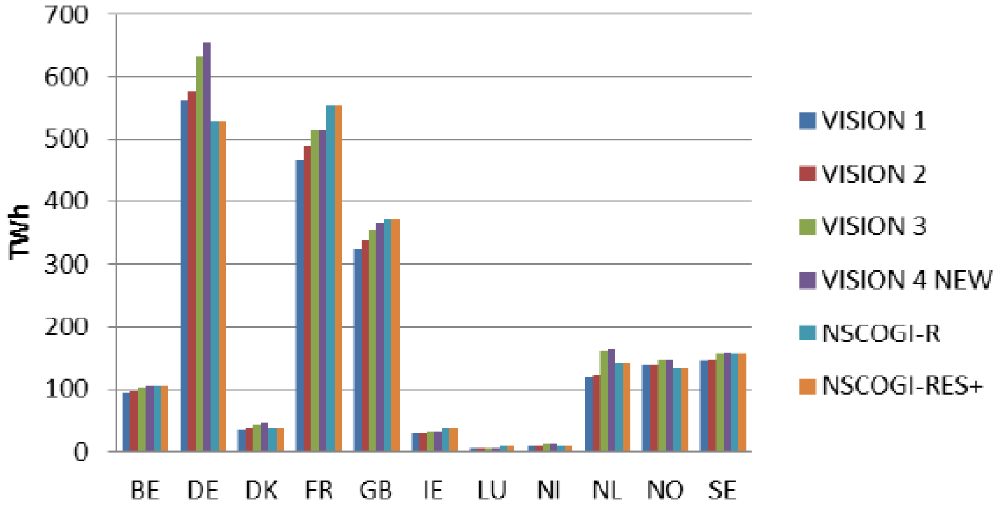


Figure 10-4 Comparison of visions/ scenarios: Demand in NSCOGI countries 2030, countrywide

A simplified summary of the input data between ENTSO-E visions and NSCOGI RES+ is given in the figure below.

Demand	V1/2	NSCOGI	V3/4
Thermal	V1/2	V3/4	NSCOGI
RES	V1/2	NSCOGI	V3/4

Figure 10-5 Summary of scenario-comparison

10.2.1 Conclusions from the Comparison NSCOGI- RES+ vs. ENTSO-E visions

The NSCOGI RES+ scenario lies within the envelope of the four ENTSO-E Visions, thus it is one version of the possible futures. Or in other words, the area spanned by the four ENTSO-E visions includes the most ambitious NSCOGI scenario (the RES+).

Both studies found a limited number of projects with sufficient maturity and offering an economically viable opportunity for hybrid projects (i.e. combining interconnector and offshore generation in a single project), referring to the investigated levels of offshore wind. The number of hybrid projects and interconnections increased in the NSCOGI RES+ scenario, when the offshore wind production was more than doubled. It did not increase for the "green" visions in the RegIP/TYNDP14, assessing a set of projects against four visions to evaluate their robustness.

Both studies show a combination of all current and future design elements. They show point to point interconnectors next to pure radial solution as well as locally coordinated solutions for the connection of offshore wind farms. All these deserve a case-by-case analysis to overcome mainly regulatory and market design barriers before they materializing in reality.

In coming editions of TYNDP and Regional Investment plans it can be expected that the offshore grid infrastructure will be subject to further adaptations – as grid designs always depend on the underlying assumptions (here: the visions). These visions will further be developed in coming TYNDP editions including new knowledge as it evolves, reflecting new developments in the region's and in European energy politics and in technical developments as well.

10.3 Reference to recent EC study

In summer 2014 the EC launched a study executed by a consortium around Tractebel on the "Benefits of a meshed offshore grid in Northern Seas Region."

This study also compared two general approaches: the business as usual (BAU) approach versus a coordinated approach.

The BAU approach is characterized by limited coordination between countries, ending up with all offshore wind farms being connected individually to shore and including only a limited number of point-to-point interconnectors. The coordinated approach leads to a higher number of interconnections between the region's countries and neighbouring offshore wind farms being clustered and connected to shore together. These clusters also might be connected to offshore hubs linking countries together.

The following results were found (see EC study, executive summary):

> "In the coordinated case, more offshore hubs are needed and fewer cables are connected to shore, but they have a higher rating. The study shows that the net effect is that the infrastructure investment cost is EUR 4.9 to 10.3 billion higher for coordinated network development. However, this investment pays for itself through the techno-economical, environmental, and strategic benefits that are enabled in this coordinated network development.
> In the coordinated case, fewer cables making landfall and shorter cable lengths are needed and CO2 emissions are reduced. The annual savings in 2030 including costs of losses, CO2 emissions and generation savings are EUR 1.5 to 5.1 billion for coordinated offshore grid development. These monetized benefits make the coordinated offshore grid profitable in all scenarios.
> The key drivers for these reductions of the total annual cost of electricity supply are the opportunities for energy trading/exchanges between Member States through

> the offshore infrastructure and the resulting better integration of offshore wind capacity and of the different generation pools in the region. When states also coordinate their reserve capacity, an additional EUR 3.4 to 7.8 billion generation investment cost reduction is obtained."

10.3.1 Comparison NSCOGI vs. Tractebel

Both studies show diverging results between, although - at first glance - investigating the same question. At second glance it can be seen that in fact different questions are investigated, which also are the explanation for diverging developments.

Developments are:

	NSCOGI from radial to meshed	Tractebel From BAU to coordinated ("meshed")
Cost development	decrease	Increase
km lines installed	~ constant	Increase
CO2 savings	Constant	Increase

The EC's study also compared a kind of "radial" to a "meshed" grid design version, but "meshed" was defined in a broader sense combining the mixed benefits of three design elements, which had been separated in the NSCOGI study.

Design elements are:

a) using hubs instead of pure radial OWF connections
b) using hybrid projects instead of building separate interconnections and OWF connections.
c) adding more interconnections between MSs (!)

The EC's study was "meshing" the region – while NSCOGI was focusing on investigating the effect of hybrid projects (i.e. combination of OWF connection and interconnector). The market needs of increasing the region's interconnection level had been fulfilled in a preceding step.

Thus, NSCOGI was keeping interconnection level between countries more or less constant, thus focused on a) and b); while c) had been optimized before the two different designs had been developed, both fulfilling the market needs.

This means that in the NSCOGI study the effect of meshing (in the sense of installing hybrid projects) was separated and evaluated, while Tractebel allowed one more degree of freedom (namely "c)") when designing the regional infrastructure. This makes the EC study more comparable to the TYNDP and Regional studies approach, comparing a situation with lower interconnection level to a situation with higher interconnection level, which means harvesting market benefits.

10.3.2 Conclusions from Comparison NSCOGI vs. Tractebel

However, finally both studies (and the TYNDP/ RegIPs as well) come to rather similar general conclusions:

- adding infrastructure is beneficial for the region, thus cooperation among countries and among stakeholders is key.
- Offshore solutions will be a combination of both, "radial" and "meshed" structures, using both, AC and DC technology.
- The choice should be made on a case-by-case basis, always on the basis of technical and economic parameters (using a CBA method).
- Offshore infrastructure in the Northern Seas region will develop in a modular way connecting the four regional synchronous areas closer to each other and connecting increasing amounts of OWFs. Thus, a large-scale offshore interconnected grid may emerge in the future, developing from the convergence of locally-coordinated solutions.

The lessons learned from recent discussions and the above mentioned studies conclude that ENTSO-E advocates naming the concept more generally an *"offshore grid infrastructure"* instead of "radial versus meshed", as there have been different definitions using the same word.

In such an offshore grid infrastructure all technical solutions, be it could be AC or DC, for either connecting offshore wind or interconnecting countries (or both in hybrid projects), all provide possibilities to integrate the regions' four synchronous areas and offshore wind farms as well. The realization of this infrastructure has in fact already started by existing projects, which all will be part of the future offshore grid infrastructure.

10.4 The Offshore Grid Infrastructure represented in the RegIP 2014

In this Regional Investment Plan (RegIP) of the North Seas, the analysis of four energy Visions up to 2030 demonstrates a need to build a considerable number of offshore infrastructure projects in the North Seas area, all of which deliver benefits for the regional society by pooling generation portfolios, integrating markets, lowering CO_2 emissions, facilitating the integration of renewables (both onshore as well as offshore) and ensuring sufficient system resilience. These projects have been evaluated in this RegIP/ TYNDP on a cluster-level as prescribed in the ENTSO-E Guidelines for Cost Benefit Analysis of Grid Development Projects. Their detailed assessment is included in the RegIP/ TYNDP appendices, and additionally highlighted below. The assessment provided refers to both, the individual clusters and their combination into a separate project as well.

When combining these individual clusters an overall picture emerges showing a strong step towards an integrated Northern European offshore grid infrastructure.

19 projects of the TYNDP 2014 (including 3 proposed by non-ENTSO-E members) develop into a global scheme for offshore grid infrastructure in the North Seas. This total scheme including its assessment is presented below.

The 19 projects combine altogether and complete existing assets in order to enable the integration of wind generation (on- and offshore) and increase the interconnection level between the regions's synchronous areas and neighbouring countries as well. The interconnections crossing the Northern Seas waters are completed with onshore reinforcements.

The offshore grid infrastructure represents more than 10000 km of new DC subsea cables by 2030 in the area. Every element is taylor-made and the proposed scheme below highlights astutely both, new assets and existing ones (both offshore and onshore) to maximise its efficiency.

Four projects of the TYNDP combine both generation connection and interconnection capability between countries in the North Seas and constitute so called "hybrid projects": Kriegers' flak combined grid solution, FAB (France-Alderney-Britain), BOG (Belgian offshore grid), depending on how its design will be finalized, and potentially Isles. Only three of them resort to offshore hubs to support the two functions (FAB's intermediate hub is the Alderney island). Such a design appears the exception, where the rule is on the one hand the connection of offshore wind farms to shore (through dedicated AC or DC offshore hubs), and on the other hand a point to point interconnection to connect countries. Such a separated design saves costs, as it often appears cheaper to build and operate the large AC/DC converter station required by interconnection onshore instead of offshore.

In some specific cases does the scheduling and technology required for interconnection and wind connection (DC or AC, voltage level) actually match so that a compact design offshore could be envisaged. Different geographical conditions lead locally to different optima and ENTSO-E concludes to a design which takes advantage of all possible connection and interconnection models.

Except in the examples mentioned above hybrid projects do not appear yet. Anyhow, this RegIP shows that integrating ("meshing") emerges at specific locations and further optimizations in the design of the offshore grid infrastructure will by nature be part of the further planning process.

The overall scheme is expected to save between € 1.0 billion per year and € 4.1 billions per year depending on the Visions, for a cost of about € 17-22 billions.

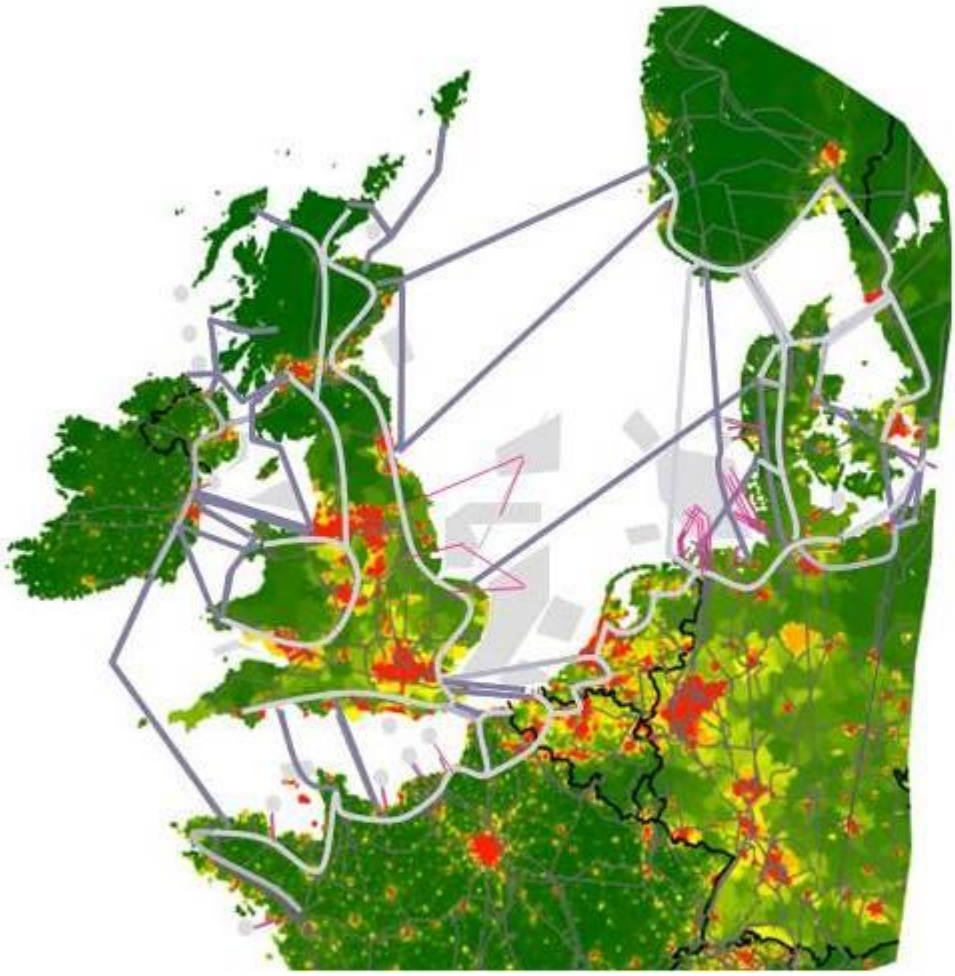


Figure 6 Schematic picture of future Northern Seas grid infrastructure based on existing infrastructure combined with identified and assessed TYNDP2014 projects

10.5 Assessment of the RegIP North Seas Grid Infrastructure

19 individual projects of the TYNDP 2014 (including the ones proposed by non-ENTSO-E members) develop into a global scheme for offshore grid infrastructure in the North Seas. This paragraph presents the assessment of the offshore grid infrastructure as if it was one single project.

Table 10-1 List of individual projects crossing Northern waters.

Country/ies	Project ID	Project Name	Offshore interconnection Capacity [MW]
FR, GB	25	IFA2	1000
FR, GB	153	France – Alderney – Britain	1400
FR, GB	172	Eleclink	1000
BE, GB	74	Thames Estuary cluster (NEMO)	1000
BE, GB	121	2nd Interconnector Belgium-UK	1000
FR, IE	107	Celtic Interconnector	700
IE, GB	106	Ireland GB Interconnector	700
IE, GB	185	Greenwire IE-GB	1500
IE, GB	228	Marex	1900
GB, NI	189	Irish-Scottish Isles	1000
GB, NO	110	Norway-Great Britain 1	1400
GB, NO	190	Norway-Great Britain 2	1400
DE, NO	37	Southern Norway - Germany	1400
DKW, NL	71	COBRA cable	700
DKW, GB	167	DKW – GB (Viking link)	1400
DKW, DKE	175	Great Belt II	600
DE, DKE	179	DKE-DE	600
DE, DKE	36	Kriegers Flak CGS	400
DE, SE	176	Hansa PowerBridge	600

The complete list of all related investments is provided in the appendix.

CBA results

The tables below summarize the Cost Benefits Analysis results of this portfolio of offshore projects.

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)**
Irland / GB : +5 GW Irland & GB / mainland: +10 GW NO & SE / DK & DE: +5 GW DK / DE & NL : +2 GW		2	5	More than 100km	15-25 km	17000- 22000

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration [TWh]**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[1600 - 2300]	[10-15]	[4.8;5.8] TWh	[-5.7;-6.9] Mt/yr
Scenario Vision 2 - 2030	-	[1000 - 1600]	[3-5]	[4.5;5.6] TWh	[-5.3;-6.5] Mt/yr

Scenario Vision 3 - 2030	-	[2900 - 4000]	[20-25]	[5.2;6.3] TWh	[-19.3;-23.6] Mt/yr
Scenario Vision 4 - 2030	-	[3500 - 4100]	[25-30]	[5.4;6.6] TWh	[-20.8;-25.5] Mt/yr

Additional comments

Comment on the RES indicator: spillage occurs almost exclusively in Ireland and Great-Britain.

Comment on the CBA assessment: by exception, CBA clustering rules are not complied with for this project, but they are for all its contributing parts. The offshore grid project integrates a certain capacity of offshore wind into the system, ranging up to 111 GW in vision 4. The RES indicator refers to the amount of RES spillage that is being avoided due to the market integration effect of this project, knowing that in vision 3 and 4 potential remains for further developments (there is still RES spillage left).

Furthermore, the socio-economic welfare in visions 1 and 2 are based on target capacities which do not reflect the full benefits of this integrated offshore grid. As such caution has to be applied when comparing costs to benefits.

10.6 Challenges

With respect to the technology development, ENTSO-E notes that a stable market and regulatory framework (e.g. RES incentives, anticipatory investment possibilities), and adequate expectations about future market price differences are key factors in creating a stimulating environment for suppliers and research institutions to invest in further investigations, regarding e.g. the system –behaviour of meshed DC systems and a parallel operation of AC and DC systems. Currently offshore platforms are still very expensive, limiting offshore opportunities, thus much system integration is provided by the onshore systems behind the point-to-point interconnections. The “meshing” is done onshore. One the other hand manufacturers of offshore assets will need a certain amount of projects before prices can decrease due to effects of large-scale application and benefits of learning curves.

The regulatory framework should support parties collaborating to develop hybrid solutions or multilateral interconnections, but this would among others e.g. need the timing of offshore wind farms and interconnectors to be closely aligned and coordinated. Currently these are mostly planned independently from each other and by different parties, as they follow different objectives. In every case, it should be demonstrated that the benefits of the selected solution outweighs its cost.

Also a framework of guaranteed cost recovery for anticipatory investments is not yet common sense in the regulatory framework of the member-states of the EU. ENTSO-E fully agrees on the point that in this context thorough attention should be given to all existing barriers and a joint effort is needed to overcome these; the ongoing NSCOGI work has been key in identifying these and in collaborating to search for pan-European answers.

ENTSO-E is confident that the proposals put forward in the draft TYNDP2014 package provide a valuable and robust first step in establishing a future North Sea grid infrastructure.

10.7 Future Options for Offshore Grid Infrastructure Development

Concluding from the “meshed” designs looking at different offshore wind generation levels, identified in NSCOGI grid study, it is possible to draw some general conclusions concerning a development from today’s projects to a meshed offshore grid infrastructure.

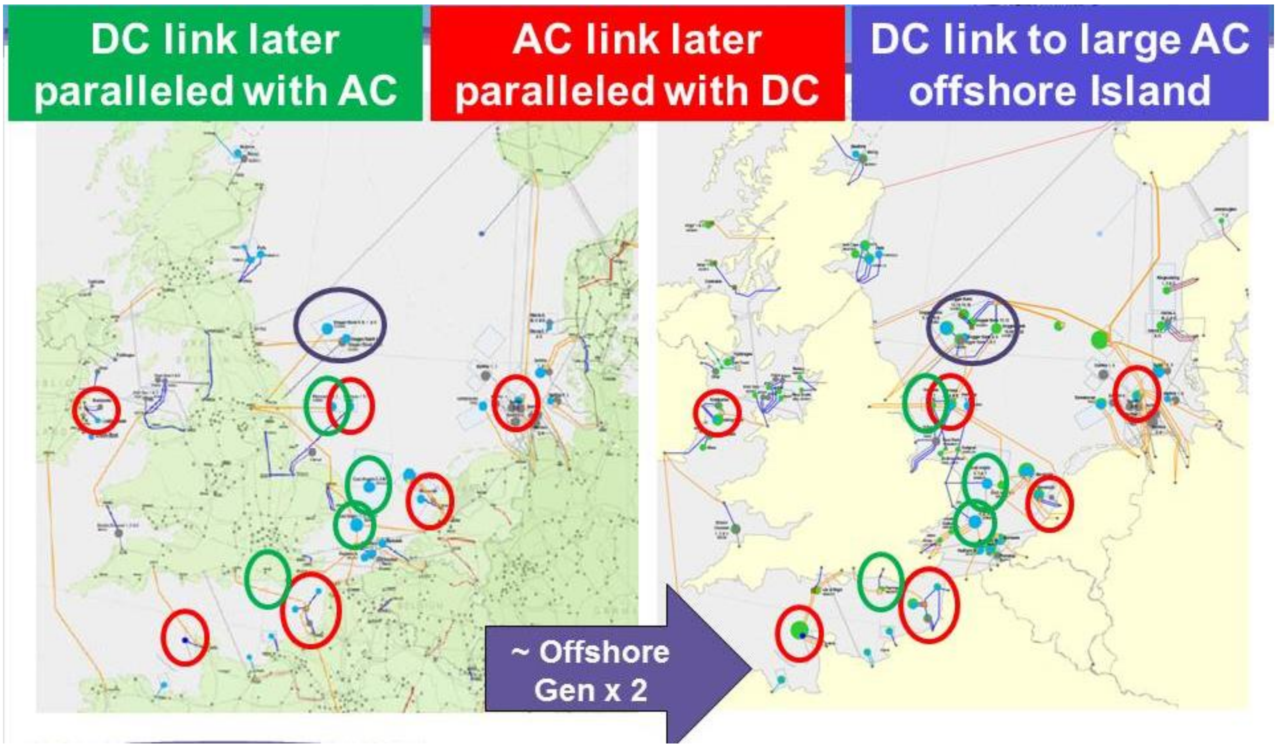
Starting from the NSCOGI Reference scenario including 55 GW offshore wind generation, all kind of projects had been identified: classical DC interconnections, classical AC interconnections and offshore wind power plants connected by AC or DC.

When doubling the amount of offshore generation, three main developments might occur:

- DC links which later are paralleled by AC (green circles)
- AC links which later are paralleled with DC (red circles)
- DC links to large AC offshore islands (blue circles).

This again emphasizes that all possible solutions which are used today, be it AC or DC for either integrating offshore wind or for interconnections are a way of integrating the four synchronous areas towards a meshed, or an integrated solution.

Thus the offshore grid infrastructure comprises AC and DC and a combination of both. Integrating comprises hybrid projects combining one offshore wind power plant to one interconnector but it can also be interpreted from a system wide perspective like visualized in the picture below.



The highly dynamic and changing environment regarding offshore generation level and future regulatory framework challenges the possibility to design an efficient final optimal grid infrastructure for 2050 a priori.

Therefore, any potential offshore grid would need to be built in a modular way. Every step has an impact on both existing as well as future projects which necessitates careful continuous planning creating a minimum level of (financial) certainty for TSO's, suppliers, wind-developers and other stakeholders leading to positive business cases for each of the involved parties.

The continuous planning is provided by ENTSO-E’s bi-annual RegIP/TYNDP process, taking new developments on board, concerning Visions, technology and market development.

11 Conclusion

The TYNDP 2014 confirms the conclusions of the TYNDP 2012

In considering the period up to 2030, the overall conclusion that can be drawn from the investment requirements identified in the TYNDP 2014 is that it confirms the conclusions of the TYNDP 2012.
The North Sea Region faces major challenges over the plan period on the way towards an efficient European Energy market and a secure European Network, whilst accommodating a large increase in the volume of renewable energy sources. These challenges have lead the TSOs within the Region to plan and take forward projects driven by:

- Security of supply, for example challenges due to German and Belgian nuclear phase-out and French nuclear reduction.
- Increased integration of the European energy market.
- Large scale connection and increased integration of renewable energy sources (wind, solar and hydro).

The generation portfolio in the North Sea Region, will most likely, experience a major shift by 2030 from thermal to renewables and from coal to gas. In order to avoid heavy curtailment of the RES generation more interconnectors will be needed. Adding interconnectors will also result in increased flexibility to the power system. This increased flexibility is required due to the increase of RES generation, which is characterized by higher variability and uncertainty compared to conventional generation resources.

Variable renewable power generation (wind and solar) is often located outside the main load centers (e.g. off-shore wind). However, solar power can also be located close to the load-centres (rooftop-solutions). This renewal of the generation mix is a major challenge for the transmission grid as both, locations and production characteristics will change. TSOs have to provide a suitable infrastructure in responding to these challenges.

Offshore infrastructure, mainly radial or locally coordinated solutions, is being developed to connect offshore wind parks and point-to-point interconnections to connect market areas. Some local meshed offshore structures, which are the results of local coordination, are enVisioned in some specific areas (Channel, ISLES project etc.). Large-scale meshed interconnector structures based on a broader regional coordination is not seen at this stage as a pre-requisite to accommodate the expected offshore RES in the different Visions, even when these Visions includes a substantial increased off-shore wind generation.
However, ENTSO-E strongly believes that these proposed new interconnectors should be seen as main facilitators of RES- and market integration and therefore will become part of an offshore grid in the future anyway.

The direction of the resulting net bulk power flow is generally on the north-south and west-east axes. It varies for the different Visions being considered and in some cases flows change direction. For example, in Vision 1 and 2 the net power flows from Continental Europe to Great Britain, whilst for Vision 3 and 4 the net power flows are from GB to Continental Europe and Nordic to Continental Europe.
In response to the investment needs, the Regional Investment Plan 2014for the North Sea Region includes internal projects in the region as well as several new interconnectors.

When comparing the number of projects identified in the TYNDP 2012 it must be recognized that the TYNDP 2014 considered both a longer period and a greater range of possible future outcomes. ENTSO-E has tested the robustness of a selected project portfolio against the four Visions. This implies that for the realisation of Vision 4, more investments are needed than identified, whilst it might well be the case that on the other hand not all proposed investments show a sufficient indication on their necessity in the event that a future closer to Vision 1 for example should start to materialise. Nevertheless, in that case projects might be of importance for other necessary needs.

The four different Visions had been developed with the engagement of the RGNS external stakeholders. These Visions establish a credible range of possible future outcomes and consider a range of potential energy policies. The aim of developing four Visions was to identify future transmission requirements in order to provide information on the consequences regarding the grid development under the various optional future energy policies. The recently changed energy policies with regards to renewables and nuclear have shown how sensitive the required investments are for major changes in (national and EU wide) energy policies. This is an important element to be carefully monitored, when exploring the impact on future possible energy policies on the desired shape of the power grid of the future.

The analysis against the four Visions has demonstrated that in general a minimum interconnector capacity between member states should be in the region minimum of 10-15% of the installed generation capacity, Anyhow, for several countries of the North Sea Region the analysis of the Visions show significantly higher needs, as e.g. for smaller countries and/ or countries with a lack of generation or a high amount of variable renewable resources.. However, a balance needs to be achieved between benefits and the costs of the investments in determining whether an investment is taken forward.
The investments investigated in this report ensure the high level of security of supply to be maintained.

A significant number of projects are at risk of being delayed due to the lack of speed in the authorisation process. However, TSOs are committed to the delivery of the key reinforcements of this plan and to facilitating the region in meeting the EU targets.

12 Appendices

12.1 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 12.1.1 displays the detailed assessment of Projects of Pan-European significance within the North 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 12.1.2 displays the list of all projects and investments within the North Sea region, including latest information on the evolution of each investment since TYNDP and RgIPs 2012.
- Section 12.1.3 displays the list of all commissioned investments within the North Sea region.
- Section 12.1.4 displays the list of all cancelled investments within the North Sea region.
- Section 12.1.5 displays the assessment of storage projects within the North Sea region, complying with Reg 314/2013.

12.1.1 Transmission projects of pan-European significance

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

12.1.1.1 Transmission projects of pan-European significance

All projects (but one) presented in Section 12.1.1 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.

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

12.1.1.2 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.

12.1.1.3 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.

12.1.1.4 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,
    - 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.

12.1.1.5 Assessment of projects of pan-European significance

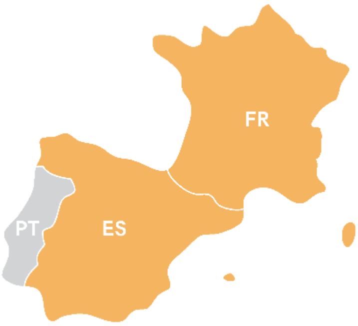
Project 5: Eastern interconnection ES-FR

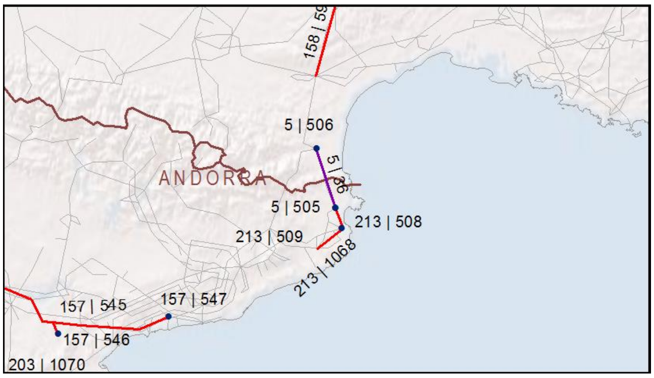
Description of the project

In order to fulfil the
governmental 2800 MW objective of exchange capacity between France-Spain, the Eastern interconnection was planned. After being classified as a Priority Project by the European Commission, and after the involvement of Prof. Monti as European Coordinator, it was stated that the unique feasible alternative for the development of the Spanish-French interconnection by the Eastern Pyrenees was a solution in DC totally buried for the cross-border section of the interconnection, with a terrestrial drawing up, as well as using, as far as possible, existing infrastructure corridors within a certain area.

The interconnection link based on the new VSC technology will connect Baixas (France) to Santa-Llogaia (Spain), via a 65-km long HVDC +/- 320 kV underground cable system, with 2*1000 MW rated power and AC/DC converters at both ends. This project is carried out by INELFE, a REE-RTE joint venture, created for this purpose.

Some internal reinforcements, both in Spain and France, are required. In France, the uprate of Baixas –Gaudiere 400kV is already commissioned. In Spain, reinforcements are included in project 213 in addition to certain individual investments of regional relevance.
The project allows important Social Economic Welfare, as it allows the use of more efficient and cheaper technologies, and avoids spillage of RES, especially in the Iberian Peninsula.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
36	Sta.Llogaia (ES)	Baixas (FR)	New HVDC (VSC) bipolar interconnection in the Eastern part of the border, via 320kV DC underground cable using existing infrastructures corridors and converters in both ending points.	1400	Under Construction	2015	Delayed	Answering all concerns expressed during the authorization process in Spain and environmental issues in France led to postponing the investment. Both issues are solved by now.
505	Sta.Llogaia (ES)		Converter station of the new HVDC (VSC) bipolar interconnection in the Eastern part of the border, via 320kV DC underground cable using	1400	Under Construction	2015	Delayed	Works completed in 2014; commercial operation expected after test period at the same

			existing infrastructures corridors.					time as the cable (investment 36).
506	Baixas (FR)		Converter station of the new HVDC (VSC) bipolar interconnection in the Eastern part of the border, via 320kV DC underground cable using existing infrastructures corridors.	1400	Under Construction	2015	Delayed	Works completed in 2014; commercial operation expected after test period at the same time as the cable (investment 36).

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)**
ES=>FR: 1200	FR=>ES: 1400	1	4	Negligible or less than 15km	Negligible or less than 15km	700

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	[100;250]	[20;130]	[110000;130000] MWh	[450000;550000]	[1600;2000]
Scenario Vision 2 - 2030	[110;260]	[22;140]	[120000;150000] MWh	[280000;380000]	[1800;2200]
Scenario Vision 3 - 2030	[120;270]	[70;150]	[590000;720000] MWh	[180000;280000]	[-1100;-870]
Scenario Vision 4 - 2030	[120;280]	[210;280]	[1300000;1500000] MWh	[360000;460000]	[-1500;-1300]

Additional comments

Comment on the security of supply: The project avoids potential Energy Not Supplied in the area of Gerona (Spain). In addition, the project increases the interconnection ratio of Spain in 0,6-1,05% in 2030 depending on the scenario.

Comment on the RES integration: Values of spillage are results from market studies without considering internal network constraints. Avoided spillage concerns RES in Iberian peninsula as a whole.

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

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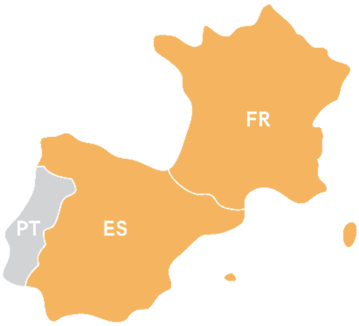
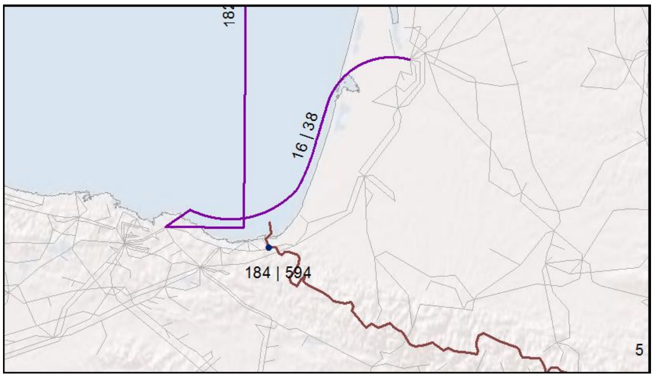
* Compared to the version sent to ACER, a mismatch in the GTC figures has been corrected after ACER had been informed.

Project 184: PST Arkale

Description of the project

This project is a new PST (phase shifting transformer) in the Spanish substation Arkale 220 kV with affection to the Arkale-Argia cross border line between France and Spain.
This device is required to increase the France-Spain exchange capacity, especially from Spain to France, and not only is able to have an independent good impact in the exchange capacity without taking into account the Eastern and Western interconnections (projects 5 and 16), but also helps making the most of these projects. In addition, as this project avoids the tripping of the Arkale-Argia tie line in case of contingencies, it helps improving the Security of supply in the French Basque country.
This project have been included in the 2013 PCI list – 2.8





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
594	Arkale (ES)		New PST in Arkale-Argia 220 kV interconnection line	-	Planning	2016	Investment on time	Draft NDP expected to be published during the preparation of TYNDP 2012 was not finally approved and published, so the investment is yet in a planning stage. If the new NDP is published by 2014, as expected, commissioning date would not be affected.

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)**
ES=>FR: 500-900	FR=>ES: 100-500	3	3	Negligible or less than 15km	Negligible or less than 15km	19-23

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	[22;27]	[5;13]	[8700;11000] MWh	[7000;11000]	[210;250]
Scenario Vision 2 - 2030	[23;28]	[7;15]	[8900;11000] MWh	[7500;12000]	[230;290]
Scenario Vision 3 - 2030	[27;33]	[12;26]	[54000;66000] MWh	[10000;14000]	[-190;-150]
Scenario Vision 4 - 2030	[36;45]	[33;53]	[150000;190000] MWh	[14000;18000]	[-280;-230]

Additional comments

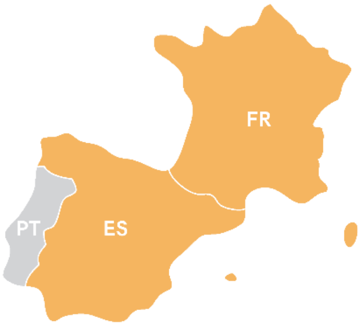
Comment on the security of supply: The project increases the interconnection ratio of Spain in 0.2-0,4% in 2030 depending on the scenario. This project improves the security of supply in the French Basque Country
Comment on the RES integration: Values of spillage are results from market studies without considering internal network constraints. Avoided spillage concerns RES in the Iberian peninsula.

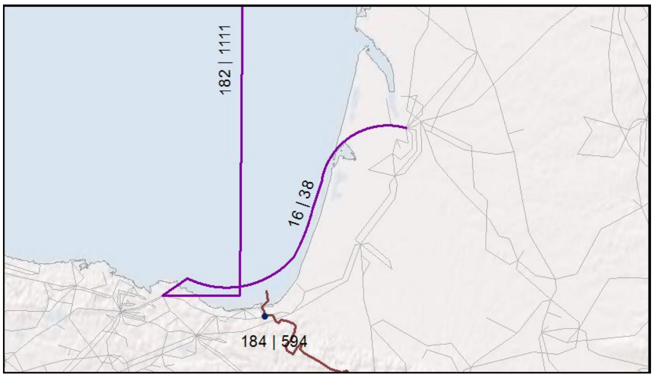
Project 16: Western interconnection FR-ES

Description of the project

In order to fulfil the governmental long term objective of exchange capacity between France-Spain, the Western interconnection is under analysis.
Deep technical and environmental prefeasibility studies across the whole French-Spanish border showed that the preferential strategy was a new HVDC submarine interconnection through the Biscay/Gascogne Bay from the Basque Country in Spain to the Aquitaine area in France.
Since the last TYNDP the analysis on technical feasibility and environmental aspects, especially for the subsea route have had good process. However, the project is still under analysis and final definition is in progress.
The project allows important Social Economic Welfare, as it allows the use of more efficient and cheaper technologies, avoids spillage of RES, especially in the Iberian Peninsula and reduces the consideration of Spain as an electric island.

PCI 2.7





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
38	Gatica (ES)	Aquitaine (FR)	New HVDC interconnection in the western part of the border via DC subsea cable in the Biscay Gulf.	-	Planning	2023	Investment on time	The technical consistency of the project progresses and the commissioning date is now defined more accurately.

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)
ES=>FR: 2500	FR=>ES: 2200	2	4	Negligible or less than 15km	Negligible or less than 15km	1600-1900

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[90;210]	[130000;160000] MWh	[200000;300000]	[3300;4000]
Scenario Vision 2 - 2030	-	[95;220]	[140000;170000] MWh	[210000;310000]	[3500;4300]
Scenario Vision 3 - 2030	-	[90;250]	[900000;1100000] MWh	[240000;340000]	[-1900;-1500]
Scenario Vision 4 - 2030	-	[310;470]	[2100000;2600000] MWh	[390000;490000]	[-2400;-2000]

Additional comments

Comment on the security of supply: The project increases the interconnection ratio of Spain in 1-1,6% in 2030 depending on the scenario.

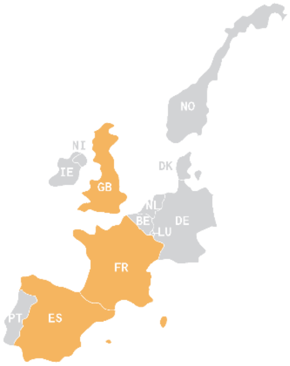
Comment on the RES integration: Values of spillage are results from market studies without considering internal network constraints. Avoided spillage concerns RES in Iberian peninsula as a whole.

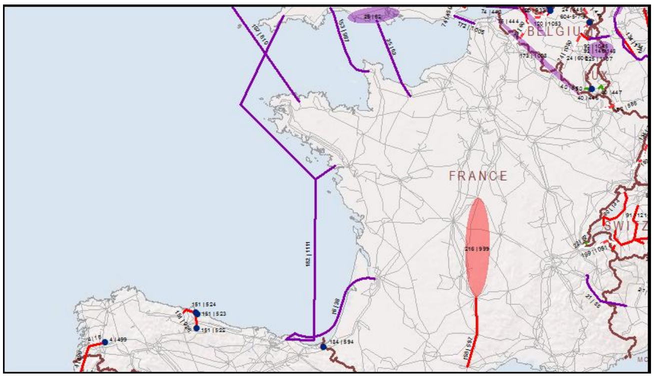
Project 182: BRITIB (GB-FR-ES)

Description of the project

Project promoted by COBRA (ACS Group)

Interconnection project between Indian Queens (Great Britain), Cordemais (France) and Gatica (Spain) in a multiterminal HVDC configuration with 2 sections of 1000 MW each, and a submarine route from Spain to Great Britain along the French coast. It is proposed to take advantage of complementarity of resources in the three countries involved in the project.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1111	Gatica	Indian Queens	Interconnection project between Indian Queens (Great Britain), Cordemais (France) and Gatica (Spain) in a multiterminal HVDC configuration with 2 sections and 3 terminals of at least 1000MW each, that allows for direct exchange of electricity between ES-FR, FR-UK and UK-ES.	-	Under Consideration	2018	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)**
Multiterminal configuration (MT): From/to ES; From/to FR; From/to GB: 1000		2	5	50-100km	Negligible or less than 15km	1700-2800

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[65;130]	[93000;110000] MWh	[200000;300000]	[900;1100]
Scenario Vision 2 - 2030	-	[75;140]	[110000;130000] MWh	[230000;330000]	[780;960]
Scenario Vision 3 - 2030	-	[200;280]	[1800000;2200000] MWh	[430000;530000]	[-1700;-1400]
Scenario Vision 4 - 2030	-	[280;350]	[2100000;2500000] MWh	[510000;610000]	[-1800;-1400]

Additional comments

Comment on the security of supply: The project increases the interconnection ratio of Spain in 0,4-0,8% in 2030 depending on the scenario

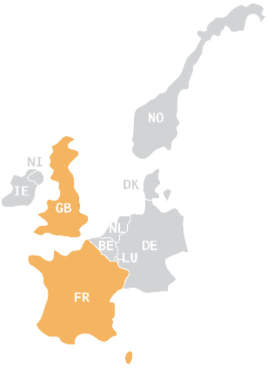
Comment on the RES integration: avoided spillage concerns RES both in the Iberian peninsula on the one hand and Great-Britain and Ireland on the other hand.

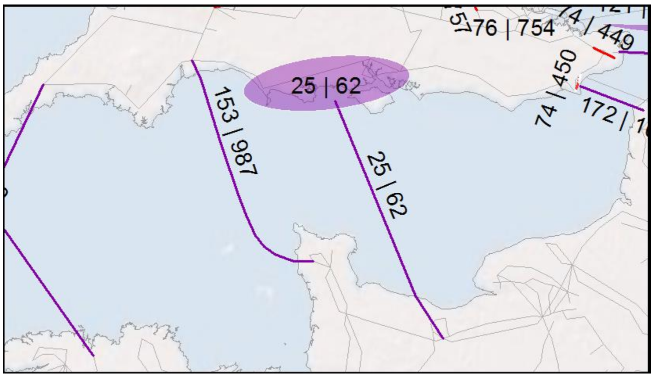
Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES

Project 25: IFA2

Description of the project

IFA2 is a new subsea HVDC VSC interconnection that will develop between the area of Caen in France and the region of Southampton in Great Britain. The objective is to increase the interconnection capacity between Great Britain and continent and to integrate RES generation, especially wind in Great Britain. It has been selected as PCI 1.7.2 in the NSCOG corridor on 14/10/13. Some mutual support is also expected but this is not reflected in the security of supply indicator assessed according to the CBA rules.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
62	Tourbe (FR)	Chilling (GB)	New subsea HVDC VSC link between the UK and France with a capacity around 1000 MW. PCI 1.7.2 (NSCOG corridor)	-	Design & Permitting	2020	Investment on time	Extensive feasibility studies (e.g. seabed surveys) have been conducted to determine the most suitable route; on the French side, the ministry of energy acknowledged the notification of the investment on 08/04/14.

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)**
FR=>GB: 1000	GB=>FR: 1000	1	4	15-50 km	Negligible or less than 15km	540-830

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[35;75]	[230000;280000] MWh	[200000;240000]	[170;210]
Scenario Vision 2 - 2030	-	[0;60]	[36000;44000] MWh	[200000;240000]	[220;260]
Scenario Vision 3 - 2030	-	[170;250]	[1700000;2000000] MWh	[190000;240000]	[-1400;-1200]
Scenario Vision 4 - 2030	-	[180;210]	[1500000;1800000] MWh	[190000;240000]	[-1100;-940]

Additional comments

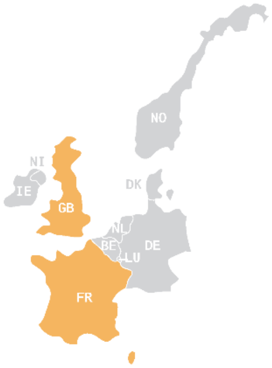
Comment on the RES integration: Avoided spillage concerns RES in Great-Britain and Ireland mostly, but also France.

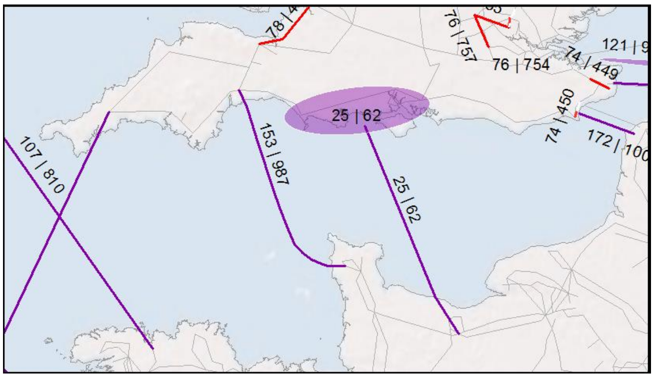
Comment on the CO2 indicator: The very high scores reflect that the project enables a better use of RES

Project 153: France-Alderney-Britain

Description of the project

France-Alderney-Britain (FAB) is a new HVDC subsea interconnector between Exeter (UK) and Cotentin Nord (France) with 1.4 GW capacity.
The project will not only increase the interconnection between Great Britain and continent but also integrate additional RES (especially wind generation from Great Britain); 2.8 GW of future tidal generation could also be connected to this link when it develops off the Cotentin coasts.
The investment has been selected as PCI 1.7.1 in the NSCOG Corridor.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
987	Cotentin Nord	Exeter	France-Alderney-Britain (FAB) is a new 220km-long HVDC subsea interconnection between Exeter (UK) and Cotentin Nord (France) with VSC converter station at both ends. Expected rated capacity is 2*700 MW.	-	Planning	2022	New Investment	Studies conducted after TYNDP2012 release have shown the economic viability of this interconnection and lead to develop this investment. Feasibility studies (marine surveys) are starting to find a suitable subsea 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)**
FR=>GB: 1400	GB=>FR: 1400	1	4	Negligible or less than 15km	Negligible or less than 15km	470-1100

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[40;100]	[300000;360000] MWh	[270000;340000]	[260;310]
Scenario Vision 2 - 2030	-	[0;90]	[59000;72000] MWh	[270000;340000]	[270;340]
Scenario Vision 3 - 2030	-	[230;350]	[2400000;2900000] MWh	[260000;320000]	[-2000;-1600]
Scenario Vision 4 - 2030	-	[260;300]	[2100000;2500000] MWh	[260000;320000]	[-1700;-1400]

Additional comments

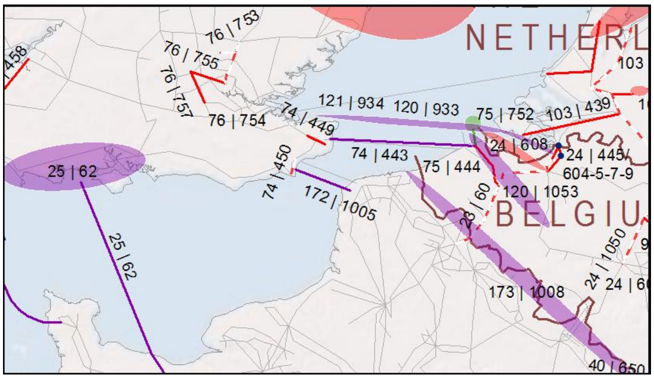
Comment on the RES integration: avoided spillage concerns RES in Great-Britain and Ireland mostly, but also France.

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

Project 172: ElecLink

Description of the project

Eleclink is a new HVDC interconnection between France and the United Kingdom with 1000 MW capacity through the Channel tunnel. This project has been selected as PCI n°1.7.3 in the NSCOG Corridor on 14/10/13.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1005	Sellindge (UK)	Le Mandarins (FR)	Eleclink is a new FR – UK interconnection cable thought the channel Tunnel between Selindge (UK) and Mandarins (FR). Converter stations will be located on Eurotunnel concession at Folkestone and Coquelles. This HVDC interconnection is a PCI project (Project of common interest). It will increase by 1GW the interconnection capacity between UK and FR by 2016.	-	Design & Permitting	2016	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)**
FR=>GB: 1000	GB=>FR: 1000	1	4	Negligible or less than 15km	Negligible or less than 15km	260-440

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[35;75]	[230000;280000] MWh	[200000;240000]	[170;210]
Scenario Vision 2 - 2030	-	[0;60]	[36000;44000] MWh	[200000;240000]	[220;260]
Scenario Vision 3 - 2030	-	[170;250]	[1700000;2000000] MWh	[140000;170000]	[-1400;-1200]
Scenario Vision 4 - 2030	-	[180;210]	[1500000;1800000] MWh	[140000;170000]	[-1100;-940]

Additional comments

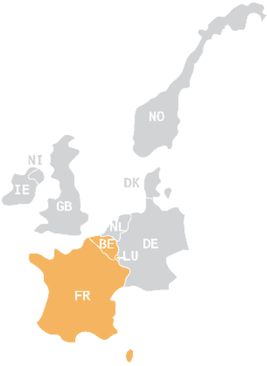
Comment on the RES integration: avoided spillage concerns RES in Great-Britain and Ireland mostly, but also France.

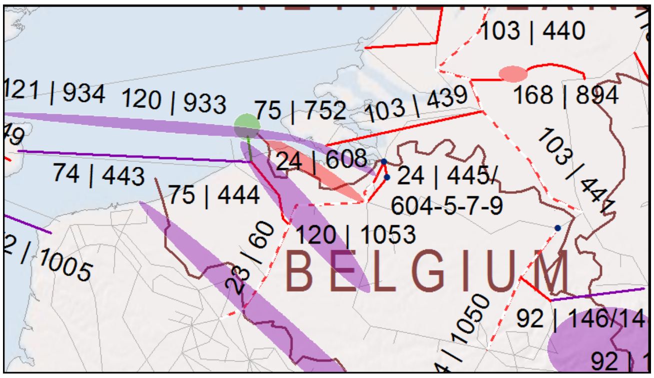
Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES

Project 23: France-Belgium Interconnection Phase 1

Description of the project

The project aims at ensuring reliable grid operation to cope with more volatile south-north flows, and at increasing the exchange capacities between France & Belgium to sustain an adequate level of market integration.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
60	Avelin/Mastaing (FR)	Horta (new 400-kV substation) (BE)	Replacement of the current conductors on the axis Avelin/Mastaing - Avelgem - Horta with high performance conductors (HTLS = High Temperature Low Sag)	-	Planning	2021	Rescheduled	Investment was at conceptual stage in TYNDP2012; on-going feasibility studies lead to a more accurate commissioning date.

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)**
FR=>BE: 600-1300	BE=>FR: 600-1300	1	3	Negligible or less than 15km	Negligible or less than 15km	110-170

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[5;15]	[18000;22000] MWh	0	[-120;-99]
Scenario Vision 2 - 2030	-	[0;10]	[19000;23000] MWh	0	[27;33]
Scenario Vision 3 - 2030	-	[10;20]	[77000;94000] MWh	0	[-130;-100]
Scenario Vision 4 - 2030	-	[20;60]	[200000;240000] MWh	0	[-240;-200]

Additional comments

Comment on the security of supply: a reinforced interconnector contributes to the security of supply of Belgium as a whole, since it offers market players additional import capacity which they can use to balance their portfolio provided that excess generation is available abroad. 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.

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

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.

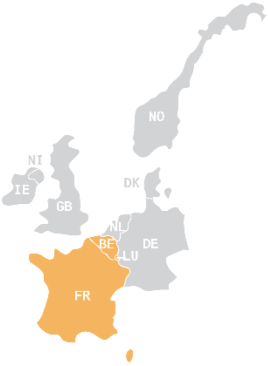
Comment on the S1 and S2 indicators: by definition, the reconductoring implies no new route, hence the indicators value is negligible.

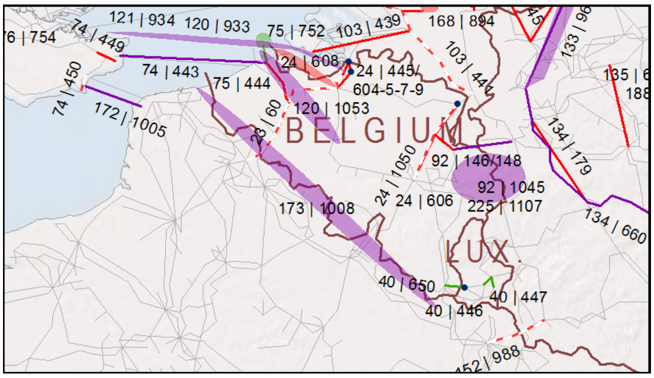
Project 173: FR-BE phase 2

Description of the project

Preliminary analyses show the need for an additional reinforcement in visions 3&4 between France & Belgium, complementary to project # 23.

The determination of the amount of additional market exchange that can be secured with this project, its optimal location & technology are subject to 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
1008	tbd(FR)	tbd(BE)	The following (combination of) options are envisioned and will be further studied: - Lonny-Achène-Gramme (reconductoring with High Temperature Low Sag conductors or HVDC) - Capelle-Courcelles (HVDC) - Warande-Zeebrugge/Alfa (HVDC)	-	Under Consideration	2030	New Investment	Preliminary analyses show the need for an additional reinforcement in visions 3 & 4 (2030) between France & Belgium, complementary to project # 23.

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)**
FR=>BE: 1400	BE=>FR: 1400	2	1	NA	NA	150-450

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 3 - 2030	-	[20;30]	[160000;200000] MWh	0	[-210;-180]
Scenario Vision 4 - 2030	-	[60;100]	[360000;430000] MWh	0	[-540;-450]

Additional comments

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

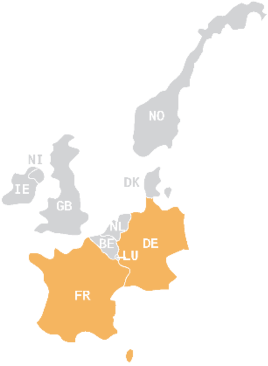
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

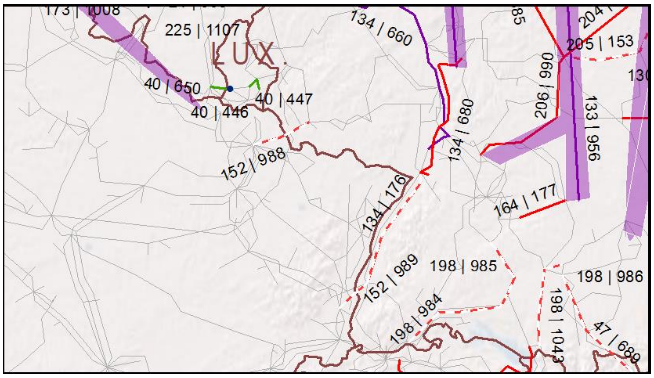
Project 152: France Germany Interconnection

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.

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/year)**	**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.

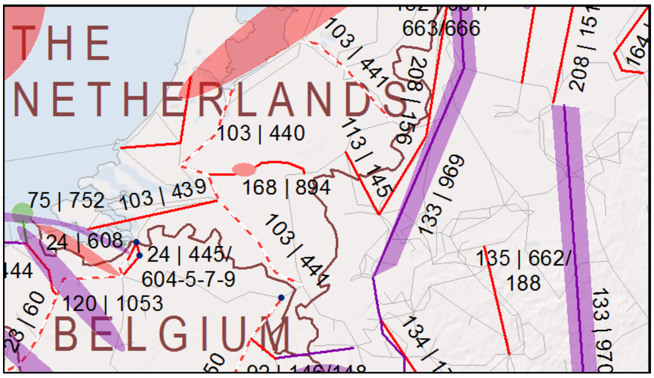
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

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/year)**	**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]

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

Project 92: ALEGrO

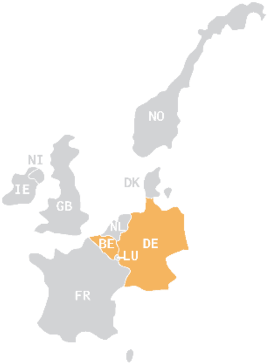
Description of the project

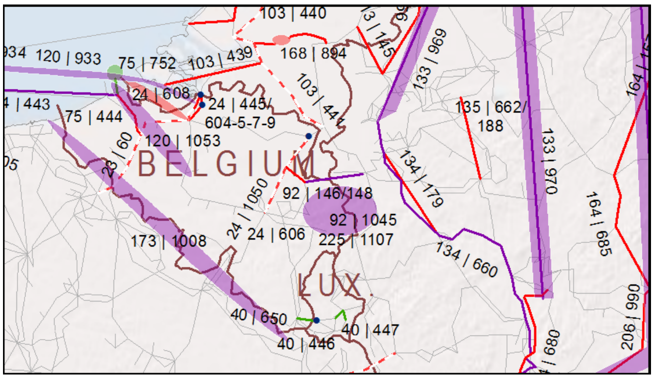
The ALEGrO (Aachen Liège Electricity Grid Overlay) project involves the realization of a HVDC link with a bidirectional rated power of approximately 1.000 MW capacity, as the first interconnection between Belgium and Germany.

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

			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/year)**	**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]

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.

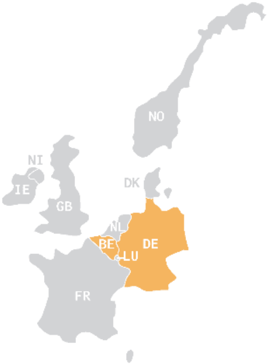
Comment on the RES integration: avoided spillage concerns RES in Germany and Belgium mostly

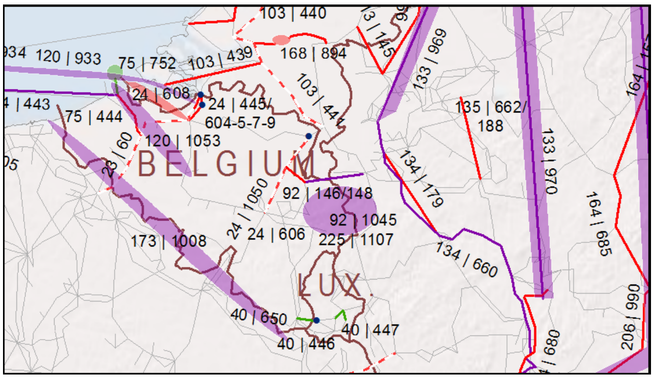
Comment on the S1 and S2 indicators: Definitive route to be determined, but taking perspective of minimizing impact.

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

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**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.

Project 40: Luxembourg-Belgium Interco

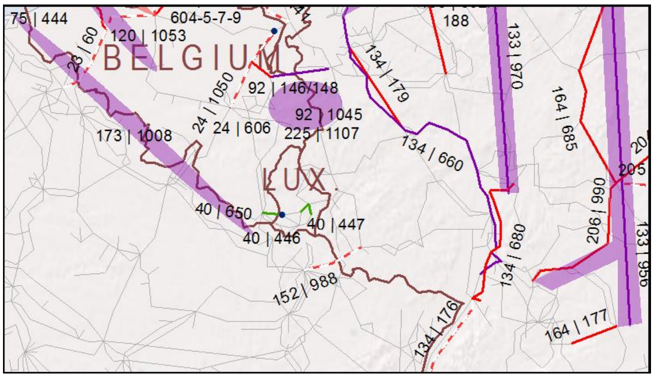
Description of the project

The project envisions the realization of an interconnection between Luxembourg and Belgium allowing to increase the transfer capability between LU, DE, BE and FR and contributing to the security of supply of both countries.

The interconnection is realized in two steps
- On short-term (end 2015) a phase shift transformer is integrated and connected to existing overhead line via an additional cable, in order to control the transit flows from Germany to Belgium
- On longer-term (2020) a solution with cables is under study envisioning an 1000 MVA path between Belgium and Luxembourg

In parallel a 1000 MVA reinforcement of the internal Luxembourg network is being constructed in order to create a loop around Luxembourg city, including substations for in feed in lower voltage levels.

PCI 2.3



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
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.	400	Under construction	2015	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.	700	Design & Permitting	2017	Investment on time	Substation Blooren is authorized and under construction, Authorization for line section is still pending
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	300	Under Consideration	2020	Investment on time	An ongoing network study investigates the robustness of the planned 220kV

			via a 16km double circuit 225kV underground cable with a capacity of 1000 MVA.					connection between LU and BE.

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)**
LU=>BE: 700	BE=>LU: 700	2	4	Negligible or less than 15km	Negligible or less than 15km	150-170

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	[900;1100]	[0;10]	[16000;20000] MWh	0	[80;97]
Scenario Vision 2 - 2030	[900;1100]	[0;10]	[9000;11000] MWh	0	[54;66]
Scenario Vision 3 - 2030	[900;1100]	[20;30]	[9000;11000] MWh	0	[-530;-440]
Scenario Vision 4 - 2030	[900;1100]	[30;50]	[130000;160000] MWh	0	[-870;-710]

Additional comments

Comment on the security of supply:
Luxembourg: principal driver for the project is the security of supply.
Belgium: a new interconnector contributes to the security of supply of Belgium as well due to the diversification it offers to the market players to import energy from countries where excess generation could be available.

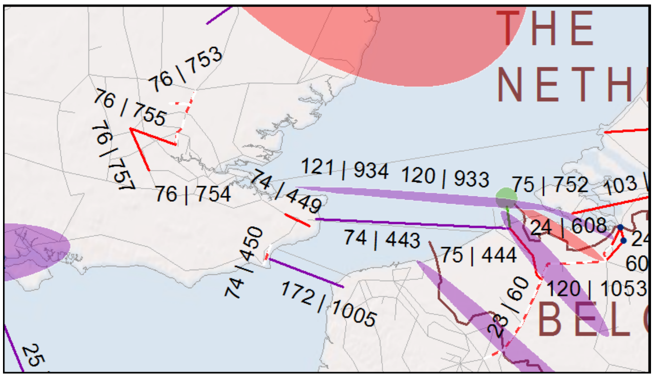
Comment on the Losses indicator: basically, the project enables power exchanges over greater distances (increasing losses), and conversely reduce the overall resistance of the grid. Losses variation is hence symbolically 0, with depending on the point in times losses being lower or greater, with variation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

Project 74: Thames Estuary Cluster (NEMO)

Description of the project

This group of investments includes the 1 GW NEMO interconnector between Great Britain and Belgium and a number of onshore UK reinforcements to facilitate this and other potential interconnector connections within the Thames Estuary region.

The project includes the PCI 1.1.1, 1.1.2 and 1.1.3.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
443	Richborough (GB)	Under analysis(BE)	NEMO New DC sea link including 135km of 400kV (voltage level subject to outcome of detailed engineering) DC subsea cable with 1000MW capacity. The assessment of the Final Investment Decision is planned in 2015.	1000	Design & Permitting	2018	Investment on time	Investment on time, with a technical commissioning planned end 2018 leading to commercial operation in 2019
449	Richborough (GB)	Canterbury (GB)	New 400kV double circuit and new 400kV substation in Richborough connecting the new Belgium interconnector providing greater market coupling between the UK and the European mainland.	1000	Planning	2018	Investment on time	Progress as planned.
450	Sellindge (GB)	Dungeness (GB)	Reconductoring the existing circuit which runs from Sellindge - Dungeness with a higher rated conductor. This will facilitate the connection of more interconnectors on the South coast and prevent thermal overloading of this area.	400	Design & Permitting	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)**
BE=>GB: 1000	GB=>BE: 1000	2	5	Negligible or less than 15km	Negligible or less than 15km	600-700

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[32;74]	[220000;270000] MWh	[410000;420000]	[180;220]
Scenario Vision 2 - 2030	-	[20;30]	[50000;61000] MWh	[370000;460000]	[160;190]
Scenario Vision 3 - 2030	-	[200;280]	[1800000;2200000] MWh	[190000;230000]	[-1300;-1400]
Scenario Vision 4 - 2030	-	[240;280]	[1100000;1400000] MWh	[190000;230000]	[-1700;-1400]

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 offered to market players to import energy from countries where excess generation could be available. Giving 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.

Comment on the RES integration: avoided spillage concerns RES in UK and Belgium mainly.

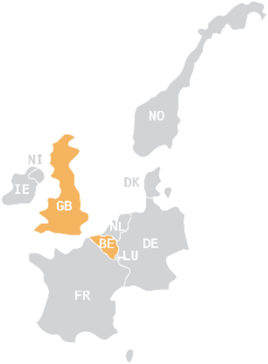
Comment on the flexibility indicator: the project appears useful in all visions, depends on a key-investment and interconnects two synchronous areas.

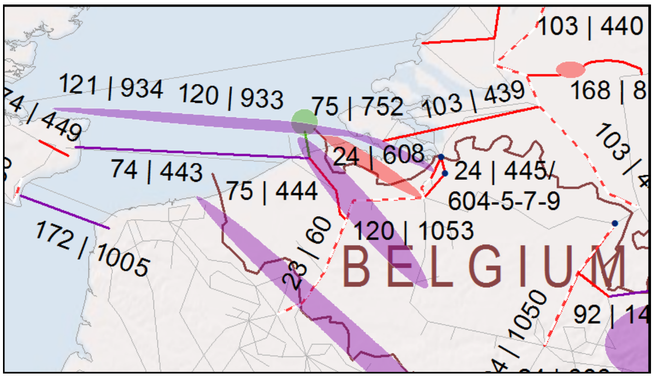
Project 121: 2nd Interco Belgium - UK (1GW)

Description of the project

This is a conceptual project that could be considered as a long-term investment option, triggered by the vision 3 & 4 scenario's where preliminary analysis shows potential of justifying additional regional welfare & RES integration increase via the construction of an additional +- 1000MW HVDC interconnection between the UK and Belgium.

The determination of the optimal capacity, location, technology, potentially needed internal grid reinforcements and possible synergies on the integration of this interconnector in relation to the BE offshore platform Alfa are subject of further studies.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
934	Kemsley (UK) for example - TBD	Doel/Zandvliet (BE) for example - TBD	NEMO 2: UK to BE 380kV inland This investment item envisions the possibility of a second 1GW HVDC connection, between UK (Kemsley) and a Belgian 380kV substation further inland in the Antwerp area (Doel, Zandvliet are indicative locations). Subject to further studies.	-	Under Consideration	2030	New Investment	Preliminary studies on vision 3&4 scenario's have indicated potential for further regional welfare & RES integration increase by further increasing the interconnection capacity between Belgium & UK up to 2 GW.

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=>GB: 1000	GB=>BE: 1000	2	2	NA	NA	450-650

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 3 - 2030	-	[170;260]	[1700000;2000000] MWh	[220000;260000]	[-1700;-1400]
Scenario Vision 4 - 2030	-	[210;250]	[1400000;1700000] MWh	[220000;260000]	[-1400;-1100]

Additional comments

Comment on the RES integration: avoided spillage concerns RES in Great-Britain and Ireland mostly.

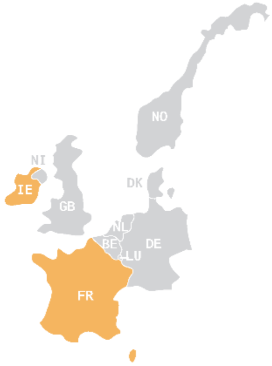
Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES

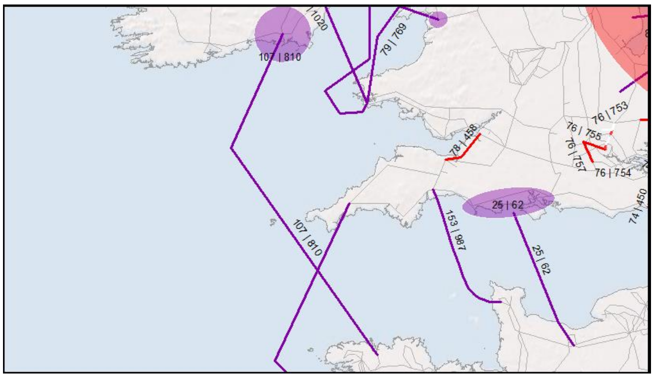
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Project 107: Celtic Interconnector

Description of the project

Celtic Interconnector will be the first interconnection between Ireland and France. This HVDC (VSC) link with 700 MW capacity will connect Great Island or Knockraha (Ireland) to the Finistère in France. It will not only create a direct link between the French and Irish markets, but also increase RES integration, especially wind in Ireland. Some positive impact on the security of supply is also expected, in particular for Brittany, although this is not shown by the corresponding indicator assessed according to the CBA rules. The project has been selected as PCI 1.6 in the NSCOG corridor on 14/10/13.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
810	Great Island or Knockraha (IE)	La Martyre (FR)	A new HVDC subsea connection between Ireland and France	-	Under Consideration	2025	Investment on time	Feasibility studies are progressing

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)**
FR=>IE: 700	IE=>FR: 700	1	4	NA	NA	900-1200

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[30;70]	[270000;320000] MWh	[200000;300000]	[63;77]
Scenario Vision 2 - 2030	-	[20;30]	[170000;200000] MWh	[200000;300000]	[-33;-27]
Scenario Vision 3 - 2030	-	[140;170]	[1300000;1600000] MWh	[170000;270000]	[-970;-790]
Scenario Vision 4 - 2030	-	[150;200]	[1500000;1800000] MWh	[170000;270000]	[-920;-760]

Additional comments

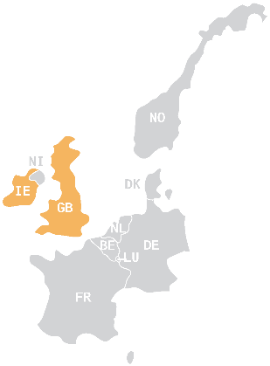
Comment on the RES integration: avoided spillage concerns RES in Ireland mostly.

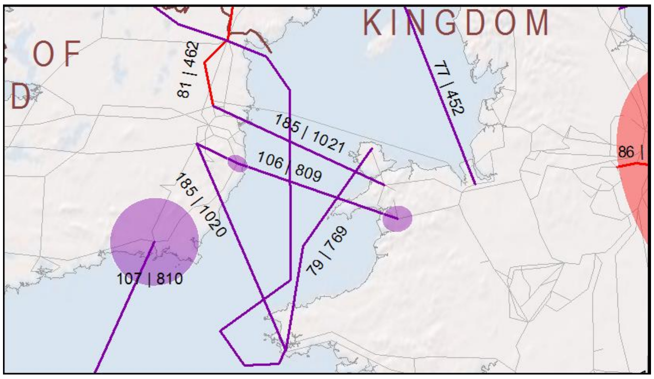
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Project 106: Ireland GB Interconnector

Description of the project

A second Ireland GB HVDC interconnector





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
809	Dunstown (IE)	Pentir (GB)	A new HVDC subsea connection between Ireland and Great Britain; this may be achieved by a direct link or by integrating an interconnector with a third party connection from Ireland to GB.	-	Under Consideration	2025	Investment on time	Joint studies between National Grid and EirGrid indicate a strong benefit for a second interconnector between Ireland and GB.

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)**
IE=>GB: 700	GB=>IE: 700	2	4	NA	NA	440-660

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[10;24]	[140000;170000] MWh	[69000;84000]	[-74;-61]
Scenario Vision 2 - 2030	-	[10;20]	[110000;130000] MWh	[72000;88000]	[-130;-100]
Scenario Vision 3 - 2030	-	[45;65]	[390000;470000] MWh	[72000;88000]	[-290;-240]
Scenario Vision 4 - 2030	-	[57;93]	[540000;660000] MWh	[77000;94000]	[-370;-300]

Additional comments

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

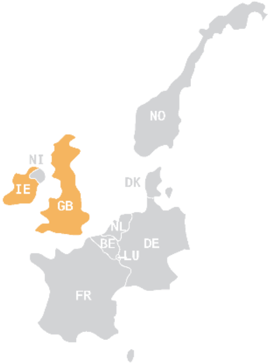
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

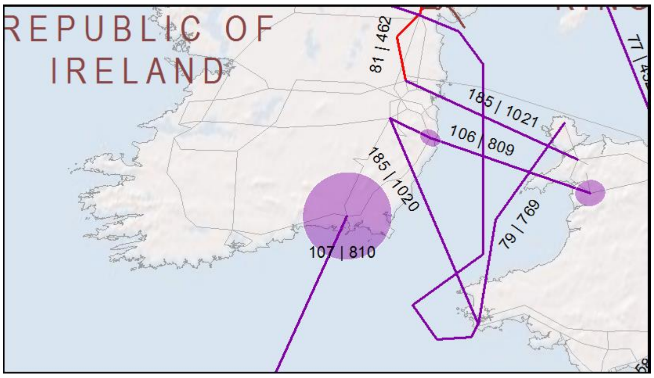
Project 185: Greenwire IE-GB

Description of the project*

Project promoted by by Element Power.
Greenwire Interconnector spurs, enables additional 1500MW of interconnection between UK and Irish market

PCI 1.9.1





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1020	Dunstown	Pembroke	Greenwire Interconnector spur 1, enables additional 500MW of interconnection between UK and Irish market	500	Planning	2018	New Investment	Opportunity to connect Irish RES to GB market
1021	Woodland	Pentir	Greenwire Interconnector spur 2, enables additional 1000MW of interconnection between UK and Irish market	1000	Planning	2017	New Investment	Project application to TYNDP 2014.

** Elementpower ltd delivered to ENTSO-E the following updated information on Nov 24th (after submission of the draft TYNDP2014 to ACER):*

- *Description: Greenwire enables wind exports from Ireland directly to GB and enables Interconnection between GB and Irish Markets of up to 1500MW. The Interconnection is expected to be developed in 3x500MW building blocks due to the current 500MW largest infeed loss limit in Ireland. Greenwire has 3GW of transmission connection capacity secured with National Grid, a mix of Interconnection and direct transmission of generation could utilise that capacity. A first stage project, called Greenlink, for interconnection between UK and Ireland, has been declared eligible for assessment under Cap and Floor regulation by the national regulator Ofgem. Greenwire interconnector 1 (resp. 2) has a capacity of 1000 MW (resp. 500 MW).*
- *Location: CBA assessment is made based on the connection in the Irish system to Dunstown / Woodland. The project promoter informed ENTSO-E that other locations (on the Irish side) may be possible still including Great Island.*
- *Expected date of commissioning: the date of commissioning of the 2 investments has been shifted to 2020.*
- *Evolution driver: the same driver applies for both investments: the opportunities to further interconnect GB and Irish grids and/or connect Irish RES to GB market.*

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)**
IE=>GB: 1500	GB=>IE: 1500	6	4	15-50km	15-25km	1925-2225

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[510;660]	[7000000;8600000] MWh	[360000;440000]	[-4500;-3700]
Scenario Vision 2 - 2030	-	[590;670]	[7200000;8800000] MWh	[360000;440000]	[-4600;-3800]
Scenario Vision 3 - 2030	-	[420;640]	[5100000;6200000] MWh	[490000;600000]	[-2400;-1900]
Scenario Vision 4 - 2030	-	[360;390]	[4200000;5200000] MWh	[490000;600000]	[-1600;-1300]

Additional comments

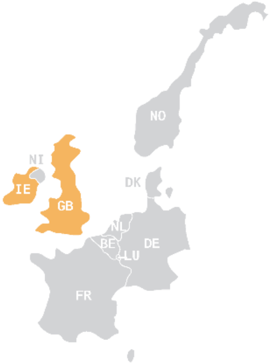
Comment on the RES integration: avoided spillage concerns RES in Ireland mostly.

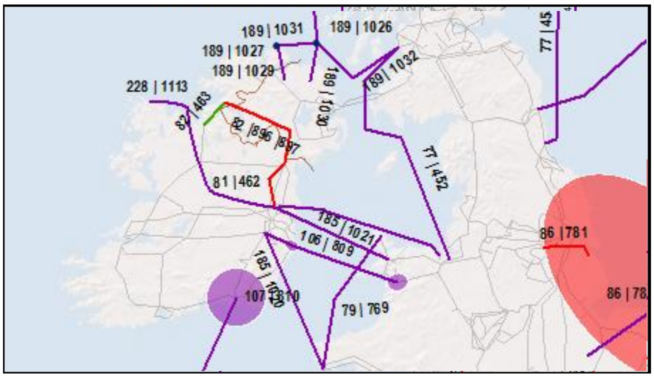
Project 228: Marex

Description of the project

Project promoted by Organic Power Limited.
Combined 1900MW wind generation, with 6.1GWh storage in mayo Ireland, connected to GB via 1500mw HVDC VSC cable

PCI 1.11.4





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1113	Glinsk 400kV	Connah's Quay 400kV	1500 MW HVDC VSC cable	-	Planning	2018	New Investment	Project application 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)**
IE=>GB: 1900	GB=>IE: 1900	0	0	More than 100km	Negligible or less than 15km	1100-1500

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[290;400]	[190000;240000] MWh	0	[-2800;-2300]
Scenario Vision 2 - 2030	-	[58;71]	[370000;380000] MWh	0	[-2800;-2300]
Scenario Vision 3 - 2030	-	[200;240]	[1900000;2300000] MWh	0	[-930;-760]
Scenario Vision 4 - 2030	-	[170;180]	[1700000;2100000] MWh	0	[-580;-470]

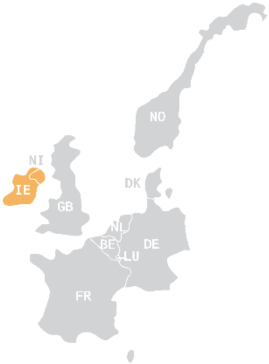
Additional comments

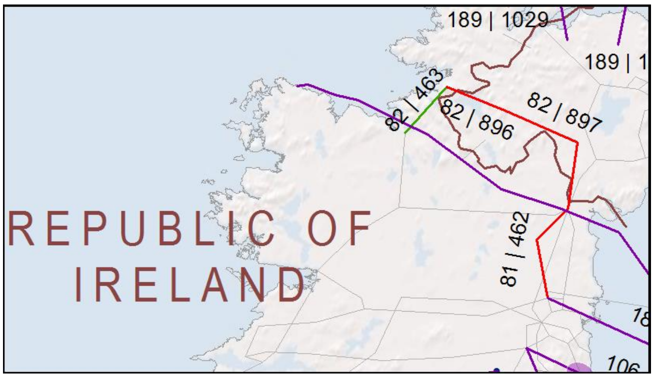
Project 81: North South Interconnector

Description of the project

A new 400 kV interconnector between Woodland in Ireland and Turleenan in Northern Ireland.

PCI 2.13.1





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
462	Woodland (IE)	Turleenan (NI)	A new 140 km single circuit 400 kV 1500 MVA OHL from Turleenan 400/275 kV in Northern Ireland to Woodland 400/220 kV in Ireland. This is a new interconnector project between Ireland and Northern Ireland.	-	Design & Permitting	2017	Delayed	Further studies required before re-submission for planning consents

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)**
IE=>NI: 660	NI=>IE: 580	3	3	Negligible or less than 15km	Negligible or less than 15km	270-330

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[18;36]	[6300;7700] MWh	[-50000;-41000]	[-45;-36]
Scenario Vision 2 - 2030	-	[12;15]	[9000;11000] MWh	[-47000;-39000]	[-27;-22]
Scenario Vision 3 - 2030	-	[27;34]	[45000;55000] MWh	[-47000;-39000]	[-49;-40]
Scenario Vision 4 - 2030	-	[55;77]	[1800;2200] MWh	[-45000;-37000]	[-110;-90]

Additional comments

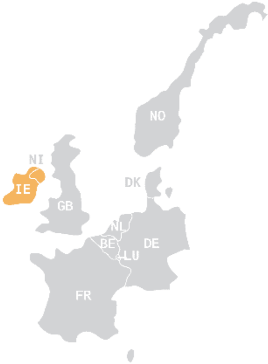
Comment on the RES integration: avoided spillage concerns RES in Ireland as a whole

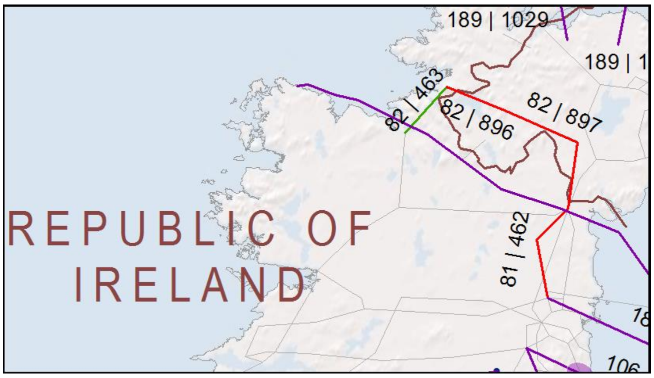
Project 82: RIDP I

Description of the project

The infrastructure development is required to facilitate connection of renewables in the North and West of the Island; It will further integrate the Ireland and Northern Ireland transmission systems and provide capacity for substantial demand growth in the area.

PCI 2.13.2





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)*	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
463	Sranangh (IE)	New substation in South Donegal (IE)	A new EHV overhead line from Sranangh in Co. Sligo to a new substation in south Co. Donegal	570	Planning	2020	Investment on time	The preferred scheme has been selected since the last TYNDP; this is one of the elements of the preferred scheme.
896	South Donegal (IE)	Omagh South (NI)	A new 275 kV cross border link between a new substation in South Donegal in Ireland and a new substation established south of Omagh in Northern Ireland	570	Planning	2024	New Investment	Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study.
897	Omagh South	Turleenan	A new 275 kV overhead line from a new substation established south of Omagh to a new 400/275 kV substation, established at Turleenan by the North South Interconnection Development	570	Planning	2020	New Investment	Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study.

** the values were corrected after submission of the report to ACER.*

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)**
IE=>NI: 570	NI=>IE: 570	3	4	Negligible or less than 15km	Negligible or less than 15km	317-475

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[120;140]	[120000;150000] MWh	[-52000;-64000]	[-1100;-920]
Scenario Vision 2 - 2030	-	[140;150]	[32000;39000] MWh	[-59000;-72000]	[-120;-94]
Scenario Vision 3 - 2030	-	[70;100]	[810000;1000000] MWh	[-59000;-72000]	[-400;-320]
Scenario Vision 4 - 2030	-	[55;75]	[970000;1200000] MWh	[-70000;-86000]	[-190;-160]

Additional comments

Comment on the RES integration: avoided spillage concerns RES in Ireland as a whole

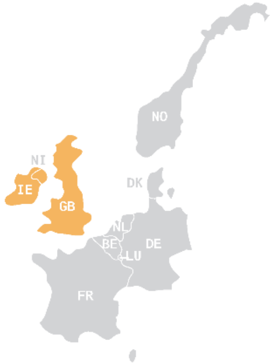
Project 189: Irish-Scottish Isles

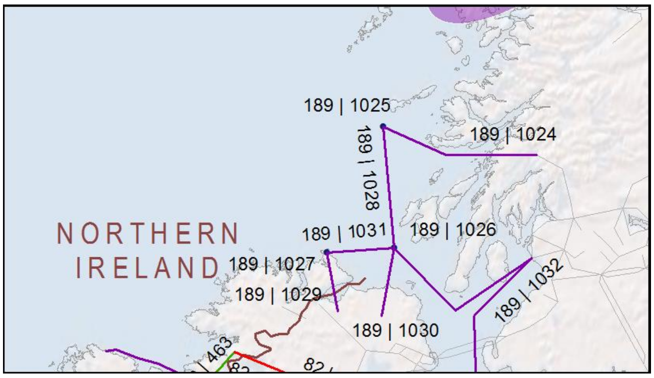
Description of the project

Project partners are the Scottish Government, the Department of Communications, Energy and Natural Resources in Ireland and the Department of Enterprise Trade & Investment in Northern Ireland. The project is part-financed under the EU INTERREG IVA Programme for Ireland, Northern Ireland and Scotland.

Conceived as a number of complementary multi-terminal HVDC connections that can be operated without the need for DC breakers and without breaching existing onshore loss of in feed limits but which can be reconfigured post-fault to re-establish power transfer paths. The benefits of the design are that offshore wind or tidal power can be brought to either of two shores, there is redundancy in connections and, in particular, interconnection capacity is provided between the GB market and the Single Electricity Market on the island of Ireland. Thus, while not 'dedicated to security of supply', it contributes to it.

PCI 1.9.2





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1024	Cruachan	Argyll hub	HVDC link between Cruachan (onshore) to Argyll offshore hub	1000	Under Consideration	2030	New Investment	The ISLES project will serve the development of multiple offshore generation resources in the waters of Scotland, Ireland and Northern Ireland and facilitate increased inter-connection between the GB and the SEM on the island of Ireland.
1025	Argyll hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	1000	Under Consideration	2030	New Investment	
1026	Coleraine hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	1000	Under Consideration	2030	New Investment	
1027	Coolkeeragh hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	1000	Under Consideration	2030	New Investment	

1028	Argyll	Coleraine	HVDC link between Argyll offshore hub and Coleraine offshore hub	1000	Under Consideration	2030	New Investment	
1029	Coolkeeragh	Coolkeeragh hub	HVDC link between Coolkeeragh onshore and Coolkeeragh offshore hub	1000	Under Consideration	2030	New Investment	
1030	Coleraine	Coleraine hub	HVDC link between Colerain onshore and Coleraine offshore hub	1000	Under Consideration	2030	New Investment	
1031	Coleraine hub	Coolkeeragh hub	HVDC link between Coleraine offshore hub and Coolkeeragh offshore hub	1000	Under Consideration	2030	New Investment	
1032	Hunterston	Coleraine hub	HVDC link between Hunterston (onshore) to Argyll offshore hub	1000	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)**
NI=>GB: 1000	GB=>NI: 1000	3	5	NA	NA	1600 - 3700

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[0;10]	[30000;40000] MWh	[180000;220000]	[-30;-40]
Scenario Vision 2 - 2030	-	[0;10]	[9000;11000] MWh	[180000;220000]	[-75;-95]
Scenario Vision 3 - 2030	-	[30;40]	[180000;220000] MWh	[270000;330000]	[-190;-160]
Scenario Vision 4 - 2030	-	[45;55]	[400000;490000] MWh	[270000;330000]	[-310;-250]

Additional comments

Comment on the RES integration: avoided spillage concerns RES connected by the project.

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

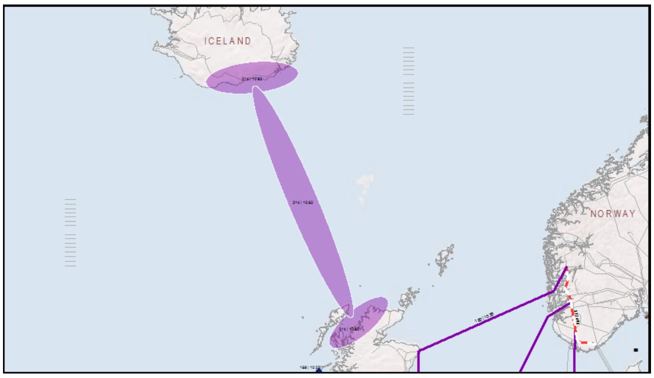
Comment on the flexibility indicator: the project may not be useful in all visions, consists of various investments complementing each other, and integrates two synchronous areas

Project 214: Interco Iceland-UK

Description of the project

Interconnector (Sea cable) between Iceland and Great Britain. The Cable is DC with 800-1200 MW capacity and 1.000 km long. 99.98% of the generation in Iceland is RES.

Iceland's hydro generation is highly flexible and ideal for complementing intermittency of GB's growing wind sector. It will provide flexible electricity for fast delivery of energy during peak periods and is also able to provide ancillary services to GB



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1082	tbd	tbd	Interco Iceland-UK	-	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)**
IS=>GB: 1000	GB=>IS: 1000	2	3	NA	NA	2200-2500

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[410;470]	[63000;77000] MWh	[810000;990000]	[-2900;-2300]
Scenario Vision 2 - 2030	-	[420;460]	[14000;17000] MWh	[810000;990000]	[-2800;-2300]
Scenario Vision 3 - 2030	-	[340;370]	0	[810000;990000]	[-1600;-1300]
Scenario Vision 4 - 2030	-	[290;310]	0	[810000;990000]	[-1300;-1000]

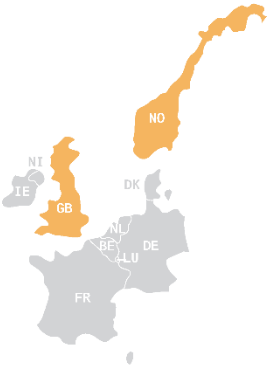
Additional comments

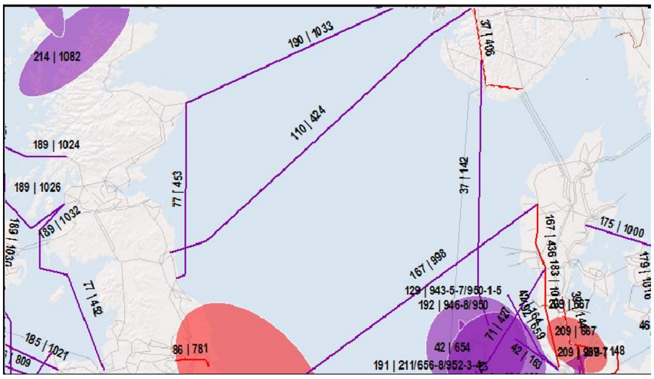
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

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 CO2-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/year)**	**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).

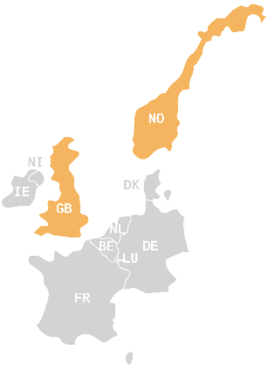
Comment on the CO2 indicator: the very high scores reflect that the project enables a better use of RES (by bringing it to load centres or to and from storage facilities)

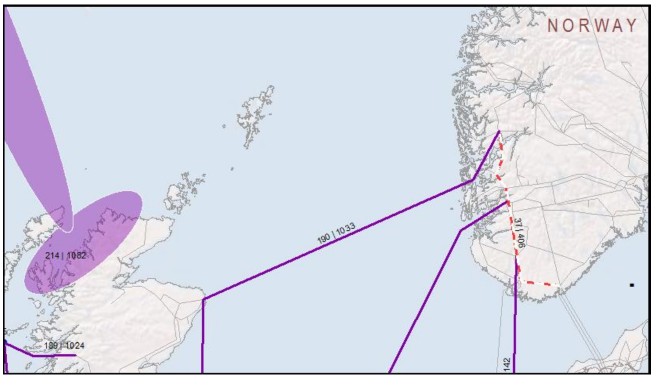
Comment on the Losses indicator: the load factor of the cable is similar in all Visions, leading to the same and very high additional losses.

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 CO2-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	1700

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**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).

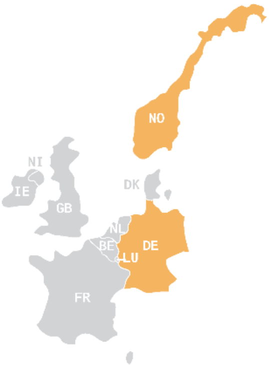
Comment on the Losses indicator: the load factor of the cable is similar in all Visions, leading to the same and very high additional losses.

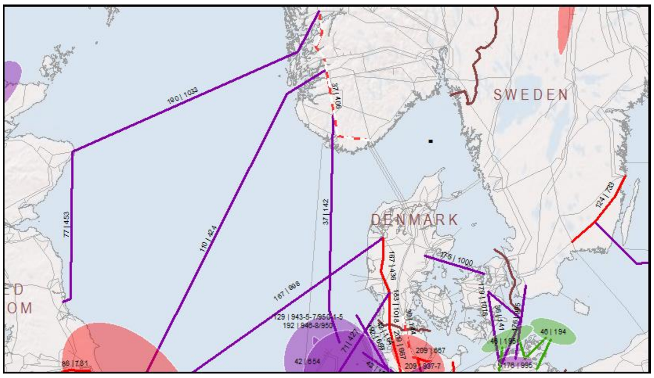
Project 37: Southern Norway - Germany

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 contribution (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 (MW)	GTC direction 2 (MW)	B6 Technical Resilience	B7 Flexibility	S1 - protected areas	S2 - urban areas	C1 Estimated 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/year)**	**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)

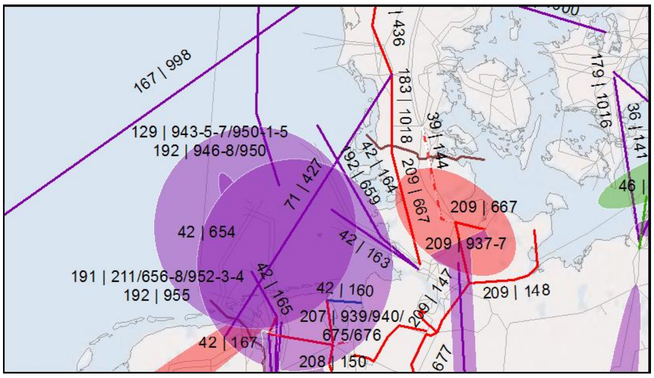
Comment on the Losses indicator: the load factor of the cable is similar in all Visions, leading to the same and very high additional losses.

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.

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 contri bution (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/year)**	**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.

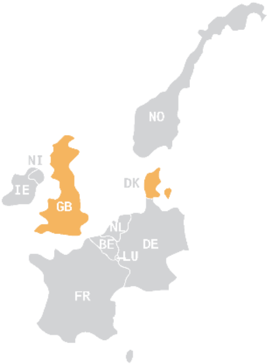
Comment on the RES integration: The significant increase of RES between Vision 1 and Vision 4 in both countries contributes to an increased number of hours with more volatile prices and thus higher flows in both directions. Additionally, the higher CO2 price in vision 4 causes a shift between coal and 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.

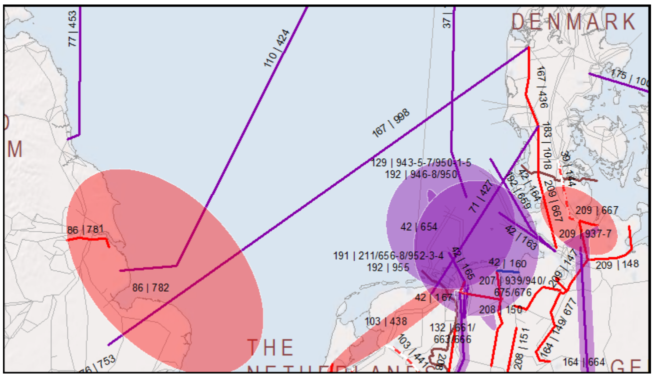
Project 167: Viking DKW-GB

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

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/year)**	**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

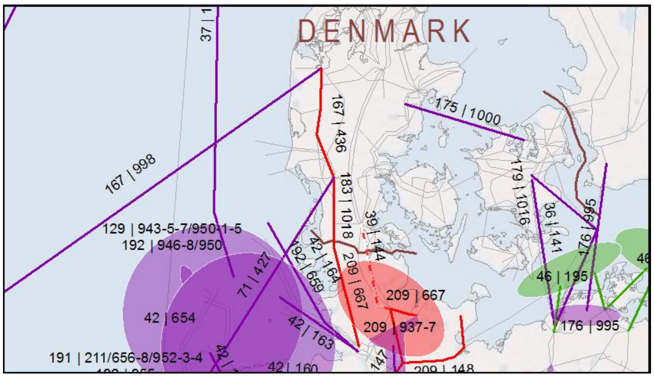
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

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€.

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/year)**	**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]

Additional comments

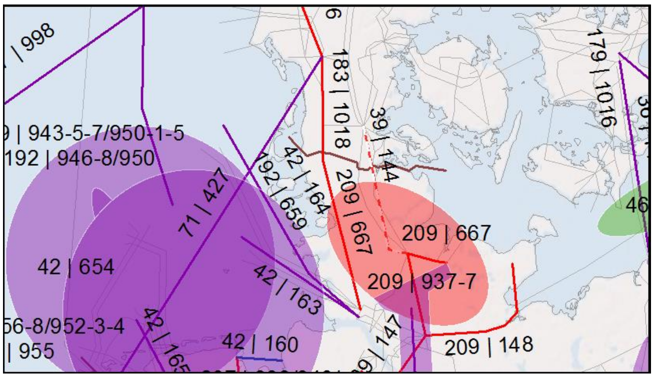
Comment on the security of supply: the project improves the SoS of Western Denmark and the area of Schleswig Holstein in Germany.

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

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 contri bution (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/year)**	**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

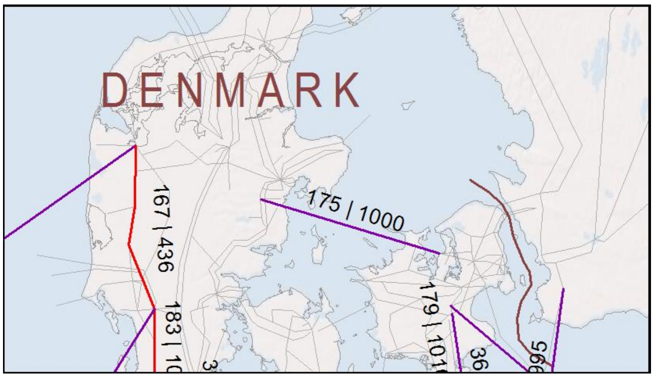
Comment on the security of supply: the project improves the SoS of Western Denmark and the area of Schleswig Holstein in Germany.

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.

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/year)**	**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.

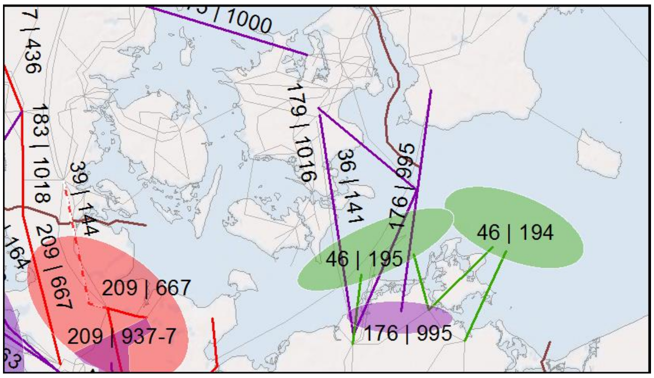
Comment on the RES integration: In Vision 1 there is only a relative small amount of RES in the region which can be absorbed by the system. Thus the curtailment value does not change due to the project - it stays at zero.

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

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 contri bution (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/year)**	**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.

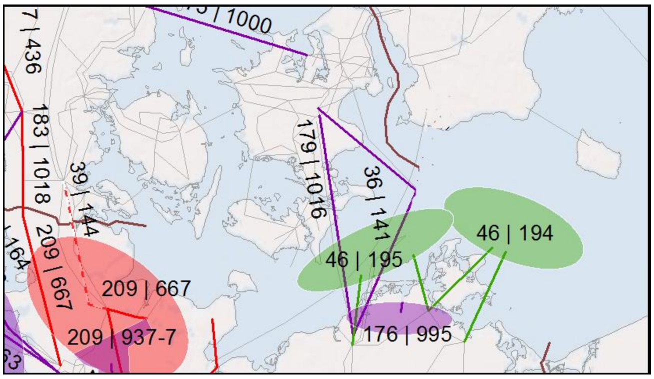
Comment on the RES integration: avoided spillage concerns RES in Germany and Denmark mostly.

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

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/year)**	**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]

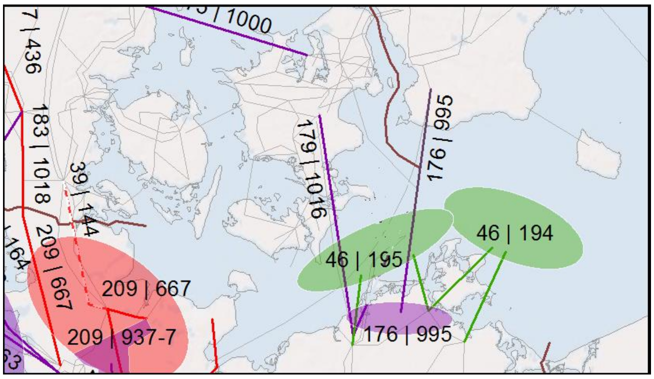
Additional comments

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

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/year)**	**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]

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.

Project 58: GerPol Power Bridge

Description of the project

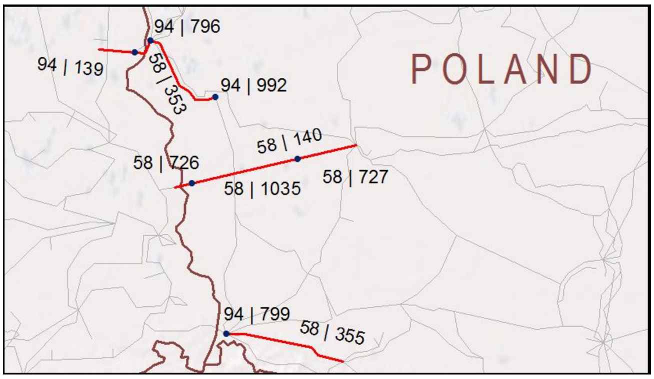
The construction of a new (third) interconnection between Polish and German power systems includes the construction of the interconnector between Eisenhuetenstadt and Plewiska as well as two internal lines (Mikułowa-Świebodzice and Krajnik -Baczyna) and substations Plewiska BIS, Gubin and Zielona Góra 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 contribution (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	800	Planning	2030	Rescheduled	Change of the commissioning date as the investment is correlated with the investment 140

			line Plewiska (PL)-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/year)**	**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 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.

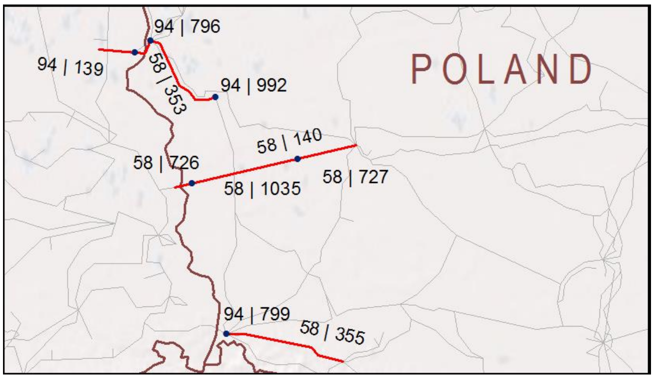
Project 94: GerPol Improvements

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	2017	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/year)**	**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.

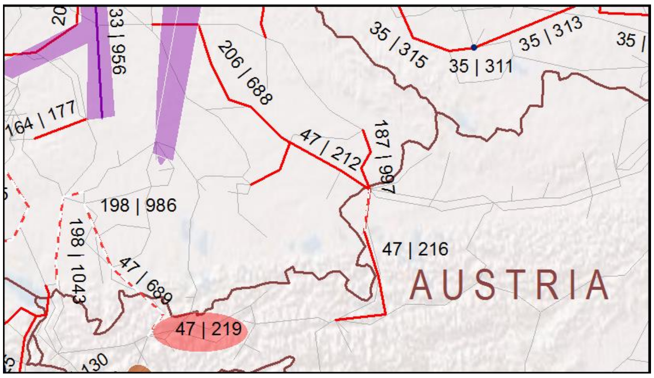
Comment on the RES integration:
The project, depending on the vision, helps integrating RES in the region of north-west Poland as well as eastern part of Germany.

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 contri bution (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/year)**	**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.

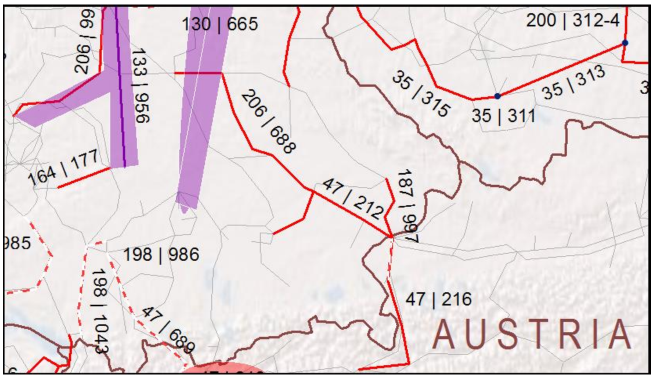
Comment on the RES integration:
The project supports the interaction of RES in Northern Europe (mainly in Germany) and in the eastern part of Austria with the pump storages in the Austrian Alps and therewith facilitates their utilisation.

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)

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/year)**	**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]

Additional comments

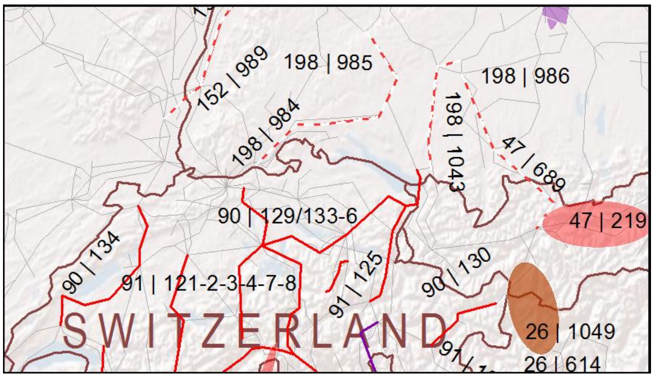
Comment on the RES integration:
The project supports the interaction of RES in Northern Europe (mainly in Germany) and in the eastern part of Austria with the pump storages in the Austrian Alps and therewith facilitates their utilisation.

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 contribution (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/year)**	**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.

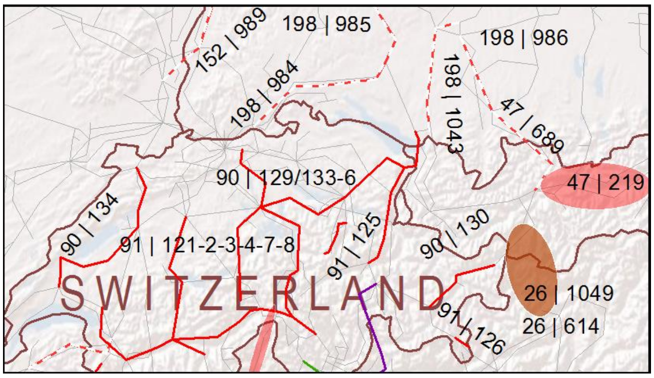
Comment on the RES integration: avoided spillage concerns RES in Germany mostly.

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 contribution (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/year)**	**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

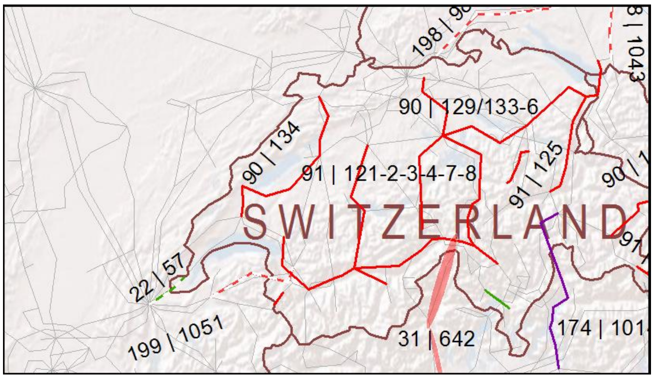
Comment on the RES integration: avoided spillage concerns RES in Germany mostly

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)

Project 22: Lake Geneva West

Description of the project

The project will increase the France-Switzerland cross-border capacity and secure the supply to Geneva by uprating the existing 225kV cross-border line Genissiat (FR)-Verbois (CH).



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
57	Genissiat (FR)	Verbois (CH)	Reconductoring of the existing 225kV double circuit line Genissiat-Verbois with high temperature conductors.	-	Planning	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)**
FR=>CH: 500	CH=>FR: 200	1	3	Negligible or less than 15km	Negligible or less than 15km	8-12

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[3;4]	0	[9000;11000]	0
Scenario Vision 2 - 2030	-	[4;5]	0	[9000;11000]	0
Scenario Vision 3 - 2030	-	[27;33]	[16000;19000] MWh	[9000;11000]	[-190;-160]
Scenario Vision 4 - 2030	-	[72;89]	[90000;110000] MWh	[23000;28000]	[-510;-420]

Additional comments

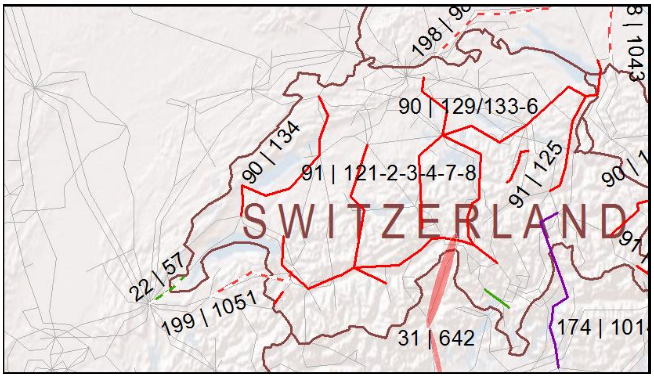
Comment on the RES integration: avoided spillage concerns RES in France mostly.

Comment on the S1 and S2 indicators: by definition, the reconductoring implies no new route, hence the indicators value is negligible.

Project 199: Lake Geneva South

Description of the project

This project comes on top of the Lake Geneva West project and will further increase the France-Switzerland cross-border capacity by upgrading to 400 kV the existing 225kV line south of Lake Geneva; some grid restructuration in Genissiat area will allow taking full benefit of this new axis. Main benefits are expected in terms of market integration and better integration of Swiss hydro generation, especially storage.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
1051	CORNIER (FR)	CHAVALON (CH)	Upgrade of the double circuit 225 kV line between Cornier (France) and Riddes and Saint Triphon (Switzerland) to a single circuit 400 kV line between Cornier and Chavalon (Switzerland). In order to take most benefit from this, the existing 400 kV Genissiat substation will be connected in/out to the existing line Cornier-Montagny.	-	Under Consideration	2025	New Investment	grid studies conducted after TYNDP2012 release allowed to define 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)**
FR=>CH: 1000	CH=>FR: 1500	0	3	NA	NA	110-140

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[8;9]	0	[-39000;-32000]	[-130;-100]
Scenario Vision 2 - 2030	-	[7;8]	0	[-37000;-31000]	[700;860]
Scenario Vision 3 - 2030	-	[63;77]	[36000;44000] MWh	[-33000;-27000]	[-430;-350]
Scenario Vision 4 - 2030	-	[150;180]	[180000;220000] MWh	[9000;11000]	[-1000;-840]

Additional comments

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

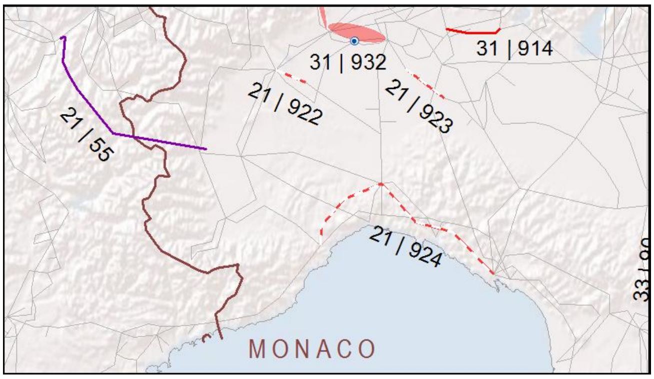
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Project 21: Italy-France

Description of the project

The Project comprises a new HVDC interconnection between France and Italy as well as the removing of limitations on existing 380 kV internal Italian lines. The removing of limitation is necessary to take full advantage of the increase of interconnection capacity provided by the cross-border line. The project favours the market integration between Italy and France as well as the use of the most efficient generation capacity; it also increases possible mutual support of both countries. In addition, the project can contribute to RES integration in the European interconnected system by improving cross border exchanges. Such benefits are ensured within different future scenarios.

PCI 2.5.1



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
55	Grande Ile (FR)	Piossasco (IT)	"Savoie - Piémont" Project : New 190km HVDC (VSC) interconnection FR-IT via underground cable and converter stations at both ends (two poles, each of them with 600MW capacity). The cables will be laid in the security gallery of the Frejus motorway tunnel and also along the existing motorways' right-of-way.	1200	Under Construction	2019	Delayed	After some delay in the works of the Frejus service gallery of the motorway, in which the cables will be installed, the project timeline has been updated. Works are already in progress.
922	Rondissone (IT)	Trino (IT)	Removing limitations on the existing 380 kV Rondissone-Trino	300	Planning	2019	New Investment	The item contributes to get the full advantage of the new HVDC cables was planned for the first time in the Italian National Development Plan 2013
923	Lacchiarella(IT)	Chignolo Po(IT)	Removing limitations on the existing 380 kV Lacchiarella-Chignolo Po	300	Planning	2019	New Investment	The item contributes to get the full advantage of the new HVDC cables was planned for the first time in the Italian National Development Plan 2013

924	Vado (IT)	La Spezia (IT)	Removing limitations on the existing 380 kV Vado-Vignole and Vignole-Spezia	300	Planning	2019	New Investment	The item contributes to get the full advantage of the new HVDC cables was planned for the first time in the Italian National Development Plan 2013

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)**
FR=>IT: 1200	IT=>FR: 1000	1	4	Negligible or less than 15km	Negligible or less than 15km	1100-1300

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[43;53]	0	[250000;310000]	[220;260]
Scenario Vision 2 - 2030	-	[29;36]	0	[250000;300000]	0
Scenario Vision 3 - 2030	-	[94;120]	[49000;60000] MWh	[8100;9900]	[-440;-360]
Scenario Vision 4 - 2030	-	[190;230]	[290000;350000] MWh	[36000;44000]	[-1200;-970]

Additional comments

Comment on the security of supply: the new HVDC cable link can help to reduce risks of energy not supplied mainly in northern Italy.

Comment on the RES integration:
Benefits in terms of RES integration are possible even in V1 and V2 because the new interconnection improves the balance capacity of the system. This kind of benefits is not captured in all visions by market simulations because it is sometimes beyond the accuracy of the tool. Avoided spillage concerns RES in France and Italy mostly.

Comment on the Losses indicator: The flows on the Italian North border (Import of Italy) are more often very high in Visions 1 and 2 compared to Vision 3 and 4.

Project 75: Stevin (backbone)+BE offshore

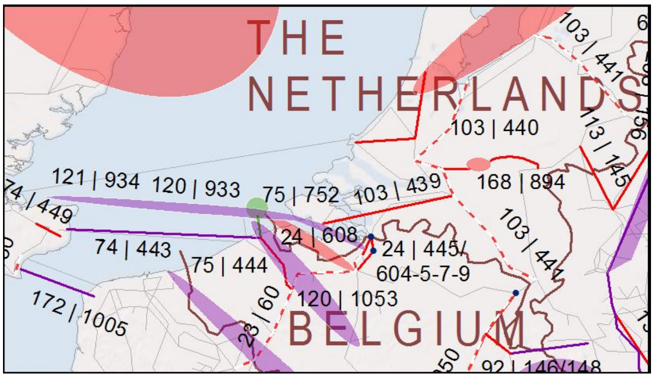
Description of the project

This project facilitates the integration of up to 2,3 GW of offshore wind production into the Belgian grid via the construction of an offshore hub (BOG: Belgian Offshore Grid project) and the extension of the 380kV backbone to the coastal area (STEVIN project) to which the offshore hub will be connected.

The final design as well as the legal, ownership & regulatory framework for BOG is being defined in concertation with stakeholders (wind farm developers,...).

Note that the STEVIN project is also required for the integration of the NEMO interconnector (BE-UK) into the BE 380kV network.

PCI 1.2



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
444	Zomergem (BE)	Zeebrugge (BE)	STEVIN The Stevin project envisions the extension of the 380kV backbone to the coastal area, via the construction of new +-50km (40km OHL; 10km cable) double-circuit (3000MVA for each circuit) between Zomergem and Zeebrugge., including the construction of a new substation in Zeebrugge.	3000	Design & Permitting	2018	Delayed	Delay due to request of 3rd parties to examine more alternatives, and procedures launched , and due to appeals against the GRUP (land use act) by 3rd parties in States Council. Meanwile arrangements have been made, and the updated planning envisions end 2017/begin 2018 as new commissioning date.
752	Offshore hub (BE)	Stevin (Zeebrugge)	Belgian Offshore Grid (BOG) The Belgian Offshore Grid investment consists of the eruption of an offshore hub connected to onshore AC grid (at Zeebrugge) via underground cables, including the necessary	1835	Design & Permitting	2018	Delayed	2018 is the earliest possible date: project is subject to outcome of ongoing design, legal, ownership & regulatory framework concertation with stakeholders.

			reactive compensation for the cables. Subject to result of ongoing design, legal, ownership & regulatory concertation with stakeholders.					

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: 3000	South=>North: 0	2	3	Negligible or less than 15km	Negligible or less than 15km	600-900

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[390;490]	1800 MW	[27000;33000]	[-4100;-3300]
Scenario Vision 2 - 2030	-	[420;490]	1800 MW	[27000;33000]	[-3400;-2700]
Scenario Vision 3 - 2030	-	[510;520]	1800 MW	[27000;33000]	[-2600;-2100]
Scenario Vision 4 - 2030	-	[330;460]	1800 MW	[27000;33000]	[-2000;-1600]

Additional comments

Comment on the SEW: the SEW is decreasing in Vision 4 because of the competition of other RES developments

Comment on the security of supply: the STEVIN project contributes to the SoS of Belgium because it allows the integration of the new interconnector NEMO. And also contributes to the SoS of the Coastal Area by integrating this area into the 380kV backbone in a structural way (in feed from 380kV to 150kV in Zeebrugge)

Comment on the Losses indicator: connected RES is assumed to be the same in all 4 Visions, leading to the same additional losses.

Project 120: 2nd Offshore-Onshore Corridor

Description of the project

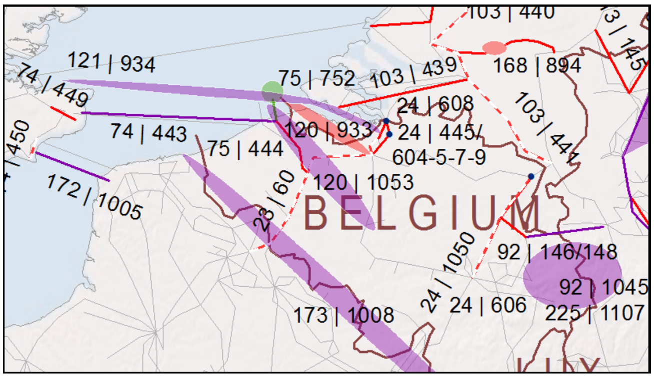
Second Offshore-Onshore Corridor

This is a conceptual project that could be considered as a long-term investment option, triggered by the vision 3 & 4 scenario's where up to 4GW of offshore wind capacity is envisioned in the Belgian part of the North Sea (note that this 4 GW is not ensured in official government plans for offshore wind development).

Compared to the current forecast of 2,3 GW of offshore wind as to which Elia's portfolio is designed, it implies an additional reinforcement under the form of a second offshore-onshore corridor.

Preliminary analysis indicates that this corridor could consist of multiple reinforcements to different inland locations.

The determination of optimal location/route, technology and the integration of this corridor in relation to the BE offshore hub Alfa and nearby onshore substation Stevin at Zeebruge 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
933	Offshore Hub OR Stevin - TBD	Izegem - TBD	Further connection to inland: phase 2 Preliminary analysis shows the need to reinforce the 380kV network with a second offshore-onshore corridor in order to evacuate up to 4 GW of offshore wind. The solutions under study consist of multiple investment items. This investment item envisions the possibility of an AC OR DC solution going from an offshore hub OR onshore substation Stevin in Zeebrugge towards a further inland location.	1000	Under Consideration	2030	New Investment	Additional offshore-onshore corridor needed in order to evacuate full potential of up to 4GW (compared to current target of 2,3 GW) of offshore wind in the Belgian part of the North Sea in visions 3 & 4.

			The reference solution presented here is an AC corridor towards Izegem. To be confirmed by further detailed studies in the coming years. The cost estimation does not take into account the offshore part of the corridor.					
1053	Offshore Hub - TBD	Doel - TBD	1 GW connection to inland: phase 1 Preliminary analysis shows the need to reinforce the 380kV network with a second offshore-onshore corridor in order to evacuate up to 4 GW of offshore wind. The solutions under study consist of multiple investment items. This investment item envisions the possibility of a 1 GW DC solution between an offshore hub towards an inland location (substation Doel or further inland could be a possible location). Subject to further studies. The cost estimate does not take into account the construction of an eventual offshore hub.	1000	Under Consideration	2030	New Investment	Additional offshore-onshore corridor needed in order to evacuate full potential of up to 4GW (compared to current target of 2,3 GW) of offshore wind in the Belgian part of the North Sea in visions 3 & 4.

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)**
outside=>inside: 1800	inside=>outside: 0	2	1	NA	NA	600-900

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 3 - 2030	-	[510;520]	1800 MW	[170000;210000]	[-2600;-2200]
Scenario Vision 4 - 2030	-	[430;450]	1800 MW	[170000;210000]	[-2000;-1600]

Additional comments

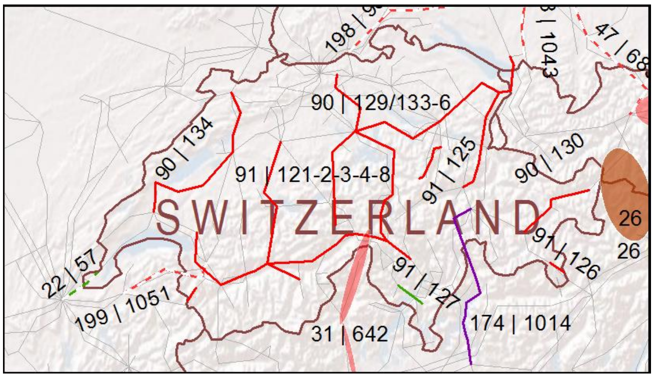
Comment on the CO2 indicator: the very high scores reflect that the project connects RES sources to load centres

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

Project 91: Swiss Ellipse

Description of the project

The project helps accommodating new pumping storage units which mainly support the increasing RES generation in the European areas with solar or wind generation.
While importing or exporting, the Swiss Ellipse project uses the capacity of the 'Italy - Switzerland' (31), 'Swiss Roof' (90) and 'France - Switzerland' (22) projects.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
121	Bickigen (CH)	Romanel (CH)	Construction of different new 400kV OHL sections and voltage upgrade of existing 225kV lines into 400kV lines. Total length: 250km.	900	Design & Permitting	2020	Delayed	long permitting procedure (comprising several phases)
122	Chippis (CH)	Lavorgo (CH)	Construction of different new 400kV line sections and voltage upgrade of existing 225kV lines into 400kV. Total length: 120km.	680	Design & Permitting	2020	Delayed	long permitting procedure (comprising several phases)
123	Mettlen (CH)	Ulrichen (CH)	Construction of different new 400kV line sections and voltage upgrade of existing 225kV lines into 400kV lines. Total length: 90km.	600	Planning	2019	Investment on time	Progress as planned.
125	Schwanden (CH)	Limmern (CH)	New 400kV double circuit (OHL and underground cable) between Schwanden and Limmern. OHL part	1000	Under Construction	2015	Investment on time	Progress as planned.
126	Golbia (CH)	Robbia (CH)	New 2x 400kV cable connection between Golbia and the Bernina line double circuit.	1000	Under Consideration	2019	Investment on time	Progress as planned.
127	Magadino (CH)	Verzasca (CH)	Upgrade of existing 150kV line into 220kV line.	400	Under Consideration	2020	Investment on time	Progress as planned.
128	Bâtiaz (CH)	Nant de Drance (CH)	New 400kV double circuit OHL between Bâtiaz and Châtelard. New 2x 400kV cable connection between Châtelard and Nant de Drance. Total length: 22km.	900	Design & Permitting	2020	Delayed	long permitting procedure (comprising several phases)

795	Schwanden (CH)	Limmern (CH)	New 400kV double circuit (OHL and underground cable) between Schwanden and Limmern. Underground cable part	1000	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)**
inside=>outside: 5000	outside=>inside: 5000	1	3	NA	NA	1100

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[18;23]	[170;200] MWh	0	[730;890]
Scenario Vision 2 - 2030	-	[21;26]	[1000;1300] MWh	0	[440;530]
Scenario Vision 3 - 2030	-	[200;250]	[36000;44000] MWh	0	[-480;-390]
Scenario Vision 4 - 2030	-	[310;380]	[230000;280000] MWh	0	[-800;-650]

Additional comments

Comment on the RES integration: avoided spillage concerns RES in Germany and hydro storage in Switzerland.

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.

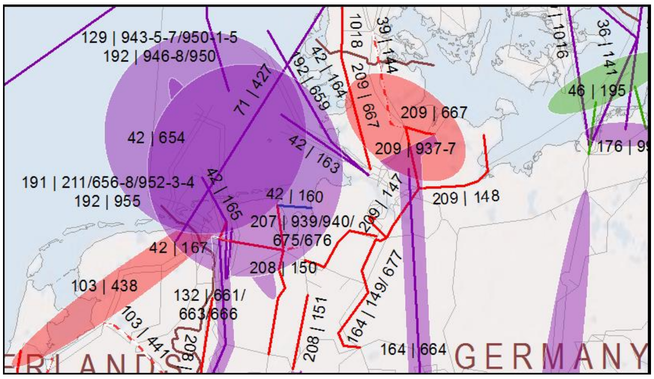
German Offshore wind parks connection

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.

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 contri bution (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.
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/year)**	**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

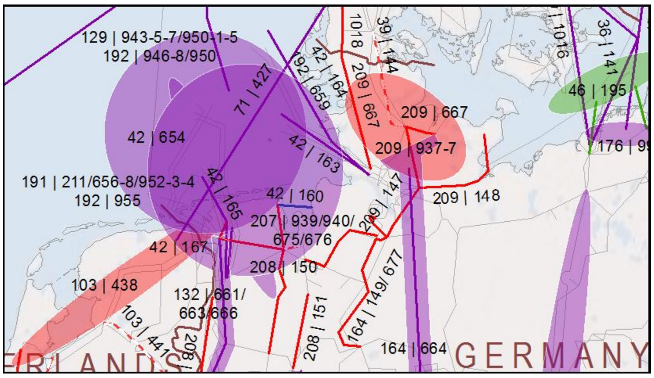
Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

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

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 contri bution (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

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/year)**	**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

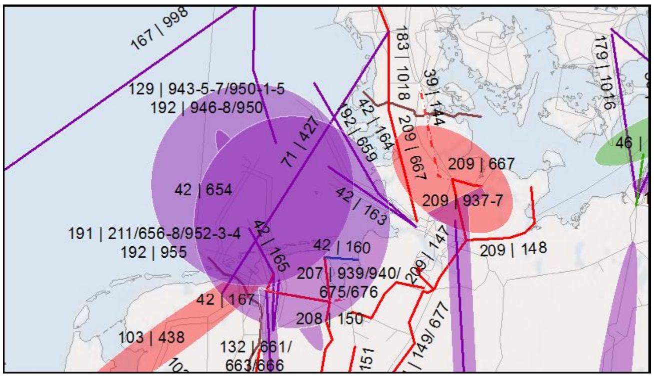
Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

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

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

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/year)**	**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

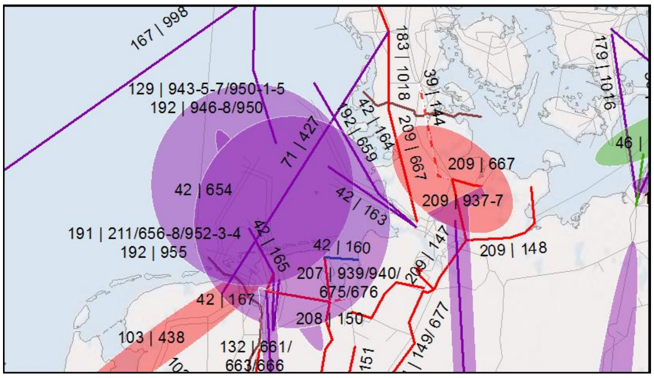
Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

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

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/year)**	**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

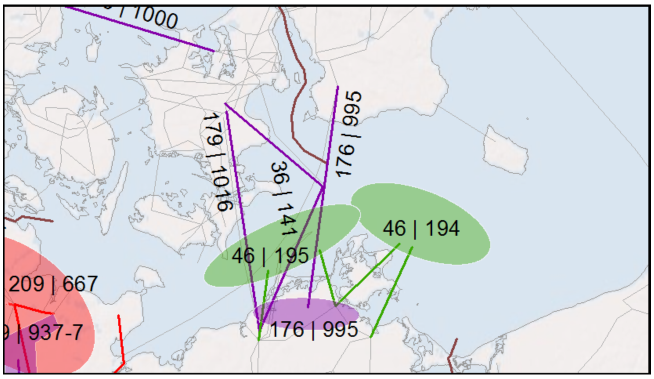
Comment on the Losses indicator: the losses variation for this direct connection project have not been valuated.

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

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/year)**	**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.

North South Eastern German Corridor

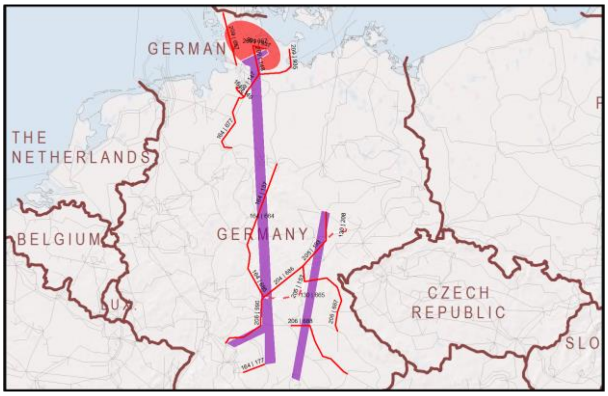
Description of the corridor

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 contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver

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 including two new	2264	Design & Permitting	2018	Delayed	delay due to long permitting process

			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 investment 153). The	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 permitting process with

			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.					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/year)**	**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

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 (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
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								
176	Daxlanden (DE)	Eichstetten (DE)	This AC project is necessary in order to evacuate the energy arriving from HVDC	754	Under Consideration	2020	Investment on time	Progress as planned.

			corridors towards southern Germany and reinforce the interconnection capacity with Switzerland					
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/year)**	**B5 CO2 Emissions (kT/year)**
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.

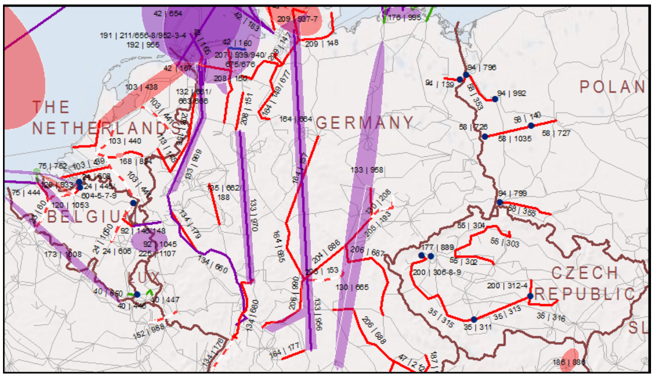
Comment on the technical resilience indicator:
The project is necessary to enable switch-off of assets for maintenance. The project includes VSC-DC-Links, which are necessary for (n-1)-security, voltage control and system stability.

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

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/year)**	**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.

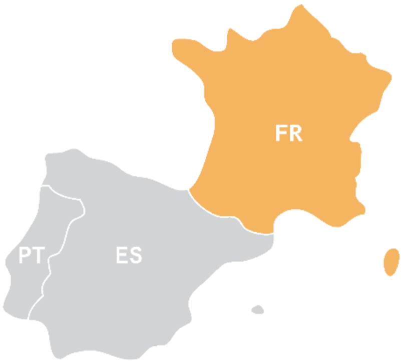
Comment on the S1 and S2 indicators:
Values for this project are not available due to the early state in the planning process

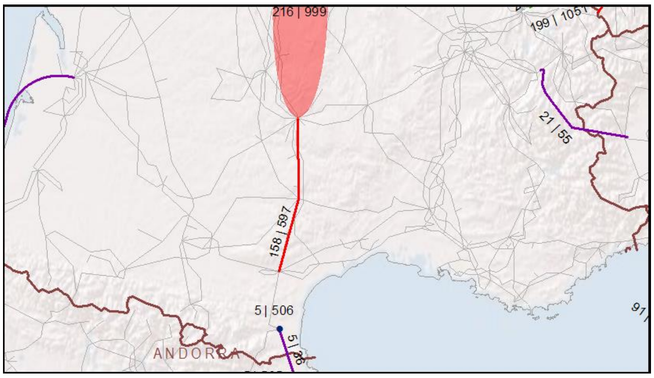
Comment on the technical resilience indicator:
The project is necessary to enable switch-off of assets for maintenance. The project includes VSC-DC-Links, which are necessary for (n-1)-security, voltage control and system stability.

Project 158: Massif Central South

Description of the project

The main driver for the project is the integration of existing and new wind &hydro generation in the Massif Central (France) including possible pump storage. The project will develop in the north-south direction, mainly consisting of a new 400kV line substituting to the existing one. For visions 3&4, it will be complemented by a northern part (project 216). In TYNDP2012, both parts were described as a single investment.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
597	La Gaudière (FR)	Rueyres (FR)	New 175-km 400kV double circuit OHL Gaudière-Rueyres substituting to the existing single circuit 400kV OHL	-	Under Consideration	2023	Investment on time	Studies conducted after TYNDP2012 release have led to better investment definition.

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: 3300	South=>North: 3800	2	2	NA	NA	300-400

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[18;22]	[90000;110000] MWh	[-41000;-33000]	[-220;-180]
Scenario Vision 2 - 2030	-	[18;22]	[90000;110000] MWh	[-41000;-33000]	[-220;-180]
Scenario Vision 3 - 2030	-	[85;100]	[540000;660000] MWh	[-99000;-81000]	[-770;-630]
Scenario Vision 4 - 2030	-	[85;100]	[540000;660000] MWh	[-99000;-81000]	[-770;-630]

Additional comments

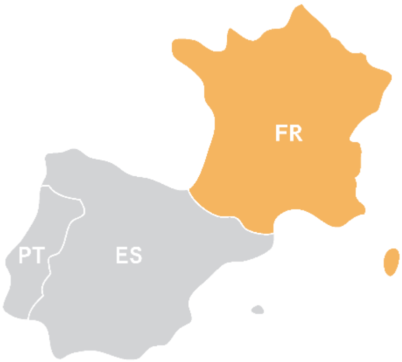
Comment on the RES integration: avoided spillage concerns RES in Massif central, wind farms and hydro.

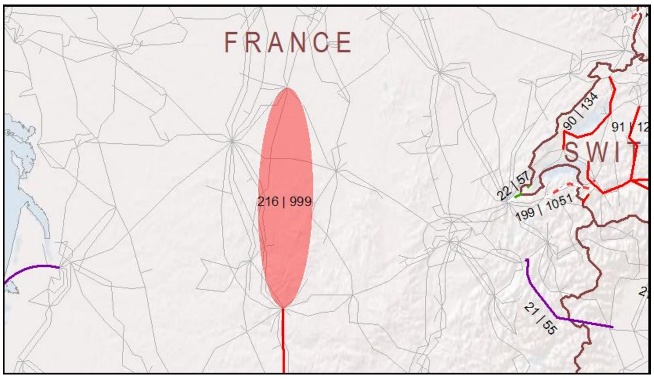
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Project 216: Massif Central North

Description of the project

The main driver of the project is the integration of existing and new wind&hydro generation in the Massif Central (France) including possible pump storage. The project will develop in the north to south direction, north of project 158 that it complements.
It is needed only for visions 3 and 4. Studies are ongoing to define the scope of the project.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
999	Marmagne	Rueyres	Erection of a new 400-kV double circuit line substituting an existing 400-kV single circuit line.	-	Under Consideration	2030	Investment on time	This long term investment is only needed for scenarios with high RES development in the area, especially wind and hydro; additional studies are needed for better investment definition.

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: 3300	South=>North: 3800	2	2	NA	NA	440-660

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 3 - 2030	-	[85;100]	[540000;660000] MWh	[-230000;-190000]	[-770;-630]
Scenario Vision 4 - 2030	-	[85;100]	[540000;660000] MWh	[-230000;-190000]	[-770;-630]

Additional comments

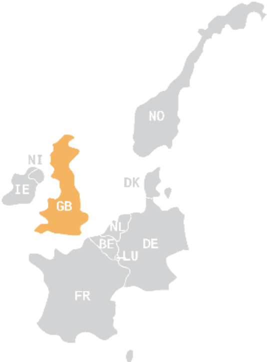
Comment on the RES integration: voided spillage relates directly to new hydro power plants in Massif central.

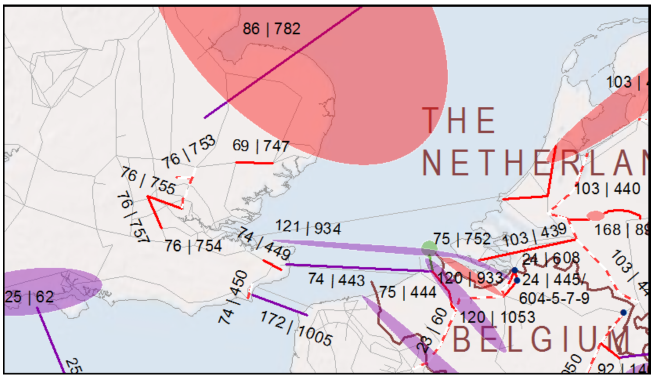
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Project 69: East Anglia Cluster

Description of the project

This group of investments are in response to an expected growth in offshore wind and nuclear generation in and around the Norfolk and East Anglia region.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
747	Bramford (GB)	Twinstead (GB)	Construction of a new transmission route from Bramford to the Twinstead Tee Point creating Bramford - Pelham and Bramford - Braintree - Rayleigh Main double circuits; the rebuild of Bramford substation and the installation of an MSC at Barking.	-	Design & Permitting	2022	Investment on time	Delay in project requirement due to generation going back.

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=>downstream: 3600	downstream=>inside: 3600	2	3	15-50km	Negligible or less than 15km	350-370

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[170;200]	[4000;4500] MW	[350000;450000]	[-8700;-9400]
Scenario Vision 2 - 2030	-	[160;200]	[4000;4500] MW	[360000;440000]	[-9900;-8100]
Scenario Vision 3 - 2030	-	[590;720]	[8600;11000] MW	[450000;550000]	[-6500;-5300]
Scenario Vision 4 - 2030	-	[580;720]	[8600;11000] MW	[440000;560000]	[-4900;-6900]

Additional comments

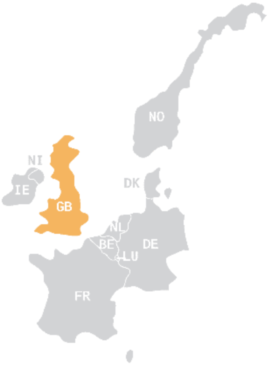
Comment on the clustering: the project also takes advantage of investment items n°748,749,750 depicted in the Regional investment plan.

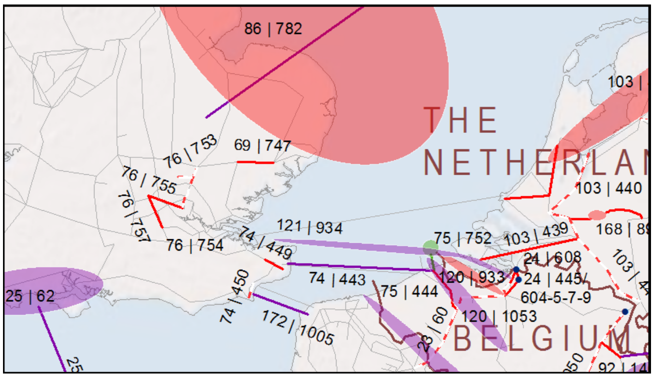
Comment on the RES integration: RES at stake is located north and east to London.
Comment on the CO2 indicator: the very high scores reflect that the project connects RES sources to load centres

Project 76: London Cluster

Description of the project

All of these investments are required due to a combination of age related asset replacement, increasing power flows and changing customer demand connection requirements. A further driver for all of these projects is that power flows through London increase during interconnector export to mainland Europe. Power flows from the north through London to the interconnectors within the Thames Estuary.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
753	Pelham (GB)	Waltham Cross (GB)	Reconductoring the existing circuit which runs from Pelham - Rye House - Waltham Cross with a higher rated conductor.	800	Design & Permitting	2021	Delayed	Postponed due to the slow build-up of generation in the East Anglia area and also in demand within London.
754	Hackney (GB)	Waltham Cross (GB)	Uprating and reconductoring of the Hackney - Tottenham - Brimsdown - Waltham Cross double circuits. Construction of a new 400kV substation at Waltham Cross and modifications to the Tottenham substation and the installation of two new transformers at Brimsdown substation.	800	Design & Permitting	2021	Delayed	Postponed due to the build-up of generation schemes in the East Anglia area and demand increases in London.
755	Hackney (GB)	St. John's Wood (GB)	This is a new Hackney - St. John's Wood 400kV double circuit. It will replace an old asset rated at 275kV that has come to the end of its life.	800	Under Construction	2018	Investment on time	Progress as planned.
757	St. John's Wood (GB)	Wimbledon (GB)	New St. John's Wood - Wimbledon 400kV double circuit.	800	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)**
North=>South: 800	South=>North: 800	2	1	NA	NA	760

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	[130;210]	[11;19]	[1600;2000] MW	[-290000;-410000]	[20000;40000]
Scenario Vision 2 - 2030	[160;240]	[14;22]	[1600;2000] MW	[-350000;-490000]	[24000;48000]
Scenario Vision 3 - 2030	[1200;1500]	[130;170]	[1600;2000] MW	[230000;330000]	[-9200;-10000]
Scenario Vision 4 - 2030	[1400;1800]	[170;220]	[1600;2000] MW	[290000;410000]	[-10000;-12000]

Additional comments

Comment on the CBA assessment: high values for SEW and SoS indicators reported in Visions 3 and 4 reflect much higher north south power flows, challenging the London grid. The project is key for the security of supply of London in these Visions.

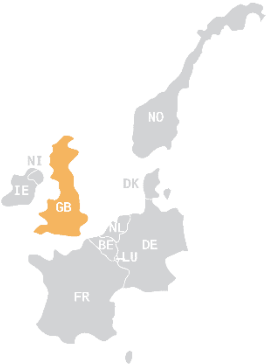
Comment on the clustering: the project also takes advantage of investment items n°756,758 depicted in the Regional investment plan.

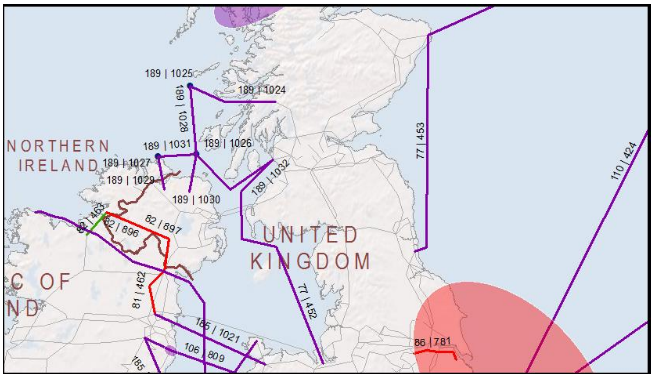
Comment on the CO2 indicator: the very high scores reflect that the project connects RES sources to load centres.

Project 77: Anglo-Scottish Cluster

Description of the project

These projects facilitate the connection of RES and the connection of the remote Scottish Islands.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
452	Hunterston (GB)	Deeside (GB)	A new 2.4GW (short term rating) submarine HVDC cable route from Hunterston to Deeside with associated AC network reinforcement works at both ends.	2400	Design & Permitting	2016	Investment on time	Progress as planned.
453	Peterhead (GB)	Hawthorn Pit (GB)	A new ~2GW submarine HVDC cable route from Peterhead to Hawthorn Pit with associated AC network reinforcement works at both ends with possible offshore HVDC integration in the Firth of Forth area.	2000	Under Consideration	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)**
North=>South: 4200	South=>North: 4200	2	1	NA	NA	3000

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[160;310]	[7500;8500] MW	0	[-9000;-11000]
Scenario Vision 2 - 2030	-	[240;330]	[7700;11000] MW	0	[-9000;-11000]
Scenario Vision 3 - 2030	-	[420;490]	[9300;12000] MW	[-600000;-900000]	[-18000;-20000]
Scenario Vision 4 - 2030	-	[520;600]	[11000;14000] MW	[-600000;-900000]	[-18000;-20000]

Additional comments

Comment on the clustering: the project also takes advantage of investment items n°454-457, 761-766, depicted in the Regional investment plan.

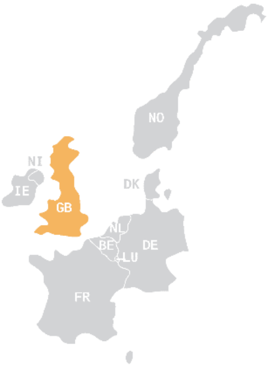
Comment on the CO2 indicator: the very high scores reflect that the project directly connects RES sources

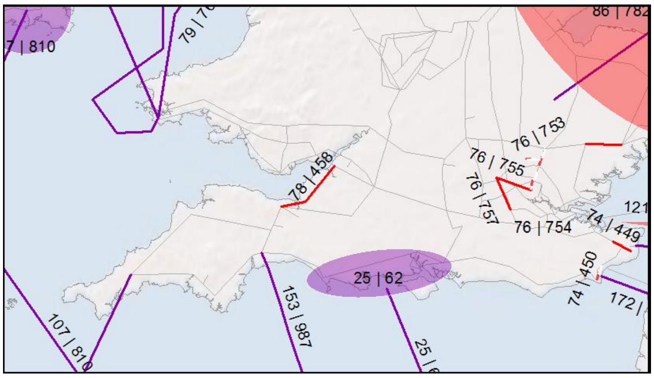
Comment on the S1 and S2 indicators: no indicator can be assessed as the project is still under consideration.

Project 78: South West Cluster

Description of the project

Project needed for renewables off of the South West peninsula, the replanting of Hinkley Point nuclear power station and further CCGT at Seabank.





Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
458	Hinkley Point (GB)	Seabank (GB)	New 400kV substation at Hinkley Point. New 400kV transmission route from Hinkley Point to Seabank. Reconstruction of Bridgewater substation for 400kV operation. Uprate Bridgewater - Melksham to 400kV.	-	Design & Permitting	2019	Investment on time	Based on current generation connection dates this investment is progressing 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)**
West=>East: 3200	East=>West: 3200	1	1	Negligible or less than 15km	Negligible or less than 15km	550

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[1600;1800]	1100 MW	[200000;240000]	[-290000;-390000]
Scenario Vision 2 - 2030	-	[2000;2300]	1100 MW	[200000;240000]	[-290000;-390000]
Scenario Vision 3 - 2030	-	[3500;3800]	[2000;4400] MW	[-300000;-400000]	[-810000;-890000]
Scenario Vision 4 - 2030	-	[4300;4700]	[3600;6000] MW	[-300000;-400000]	[-810000;-890000]

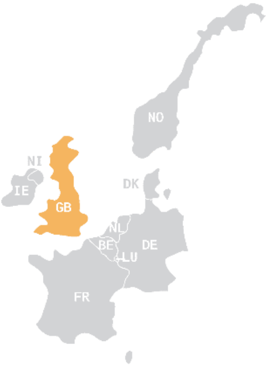
Additional comments

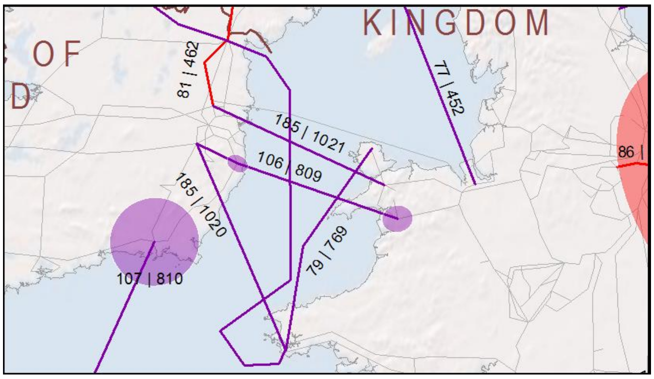
Comment on the RES integration: the very high scores reflect that the project directly connects RES sources.

Project 79: Wales Cluster

Description of the project

Reinforcement of the internal grid to facilitate the integration of nuclear plant and RES.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
769	Wylfa (GB)	Pembroke (GB)	A new ~2GW submarine HVDC cable route from Wylfa/Irish Sea to Pembroke with associated AC network reinforcement works at both ends.	-	Planning	2025	Rescheduled	Delayed due to anticipated changes in the local generation background.

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)**
West=>East: 2000	East=>West: 2000	2	1	50-100km	Negligible or less than 15km	780-790

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[15;240]	[2200;2800] MW	[-330000;-470000]	[-850;-1400]
Scenario Vision 2 - 2030	-	[140;170]	[2500;3500] MW	[-330000;-470000]	[-12000;-9900]
Scenario Vision 3 - 2030	-	[400;490]	[5200;9200] MW	[-44000;-64000]	[-19000;-20000]
Scenario Vision 4 - 2030	-	[520;610]	[6800;11000] MW	[-44000;-64000]	[-19000;-20000]

Additional comments

Comment on the clustering:
the project also takes advantage of investment items n°459-460, 767, 770, depicted in the Regional investment plan.

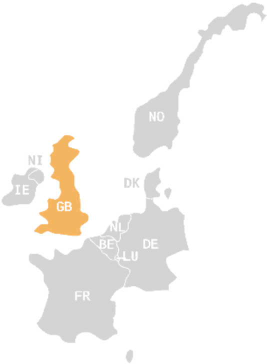
Comment on the RES integration: RES at stake is located in Wales

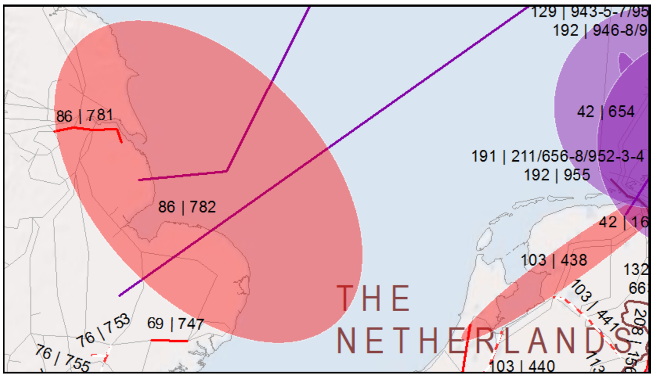
Comment on the CO2 indicator: the very high scores reflect that the project connects RES sources to load centres

Project 86: East Coast Cluster

Description of the project

A very high level indication of the works required for GB East Coast. In detail the projects will consist of multiple offshore HVDC and AC circuits and connecting platforms joining to multiple onshore connection points with their own reinforcement requirements.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
781	Under Consideration (GB)	Under Consideration (GB)	A very high level indication of the works required for GB East Coast. In detail the projects will consist of multiple offshore HVDC and AC circuits and connecting platforms joining to multiple onshore connection points with their own reinforcement requirements. It enables significant connection of offshore wind farms and provides alternative to onshore reinforcement at a cheaper overall cost.	3000	Under Consideration	2023	Investment on time	Progress as planned.
782	Under Consideration (GB)	Under Consideration (GB)	Connection of Triton Knoll, Doggerbank & Hornsea GB Wind Farms and all associated works. This is in the region of 11GW of offshore generation.	3000	Under Consideration	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)**
East=>West: 3000	West=>East: 3000	2	2	NA	NA	3400-3600

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[58;110]	[5700;7700] MW	0	[-26000;-30000]
Scenario Vision 2 - 2030	-	[81;140]	[7500;11000] MW	0	[-26000;-30000]
Scenario Vision 3 - 2030	-	[680;920]	[16000;21000] MW	[-1500;-1900]	[-33000;-38000]
Scenario Vision 4 - 2030	-	[920;1000]	[20000;27000] MW	[-1500;-1900]	[-32000;-38000]

Additional comments

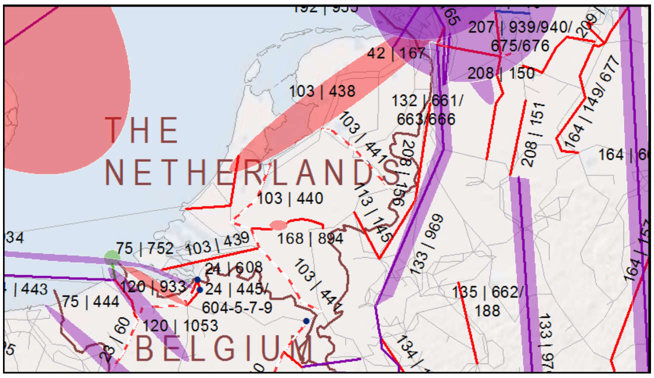
Comment on the RES integration: the very high scores reflect that the project directly connects RES sources

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

Dutch ring

Description of the corridor

The “Dutch ring” associates to project 103 a second phase “Spaak” (project 168), spanning overall from 2017 to 2025.
The project reinforces the Dutch grid to accommodate new conventional and renewable generation, to handle new flow patterns and to facilitate the cross-border capacity increase with neighbouring countries.
The two projects have been assessed as a whole and share the same common assessment.



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
Project 103								
438	Eemshaven (NL)	Diemen (NL)	New 175-200km AC overhead line with capacity of 2x2650 MVA of 380kV. In the first phase a connection between Eemshaven Oude Schip and Vierverlaten will be built as well as an upgrade of the existing line Diemen - Lelystad - Ens	125	Design & Permitting	2018	Investment on time	Changes in plans of thermal plants at Eemshaven offers the opportunity to phase the grid expansions. The a first phase consists of a new 380 kV connection between Eemshaven-Oudeschip and Vierverlaten and the upgrade the circuits form Diemen-Lelystad-Ens
439	Borssele (NL)	Tilburg (NL)	New 100-130km double-circuit 380kV OHL with 2x2650 MVA capacity.	125	Design & Permitting	2016	Investment on time	With a 380 kV substation at Rilland, the Zuid-West 380 kV project can be taken into service in two parts. The first part consists of the Borssele - Rilland line including substation Rilland and the second part consist of the Rilland – Tilburg line.
440	Maasvlakte (NL)	Beverwijk (NL)	New 380 kV double-circuit mixed project (OHL+ underground cable) including approximately 20km of underground cable for 2650 MVA. The cable sections are a pilot project. The total length of	125	Under Construction	2017	Delayed	Permitting procedures took longer than expected. The part from Maasvlakte to Bleiswijk has been commissioned.

			cable at 380kV is frozen until more experience is gained.					
441	Zwolle (NL)	Maasbracht (NL)	Upgrade of the capacity of the existing 300km double circuit 380kV OHL to reach a capacity of 2x2650 MVA along the Dutch Central ring (Hengelo-Zwolle-Ens Diemen-Krimpen-Geertruidenberg-Eindhoven-Maasbracht)	125	Under Consideration	2019	Investment on time	The investment is merged with the Ring Zuid project
Project 168								
894	Sliedrecht area	Dodewaard	New Overhead line from Sliedrecht to Dodewaard of 2x2633 MVA in Wintrack, 65 km	-	Under Consideration	2025	New Investment	This new investment has been identified as a beneficial project in the NSCOGI study and is part of the national 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)**
NL=>DE: 500	DE=>NL: 500	1	3	More than 100km	More than 50km	1800-3100

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	0	0	[-190000;-160000]	[13;16]
Scenario Vision 2 - 2030	-	0	0	[-190000;-160000]	[-27;-22]
Scenario Vision 3 - 2030	-	[5;15]	[45000;55000] MWh	0	[-210;-180]
Scenario Vision 4 - 2030	-	[5;15]	[23000;28000] MWh	0	[-270;-220]

Additional comments

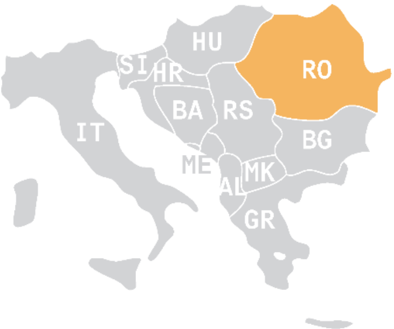
Comment on the security of supply: The project enables the long term high level of Security of Supply in The Netherlands.

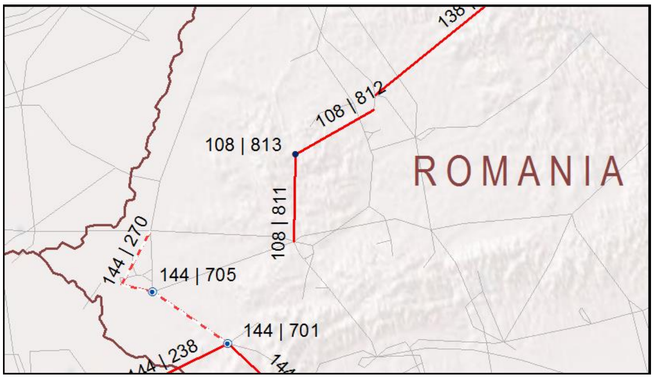
Comment on the RES integration: avoided spillage concerns RES in the Netherlands as a whole

Project 108: 1000MW HPS Tarnita connection

Description of the project

The project consists of two double circuit 400-kV lines that are needed to connect to the grid the future 1000MW Hydro Pumped Storage Tarnita-Lapustesti, situated in the North-West of Romania. The project will supply reserve/balancing services for Romania and possibly for neighboring countries (Hungary, Serbia, Bulgaria, other). It will support integration of intermittent RES generation.





Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
811	Tarnita (RO)	Mintia (RO)	New double circuit 400kV OHL Tarnita(RO)-Mintia(RO) 2x1380 MVA.	1000	Planning	2018	Investment on time	The project shall be built only if the Hydro Pumped Storage plant shall be built. Final investment decision is pending.
812	Tarnita (RO)	Cluj E - Gadalin (RO)	New double circuit 400kV OHL Tarnita(RO)- Cluj E-Gadalin (RO) 2x1380 MVA.	1000	Planning	2018	Investment on time	The project shall be built only if the Hydro Pumped Storage plant shall be built. Final investment decision is pending.
813	Tarnita (RO)		New 400kV substation connecting 1000 MW Hydro Pumped Storage Tarnita Lapustesti to the grid.	1000	Planning	2018	Investment on time	The project shall be built only if the Hydro Pumped Storage plant shall be built. Final investment decision is pending.

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=>outside: 1000	outside=>inside: 1000	3	3	Negligible or less than 15km	Negligible or less than 15km	100-170

CBA results	for each scenario				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[9;12]	[35000;43000] MWh	[-47000;-39000]	[400;490]
Scenario Vision 2 - 2030	-	[4;5]	[9900;12000] MWh	[-21000;-17000]	[250;310]
Scenario Vision 3 - 2030	-	[3;4]	[19000;23000] MWh	[-200000;-170000]	[-46;-37]
Scenario Vision 4 - 2030	-	[94;120]	[660000;800000] MWh	[51000;62000]	[-550;-450]

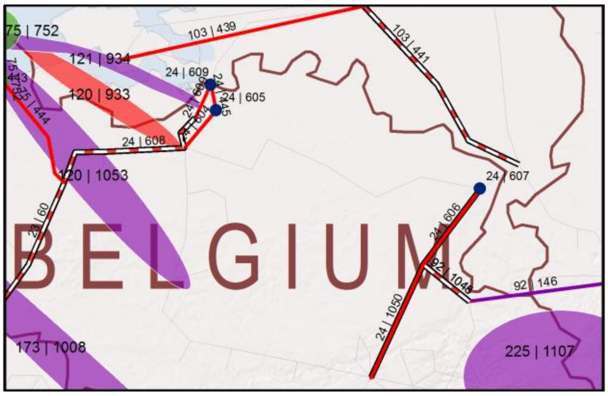
Additional comments

Project 24: Belgian North Border

Description of the project

The need to reinforce the Belgian North Border is driven by a congruation of factors
- ensuring reliable grid cooperation in a context of increasing & more volatile international fluxes on Belgian's north-south axis (Zandvliet to Horta; Van Eyck to Gramme) which could cause internal congestions and negatively effect market capacity
- desire to further develop market capacity between Belgium & the Netherlands with +- 1000 MW
- possible connection of new central production units on these north-south axis: potential projects exist on each axis of 900-1000 MW each
- increasing industrial demand around Antwerp harbour area

The project as such consists of the following subprojects facilitating its realization in a modular way:
- Brabo & PST4 (+upgrade Doel-Zandvliet): integration of 4th PST on Belgian North Border and the realization of a new 380kV circuit via Lillo creating a parallel path to the existing Zandvliet-Mercator connection
- Horta-Mercator in HTLS: the upgrade of this central link to transport fluxes between France, Stevin & the Netherlands consists in replacing the existing 380kV double circuit with high-performance conductors (HTLS).
- Gramme-Van Eyck: capacity increase by going from 1 to 2 380kV circuits and creating a subsequent substation Van Eyck
- Gramme-Van Eyck + Massenhoven-Meerhout-Van Eyck: the need to futher upgrade these axis has been identified but depends heavily on the evolution of production in the Limburg-Liège area in combination with the evolution of the (transit)flux, and will as such be further monitored



Investment index	Substation 1	Substation 2	Description	GTC contri bution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
445	Zandvliet (BE)	Lillo (BE)	Brabo: part Zandvliet-Lillo: Brabo allows to realize the intended market capacity increase on the North Border in a more robust way (greater	1000	Design & Permitting	2018	Delayed	Permitting procedure for adapation of land use (GRUP) had to be reinitiated, in order to comply with the demand of

			scenario independence compared to PST 4 only), and reinforces the network to facilitate increased demand and connection of possible new generation around Antwerp Harbor area. It consists of constructing a new 380kV circuit Zandvliet-Lillo (new substation)-Mercator, in addition to the existing Zandvliet - Mercator connection. This investment item concerns the part between Zandvliet and Lillo substations.					investigating alternative solutions.
604	Lillo (BE)	Mercator (BE)	Brabo: part Lillo-Mercator + restructuring 150kV. Brabo allows to realize the intended market capacity increase on the North Border in a more robust way (greater scenario independence compared to PST 4 only), and reinforces the network to facilitate increased demand and connection of possible new generation around Antwerp Harbor area. It consists of constructing a new 380kV circuit Zandvliet-Lillo (new substation)-Mercator, in addition to the existing Zandvliet - Mercator connection. This investment item concerns the part between Lillo and Mercator substations, involving a restructuring of the adjacent 150kV network.	1000	Design & Permitting	2018	Delayed	Permitting procedure for adapation of land use (GRUP) had to be reinitiated, in order to comply with the demand of investigating alternative solutions.
605	Lillo (BE)		Brabo - substation Lillo 380: Brabo allows to realize the intended market capacity increase on the North Border in a more robust way (greater scenario independence compared to PST 4 only), and reinforces the network to facilitate increased demand and connection of possible new generation around Antwerp Harbor area.	1000	Design & Permitting	2018	Delayed	'Permitting procedure for adapation of land use (GRUP) had to be reinitiated, in order to comply with the demand of investigating alternative solutions.

			It consists of constructing a new 380kV circuit Zandvliet-Lillo (new substation)-Mercator, in addition to the existing Zandvliet - Mercator connection. This investment item concerns the erection of new 380kV substation Lillo.					
606	Gramme (BE)	Van Eyck (BE)	Gramme-Van Eyck: second 380kV circuit First phase of reinforcement on the axis Gramme-Van Eyck, needed to facilitate connection of possible new central generation and to prepare for increasing transit fluxes whilst securing market capacity between BE & NL. This investment consist of creating a second 380kV line on the axis Gramme-Van Eyck - Section Van Eyck - Zutendaal (30 km): need to erect a new single circuit. Done with high performance conductors in order to be future proof (cfr. phase 2) - Section Grammme - Zutendaal (55km): reconfiguration of 150kV network so that an existing 150kV line can be operated at 380kV	1400	Under Construction	2015	Delayed	Implementation of the project has been aligned with maintenance period of nuclear units ==> commissioning now foreseen in 2015 instead of end 2014
607	Van Eyck (BE)		Gramme-Van Eyck: substation Van Eyck 380 First phase of reinforcement on the axis Gramme-Van Eyck, needed to facilitate connection of possible new central generation and to prepare for increasing transit fluxes whilst securing market capacity between BE & NL. This investment item consists of construction a 380kV substation named "Van Eyck", needed to integrate the second 380 kV line on the axis Gramme-Van Eyck.	1400	Under Construction	2015	Delayed	Commissioning date of this inv. item aligned with implementation of inv. item 606 thus now 2015 instead of 2014
608	Horta (BE)	Mercator (BE)	Horta-Mercator in HTLS The axis Horta-Mercator needs to be upgraded in order to transport the	1500	Design & Permitting	2019	Investment on time	The expected commissioning date of 2019 is based on the hypothesis of acquiring

			envisioned higher fluxes between France, Stevin & the Netherlands, and to facilitate connection of possible new generation (+-1000 MW) . Upgrade consists of replacing the current double circuit 380kV by high performance conductors allowing to double its transport capacity. The line currently passing Mercator going to Doel will be integrated into Mercator substation to obtain a better flux balance and avoid an upgrade between Mercator & Doel at this stage.					all necessary permits as planned, followed by the assessment of the final investment decision in 2016. Meanwhile the drivers behind this investment will be further monitored and its timing managed accordingly.
609	Zandvliet (BE)		BE PST 4 (+upgrade Zandvliet - Doel): New PST in Zandvliet substation making it the 4 th PST on the Belgian North Border, allowing a more symmetrical utilization of the PST's. Enabling this PST to increase import capacity from NL to BE implies that the current 150kV line Zandvliet-Doel is converted to 380kV, involving adaptations to be made to the configurations of Zandvliet & Doel substations and a solution to cover the supply of Doel 150kV (probably transformer 380/150). Integrating this PST at Zandvliet also implies that a "langskoppeling" is put at Zandvliet as temporary interface between Zandvliet and the NL network until the post "Rilland" is constructed in NL (investment item 439 as part of project # 103 "Reinforcements Ring NL"). Note that the realisation of investment item 439 is needed as well to allow a capacity increase direction BE to NL.	1000	Under construction	2016	Investment on time	Installation of PST (plus upgrade of line Doel-Zandvliet) will be done as a first reinforcement in the Antwerp area. The PST has been ordered, as such the status of this investment is "under construction" with an expected commissioning date of 2016.
1050	Gramme (BE)	Massenhoven (BE)	Conditional: Gramme-Van Eyck + Massenhoven-Meerhout-Van Eyck	1400	Planning	2020	Investment on time	This investment is a split off from invest item 445a from in TYNDP 2012, and

			Envisions to double the transport capacity by upgrading the Gramme-Van Eyck axis to high-performance conductors, and by putting a second 380kV circuit on the Massenhoven-Meerhout-Van Eyck axis. The need to upgrade is conditional to the evolution of production in the LImburg-Liège area and to the evolution of the physical (transit)flux towards 2020-2025. This need will be further monitored.					complemented with the Massenhoven-Meerhout-Van Eyck section. This investment is subject to further monitoring towards 2020-2025 given its dependency on production in the area in combination with evolution of the (transit)flux.

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=>BE: 1000-1500	BE=>NL: 1000-1500	5	2	15-50km	25-50km	350-450

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
S1 EU202020 - 2020	[300;570]	[18;22]	[45000;55000] MWh	0	[0;500]

Additional comments

Comment on the security of supply: A reinforced interconnector contributes to the security of supply of Belgium as a whole, since it offers market players additional import capacity which they can use to balance their portfolio provided that excess generation is available abroad. 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.

Additionally, the BRABO project ensures the SoS of the Antwerp Harbor.

Project 230: North Seas offshore grid infrastructure scheme

Description of the project

19 projects of the TYNDP 2014 (including 3 proposed by non-ENTSO-E members) develop into a global scheme for offshore grid infrastructure in the North Seas. This total scheme including its assessment is presented below.

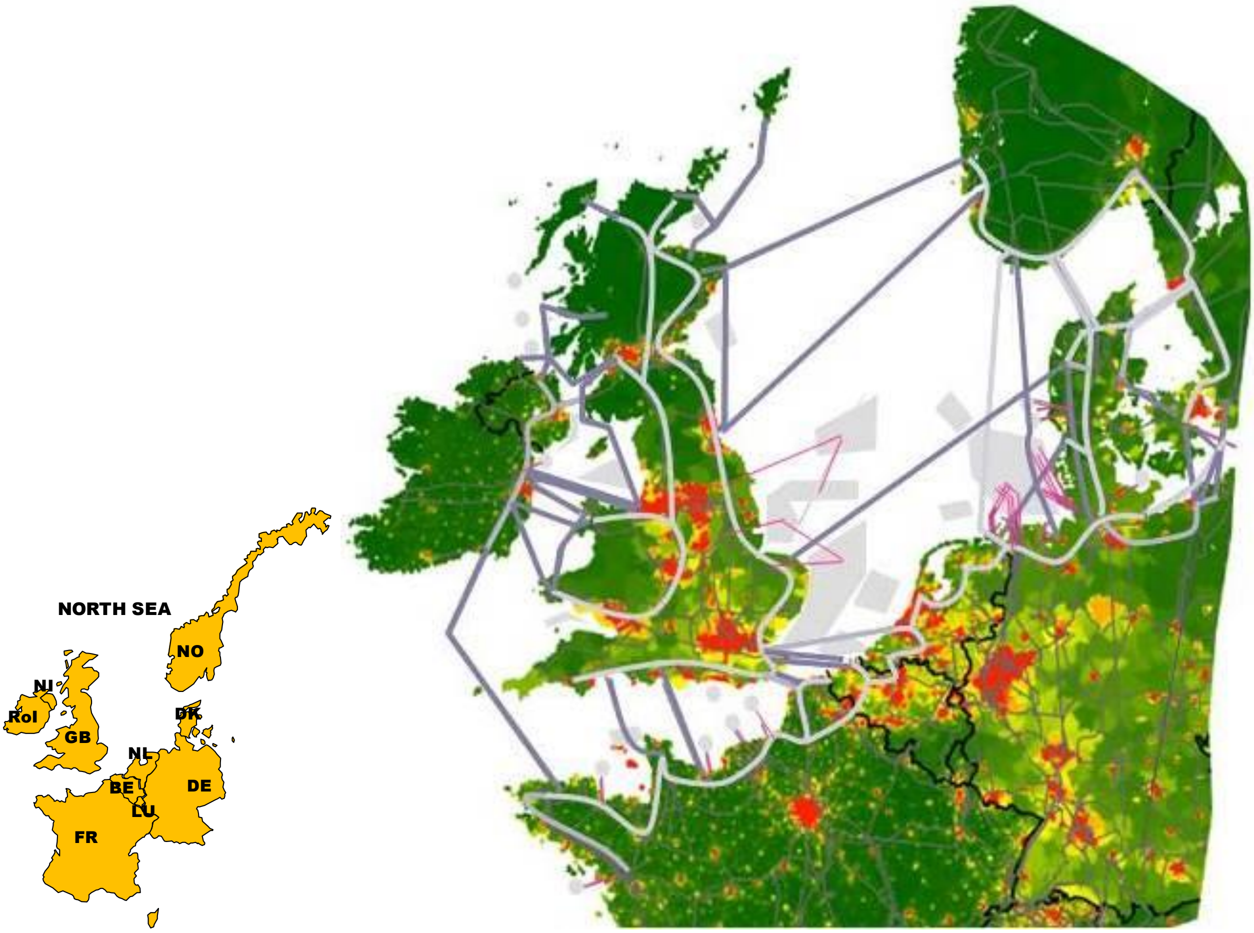
The 19 projects combine altogether and complete existing assets in order to enable the integration of wind generation (on- and offshore) and increase the interconnection level between the regions's synchronous areas and neighbouring countries as well. The interconnections crossing the Northern Seas waters are completed with onshore reinforcements.

The offshore grid infrastrucute represents more than 10000 km of new DC subsea cables by 2030 in the area. Every element is taylor-made and the proposed scheme below highlights astutely both, new assets and existing ones (both offshore and onshore) to maximise its efficiency.

Four projects of the TYNDP combine both generation connection and interconnection capability between countries in the North Seas and constitute so called "hybrid projects": Kriegers' flak combined grid solution, FAB (France-Alderney-Britain), BOG (Belgian offshore grid) depending on how its design will be finalized and potentially Isles. Only three of them resort to offshore hubs to support the two functions (FAB's intermediate hub is the Alderney island). Such a design appears the exception, where the rule is on the one hand the connection of offshore wind farms to shore (through dedicated AC or DC offshore hubs), and on the other hand a point to point interconnection to connect countries. Such a separated design saves costs, as it often appears cheaper to build and operate the large AC/DC converter station required by interconnection *onshore* instead of offshore. In some specific cases does the scheduling and technology required for interconnection and wind connection (DC or AC, voltage level) actually match so that a compact design offshore could be envisaged.

Different geographical conditions leads locally to different optima and ENTSO-E concludes to a design which takes advantage of all possible connection and interconnection models. Except in the examples mentioned above hybrid projects do not appear yet. The RegIP from the North Sea Region shows that integrating ("meshing") emerges at specific locations and further optimizations in the design of the offshore grid infrastructure will by nature be part of the further planning process.

The overall scheme is expected to save between € 1.0 billion per year and € 4.1 billions per year depending on the Visions, for a cost of about € 17 – 22 billions.



Investment index	Substation 1	Substation 2	Description	GTC contribution (MW)	Present status	Expected date of commissioning	Evolution since TYNDP 2012	Evolution driver
62	Tourbe (FR)	Chilling (GB)	New subsea HVDC VSC link between the UK and France with a capacity around 1000 MW. PCI 1.7.2 (NSCOG corridor)	-	Design & Permitting	2020	Investment on time	Extensive feasibility studies (e.g. seabed surveys) have been conducted to determine the most suitable route; on the French side, the ministry of energy acknowledged the notification of the investment on 08/04/14.
987	Cotentin Nord	Exeter	France-Alderney-Britain (FAB) is a new 220km-long HVDC subsea interconnection between Exeter (UK) and Cotentin Nord (France) with VSC converter station at both ends. Expected rated capacity is 2*700 MW.	-	Planning	2020	New Investment	Studies conducted after TYNDP2012 release have shown the economic viability of this interconnection and lead to develop this investment. Feasibility studies (marine surveys) are starting to find a suitable subsea route.
1005	Sellindge (UK)	Le Mandarins (FR)	Eleclink is a new FR – UK interconnection cable thought the channel Tunnel between Selindge (UK) and Mandarins (FR). Converter stations will be located on Eurotunnel concession at Folkestone and Coquelles. This HVDC interconnection is a PCI project (Project of common interest).	-	Design & Permitting	2016	New Investment	

			It will increase by 1GW the interconnection capacity between UK and FR by 2016.					
443	Richborough (GB)	Zeebrugge (BE)	Nemo Project: New DC sea link including 135km of 400kV (voltage level is subject to outcome of detailed engineering) DC subsea cable with 1000MW capacity	1000	Design & Permitting	2018	Investment on time	Investment on time, with a technical commissioning planned end 2018 leading to commercial operation in 2019
449	Richborough (GB)	Canterbury (GB)	New 400kV double circuit and new 400kV substation in Richborough connecting the new Belgium interconnector providing greater market coupling between the UK and the European mainland.	1000	Planning	2018	Investment on time	Progress as planned.
450	Sellindge (GB)	Dungeness (GB)	Reconductoring the existing circuit which runs from Sellindge - Dungeness with a higher rated conductor. This will facilitate the connection of more interconnectors on the South coast and prevent thermal overloading of this area.	400	Design & Permitting	2015	Investment on time	Progress as planned.
934	Kemsley (UK) for example - TBD	Doel/Zandvliet (BE) for example - TBD	NEMO 2: UK to BE 380kV inland This investment item envisions the possibility of a second 1GW HVDC connection, between UK (Kemsley) and a Belgian 380kV substation further inland in the Antwerp area (Doel, Zandvliet are indicative locations). Subject to further studies.	-	Under Consideration	2030	New Investment	Preliminary studies on vision 3&4 scenario's have indicated potential for further regional welfare & RES integration increase by further increasing the interconnection capacity between Belgium & UK up to 2 GW.
810	Great Island or Knockraha (IE)	La Martyre (FR)	A new HVDC subsea connection between Ireland and France	-	Under Consideration	2025	Investment on time	Feasibility studies are progressing
809	Dunstown (IE)	Pentir (GB)	A new HVDC subsea connection between Ireland and Great Britain; this may be achieved by a direct link or by integrating an interconnector with a third party connection from Ireland to GB.	-	Under Consideration	2025	Investment on time	Joint studies between National Grid and EirGrid indicate a strong benefit for a second interconnector between Ireland and GB.
1020	Dunstown	Pembroke	Greenwire Interconnector spur 1, enables additional 500MW of interconnection between UK and Irish market	500	Planning	2018	New Investment	Opportunity to connect Irish RES to GB market
1021	Woodland	Pentir	Greenwire Interconnector spur 2, enables additional 1000MW of interconnection between UK and Irish market	1000	Planning	2017	New Investment	Project application to TYNDP 2014.
1113	Glinsk 400kV	Connah's Quay 400kV	1500 MW HVDC VSC cable	-	Planning	2018	New Investment	Project application for TYNDP 2014.
1024	Cruachan	Argyll hub	HVDC link between Cruachan (onshore) to Argyll offshore hub	1000	Under Consideration	2030	New Investment	The ISLES project will serve the development of multiple offshore generation resources in the waters of Scotland, Ireland and Northern Ireland and facilitate increased inter-connection between the GB and the SEM on the island of Ireland.
1025	Argyll hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	1000	Under Consideration	2030	New Investment	
1026	Coleraine hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	1000	Under Consideration	2030	New Investment	
1027	Coolkeeragh hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	1000	Under Consideration	2030	New Investment	
1028	Argyll	Coleraine	HVDC link between Argyll offshore hub and Coleraine offshore hub	1000	Under Consideration	2030	New Investment	

1029	Coolkeeragh	Coolkeeragh hub	HVDC link between Coolkeeragh onshore and Coolkeeragh offshore hub	1000	Under Consideration	2030	New Investment	
1030	Coleraine	Coleraine hub	HVDC link between Colerain onshore and Coleraine offshore hub	1000	Under Consideration	2030	New Investment	
1031	Coleraine hub	Coolkeeragh hub	HVDC link between Coleraine offshore hub and Coolkeeragh offshore hub	1000	Under Consideration	2030	New Investment	
1032	Hunterston	Coleraine hub	HVDC link between Hunterston (onshore) to Argyll offshore hub	1000	Under Consideration	2030	New Investment	
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.
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.
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.
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.
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	2020	New Investment	New opportunity to integrate markets, new opportunity to exploit non correlated RES
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.
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
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.
995	Station SE4	Station DE	New DC cable interconnector between Sweden and Germany.	700	Under Consideration	2025	New Investment	RGBS common investigations for TYNDP 2014

996	LV-Grobina	SE3	A new HVDC link between LV-SE3, only as alternative of interconnector DE-SE4	600	Planning	2030	New Investment	Market integration

CBA results

The tables below summarize the Cost Benefits Analysis results of this portfolio of offshore projects.

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)**
Irland / GB : +5 GW Irland & GB / mainland: +10 GW NO & SE / DK & DE: +5 GW DK / DE & NL : +2 GW		2	5	More than 100km	15-25 km	17000-22000

CBA results	**for each scenario**				
Scenario	**B1 SoS (MWh/year)**	**B2 SEW (MEuros/year)**	**B3 RES integration [TWh]**	**B4 Losses (MWh/year)**	**B5 CO2 Emissions (kT/year)**
Scenario Vision 1 - 2030	-	[1600 – 2300]	[10-15]	[4.8;5.8] TWh	[-5.7;-6.9] Mt/yr
Scenario Vision 2 - 2030	-	[1000 - 1600]	[3-5]	[4.5;5.6] TWh	[-5.3;-6.5] Mt/yr
Scenario Vision 3 - 2030	-	[2900 - 4000]	[20-25]	[5.2;6.3] TWh	[-19.3;-23.6] Mt/yr
Scenario Vision 4 - 2030	-	[3500 - 4100]	[25-30]	[5.4;6.6] TWh	[-20.8;-25.5] Mt/yr

Additional comments

Comment on the RES indicator: spillage occurs almost exclusively in Ireland and Great-Britain.

Comment on the CBA assessment: by exception, CBA clustering rules are not complied with for this project, but they are for all its contributing parts. The offshore grid project integrates a certain capacity of offshore wind into the system, ranging up to 112 GW in vision 4. The RES indicator refers to the amount of RES spillage that is being avoided due to the market integration effect of this project, knowing that in vision 3 and 4 potential remains for further developments (there is still RES spillage left).

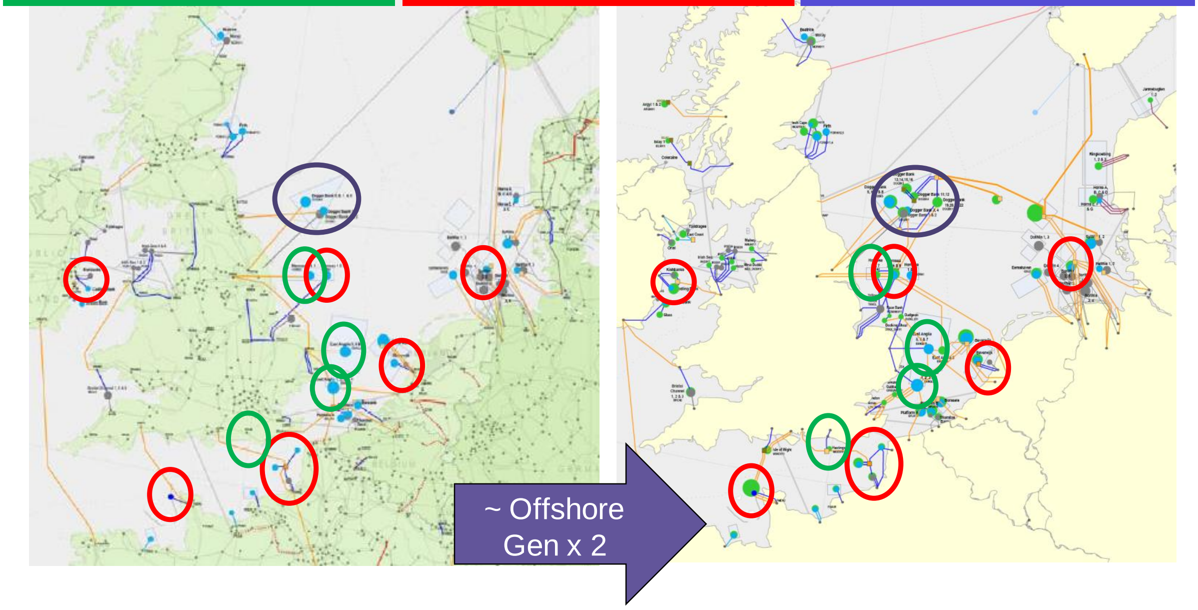
Furthermore, the socio-economic welfare in visions 1 and 2 are based on target capacities which do not reflect the full benefits of this integrated offshore grid. As such caution has to be applied when comparing costs to benefits.

General comment:
The present scheme is a basis, that will further develop with wind farms development, as indicated in the picture below, originating from NSCOGI grid study, which has further been analysed for the TYNDP 2014, see RegIP RGNS, chapter 10:

🟩 DC link later paralleled with AC

🟥 AC link later paralleled with DC

🟦 DC link to large AC offshore Island



~ Offshore Gen x 2

12.1.2 List of projects and investments within the region

The table below depicts both projects and investments of pan-European and Regional significance within the North 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
5	**Eastern interconnection ES-FR**								
		36	Sta.Llogaia (ES)	Baixas (FR)	New HVDC (VSC) bipolar interconnection in the Eastern part of the border, via 320kV DC underground cable using existing infrastructures corridors and converters in both ending points.	2015	Under Construction	Delayed	Answering all concerns expressed during the authorization process in Spain and environmental issues in France led to postponing the investment. Both issues are solved by now.
		505	Sta.Llogaia (ES)		Converter station of the new HVDC (VSC) bipolar interconnection in the Eastern part of the border, via 320kV DC underground cable using existing infrastructures corridors.	2015	Under Construction	Delayed	Works completed in 2014; commercial operation expected after test period at the same time as the cable (investment 36).
		506	Baixas (FR)		Converter station of the new HVDC (VSC) bipolar interconnection in the Eastern part of the border, via 320kV DC underground cable using existing infrastructures corridors.	2015	Under Construction	Delayed	Works completed in 2014; commercial operation expected after test period at the same time as the cable (investment 36).
16	**Western interconnection FR-ES**								
		38	Gatica (ES)	Aquitaine (FR)	New HVDC interconnection in the western part of the border via DC subsea cable in the Biscay Gulf.	2022	Planning	Investment on time	The technical consistency of the project progresses and the commissioning date is now defined more accurately.
21	**Italy-France**								
		922	Rondissone (IT)	Trino (IT)	Removing limitations on the existing 380 kV Rondissone-Trino	2019	Planning	New Investment	The item contributes to get the full advantage of the new HVDC cables was planned for the first time in the italian National Development Plan 2013

		923	Lacchiarella(IT)	Chignolo Po(IT)	Removing limitations on the existing 380 kV Lacchiarella-Chignolo Po	2019	Planning	New Investment	The item contributes to get the full advantage of the new HVDC cables was planned for the first time in the italian National Development Plan 2013
		924	Vado (IT)	Vignole (IT)	Removing limitations on the existing 380 kV Vado-Vignole and Vignole-Spezia	2019	Planning	New Investment	The item contributes to get the full advantage of the new HVDC cables was planned for the first time in the italian National Development Plan 2013
		55	Grande Ile (FR)	Piossasco (IT)	"Savoie - Piémont" Project : New 190km HVDC (VSC) interconnection FR-IT via underground cable and converter stations at both ends (two poles, each of them with 600MW capacity). The cables will be laid in the security gallery of the Frejus motorway tunnel and also along the existing motorways' right-of-way.	2019	Under Construction	Delayed	After some delay in the works of the Frejus service gallery of the motorway, in which the cables will be installed, the project timeline has been updated. Works are already in progress.
22	**Lake Geneva West**								
		57	Genissiat (FR)	Verbois (CH)	Reconductoring of the exisiting 225kV double circuit line Genissiat-Verbois with high temperature conductors.	2020	Planning	Investment on time	-
23	**France-Belgium Phase 1**								
		60	Avelin/Mastaing (FR)	Horta (new 400-kV substation) (BE)	Replacement of the current conductors on the axis Avelin/Mastaing - Avelgem - Horta with high performance conductors (HTLS = High Temperature Low Sag)	2021	Planning	Rescheduled	Investment was at conceptual stage in TYNDP2012; on-going feasibility studies lead to a more accurate commissioning date.
24	**Belgian North Border**								

		1050	Gramme (BE)	Massenhoven (BE)	Conditional: Gramme-Van Eyck + Massenhoven-Meerhout-Van Eyck Envisions to double the transport capacity by upgrading the Gramme-Van Eyck axis to high-performance conductors, and by putting a second 380kV circuit on the Massenhoven-Meerhout-Van Eyck axis. The need to upgrade is conditional to the evolution of production in the LImburg-Liège area and to the evolution of the physical (transit)flux towards 2020-2025. This need will be further monitored.	2020	Planning	Investment on time	This investment is a split off from invest item 445a from in TYNDP 2012, and complemented with the Massenhoven-Meerhout-Van Eyck section. This investment is subject to further monitoring towards 2020-2025 given its dependency on production in the area in combination with evolution of the (transit) flux.
		445	Zandvliet (BE)	Lillo (BE)	Brabo: part Zandvliet-Lillo: Brabo allows to realize the intended market capacity increase on the North Border in a more robuste way (greater scenario independence compared to PST 4 only) , and reinforces the network to facilitate increased demand and connection of possible new generation around Antwerp Harbour area. It consists of constructing a new 380kV circuit Zandvliet-Lillo(new substation)-Mercator, in addition to the existing Zandvliet - Mercator connection. This investment item	2018	Design & Permitting	Delayed	Permitting procedure for adaptation of land use (GRUP) had to be reinitiated, in order to comply with the demand of investigating alternative solutions.

					concerns the part between Zandvliet and Lillo substations.				
		605	Lillo (BE)		Brabo - substation Lillo 380: Brabo allows to realize the intended market capacity increase on the North Border in a more robuste way (greater scenario independence compared to PST 4 only) , and reinforces the network to facilitate increased demand and connection of possible new generation around Antwerp Harbour area. It consists of constructing a new 380kV circuit Zandvliet-Lillo(new substation)-Mercator, in addition to the existing Zandvliet - Mercator connection. This investment item concerns the erection of new 380kV substation Lillo.	2018	Design & Permitting	Delayed	Permitting procedure for adaptation of land use (GRUP) had to be reinitiated, in order to comply with the demand of investigating alternative solutions.

		606	Gramme (BE)	Van Eyck (BE)	Gramme-Van Eyck: second 380kV circuit FIrst phase of reinforcement on the axis Gramme-Van Eyck, needed to facilitate connection of possible new central generation and to prepare for increasing transit fluxes whilst securing market capacity between BE & NL. This investment consist of creating a second 380kV line on the axis Gramme-Van Eyck - Section Van Eyck - Zutendaal (30 km): need to erect a new single circuit. Done with high performance conductors in order to be future proof (cfr. phase 2) - Section Grammme - Zutendaal (55km): reconfiguration of 150kV network so that an existing 150kV line can be operated at 380kV	2015	Under Construction	Delayed	Implementation of the project has been algined with maintenance period of nuclear units ==> commissiong now foreseen in 2015 instead of end 2014
		607	Van Eyck (BE)		Gramme-Van Eyck: substation Van Eyck 380 FIrst phase of reinforcement on the axis Gramme-Van Eyck, needed to facilitate connection of possible new central generation and to prepare for increasing transit fluxes whilst securing market capacity between BE & NL. This investment item consists of construction a 380kV substation named "Van Eyck", needed to integrate the second 380	2015	Under Construction	Delayed	Commissiong date of this inv. item aligned with implementation of inv. item 606 thus now 2015 instead of 2014

					kV line on the axis Gramme-Van Eyck.				
		604	Lillo (BE)	Mercator (BE)	Brabo: part Lillo-Mercator + restructuring 150kV. Brabo allows to realize the intended market capacity increase on the North Border in a more robuste way (greater scenario independence compared to PST 4 only) , and reinforces the network to facilitate increased demand and connection of possible new generation around Antwerp Harbour area. It consists of constructing a new 380kV circuit Zandvliet-Lillo(new substation)-Mercator, in addition to the existing Zandvliet - Mercator connection. This investment item concerns the part between Lillo and Mercator substations, involving a restructuring of the adjacent 150kV network.	2018	Design & Permitting	Delayed	Permitting procedure for adaptation of land use (GRUP) had to be reinitiated, in order to comply with the demand of investigating alternative solutions.

		608	Horta (BE)	Mercator (BE)	Horta-Mercator in HTLS The axis Horta-Mercator needs to be upgraded in order to transport the envisioned higher fluxes between France, Stevin & the Netherlands, and to facilitate connection of possible new generation (+-1000 MW) . Upgrade consists of replacing the current double circuit 380kV by high performance conductors allowing to double its transport capacity. The line currently passing Mercator going to Doel will be integrated into Mercator substation to obtain a better flux balance and avoid an upgrade between Mercator & Doel at this stage.	2019	Design & Permitting	The expected commissiong date of 2019 is based on the hypothesis of acquiring all necessary permits as planned, followed by the assessment of the final investment decision in 2016. Meanwhile the drivers behind this investment will be further monitored and its timing managed accordingly.	The expected commissiong date of 2019 is based on the hypothesis of acquiring all necessary permits as planned, followed by the assessment of the final investment decision in 2016. Meanwhile the drivers behind this investment will be further monitored and its timing managed accordingly.

		609	Zandvliet (BE)		BE PST 4 (+upgrade Zandvliet - Doel): New PST in Zandvliet substation making it the 4 th PST on the Belgian North Border, allowing a more symmetrical utilisation of the PST's. Enabling this PST to increase import capacity from NL to BE implies that the current 150kV line Zandvliet-Doel is converted to 380kV, involving adaptations to be made to the configurations of Zandvliet & Doel substations and a solution to cover the supply of Doel 150kV (probably transfo 380/150). Integrating this PST at Zandvliet also implies that a "langskoppeling" is put at Zandvliet as temporary interface between Zandvliet and the NL network until the post "Rilland" is constructed in NL (investment item 439 as part of project # 103 "Reinforcements Ring NL"). Note that the realisation of investment item 439 is needed as well to allow a capacity increase direction BE to NL.	2016	Under construction	Investment on time	Installation of PST (plus upgrade of line Doel-Zandvliet) will be done as a first reinforcement in the Antwerp area. The PST has been ordered, as such the status of this investment is "under construction" with an expected commissioning date of 2016.
25	**IFA2**								

		62	Tourbe (FR)	Chilling (GB)	New subsea HVDC VSC link between the UK and France with a capacity around 1000 MW. PCI 1.7.2 (NSCOG corridor)	2020	Design & Permitting	Investment on time	Extensive feasibility studies (e.g. seabed surveys) have been conducted to determine the most suitable route; on the French side, the ministry of energy aknowledged the notification of the investment on 08/04/14.
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	Under construction	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
		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	
		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.
		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.
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.
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**								
		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.
69	**East Anglia Cluster**								

		747	Bramford (GB)	Twinstead (GB)	Construction of a new transmission route from Bramford to the Twinstead Tee Point creating Bramford - Pelham and Bramford - Braintree - Rayleigh Main double circuits; the rebuild of Bramford substation and the installation of an MSC at Barking.	2022	Design & Permitting	Investment on time	Delay in project requirement due to generation going back.
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.
74	**Thames Estuary Cluster (NEMO)**								
		443	Richborough (GB)	Under Analysis (BE)	NEMO New DC sea link including 135km of 400kV (voltage level subject to outcome of detailed engineering) DC subsea cable with 1000MW capacity. The assessment of the Final Investment Decision is planned in 2015.	2018	Design & Permitting	Investment on time	Investment on time, with a technical comissioning planned end 2018 leading to commercial operation in 2019

		449	Richborough (GB)	Canterbury (GB)	New 400kV double circuit and new 400kV substation in Richborough connecting the new Belgium interconnector providing greater market coupling between the UK and the European mainland.	2018	Planning	Investment on time	Investment on time
		450	Sellindge (GB)	Dungeness (GB)	Reconductor the existing circuit which runs from Sellindge - Dungeness with a higher rated conductor. This will facilitate the connection of more interconnectors on the South coast and prevent thermal overloading of this area.	2015	Design & Permitting	Investment on time	Investment on time
75	**Stevin (backbone)+BE offshore**								
		444	Zomergem (BE)	Zeebrugge (BE)	STEVIN The Stevin project envisions the extension of the 380kV backbone to the coastal area, via the construction of new +-50km (40km OHL; 10km cable) double-circuit (3000MVA for each circuit) between Zomergem and Zeebrugge., including the construction of a new substation in Zeebrugge.	2018	Design & Permitting	Delayed	Delay due to request of 3rd parties to examine more alternatives, and procedures launched , and due to appeals against the GRUP (land use act) by 3rd parties in States Council. Meanwhile arrangements have been made, and the updated planning envisions end 2017/begin 2018 as new commissioning date.
		752	Offshore platform(s)	Offshore Hub (BE)	Belgian Offshore Grid (BOG) The Belgian Offshore Grid investment consists of the eruption of an offshore hub connected to onshore AC grid (at Zeebrugge) via underground cables, including the necessary reactive compensation for the cables. Subject to result of ongoing design, legal, ownership &	2018	Design & Permitting	Delayed	2018 is the earliest possible date: project is subject to outcome of ongoing design, legal, ownership & regulatory framework concertation with stakeholders.

					regulatory concertation with stakeholders.				
76	**London Cluster**								
		753	Pelham (GB)	Waltham Cross (GB)	Reconductor the existing circuit which runs from Pelham - Rye House - Waltham Cross with a higher rated conductor.	2021	Design & Permitting	Delayed	Postponed due to the slow build up of generation in the East Anglia area and also in demand within London.
		754	Hackney (GB)	Waltham Cross (GB)	Uprating and reconductoring of the Hackney - Tottenham - Brimsdown - Waltham Cross double circuits. Construction of a new 400kV substation at Waltham Cross and modifications to the Tottenham substation and the installation of two new transformers at Brimsdown substation.	2021	Design & Permitting	Delayed	Postponed due to the build up of generation schemes in the East Anglia area and demand increases in London.
		755	Hackney (GB)	St. John's Wood (GB)	This is a new Hackney - St. John's Wood 400kV double circuit. It will replace an old asset rated at 275kV that has come to the end of its life.	2018	Under Construction	Investment on time	Investment on time
		757	St. John's Wood (GB)	Wimbledon (GB)	New St. John's Wood - Wimbledon 400kV double circuit.	2018	Design & Permitting	Investment on time	Investment on time
77	**Anglo-Scottish Cluster**								
		452	Hunterston (GB)	Deeside (GB)	A new 2.4GW (short term rating) submarine HVDC cable route from Hunterston to Deeside with associated AC network	2016	Design & Permitting	Investment on time	Investment on time

					reinforcement works at both ends.				
		453	Peterhead (GB)	Hawthorn Pit (GB)	A new ~2GW submarine HVDC cable route from Peterhead to Hawthorn Pit with associated AC network reinforcement works at both ends with possible offshore HVDC integration in the Firth of Forth area.	2020	Under Consideration	Investment on time	Investment on time
78	**South West Cluster**								
		458	Hinkley Point (GB)	Seabank (GB)	New 400kV substation at Hinkley Point. New 400kV transmission route from Hinkley Point to Seabank. Reconstruction of Bridgewater substation for 400kV operation. Uprate Bridgewater - Melksham to 400kV.	2019	Design & Permitting	Investment on time	Based on current generation connection dates this investment is progressing on time.
79	**Wales Cluster**								
		769	Wylfa (GB)	Pembroke (GB)	A new ~2GW submarine HVDC cable route from Wylfa/Irish Sea to Pembroke with associated AC network reinforcement works at both ends.	2025	Planning	Rescheduled	Delayed due to anticipated changes in the local generation background.
81	**North South Interconnector**								
		462	Woodland (IE)	Turleenan (NI)	A new 140 km single circuit 400 kV 1500 MVA OHL from Turleenan 400/275 kV in Northern Ireland to Woodland 400/220 kV in Ireland. This is a new interconnector project between Ireland and Northern Ireland.	2017	Design & Permitting	Delayed	Further studies required before re-submission for planning consents
82	**RIDP I**								

		896	South Donegal (IE)	Omagh South (NI)	A new 275 kV cross border link between a new substation in South Donegal in Ireland and a new substation established south of Omagh in Northern Ireland	2024	Planning	New Investment	Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study.
		897	Omagh South	Turleenan	A new 275 kV overhead line from a new substation established south of Omagh to a new 400/275 kV substation, established at Turleenan by the North South Interconnection Development	2020	Planning	New Investment	Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study.
		463	Srananagh (IE)	New substation in South Donegal (IE)	A new EHV overhead line from Srananagh in Co. Sligo to a new substation in south Co. Donegal	2020	Planning	Investment on time	The preferred scheme has been selected since the last TYNDP; this is one of the elements of the preferred scheme.
83	**Grid Link**								
		469	Knockraha (IE)	Dunstown (IE)	A new 250km single circuit 400kV OHL from Cork to the east, with one intermediary station in the South-East.	2020	Design & Permitting	Investment on time	Consultation and studies on routing options have been undertaken
84	**Dunstown Woodland**								
		471	Dunstown (IE)	Woodland (IE)	A new 400kV OHL between Woodland 400 kV station to the north-west of Dublin to Dunstown 400 kV station to the south-west of Dublin, thereby bypassing Dublin city 220 kV network.	2022	Under Consideration	Investment on time	Further grid studies have been carried out to take account of changing assumptions, to identify optimum solution and required delivery date
86	**East Coast Cluster**								

		781	Under Consideration (GB)	Under Consideration (GB)	A very high level indication of the works required for GB East Coast. In detail the projects will consist of multiple offshore HVDC and AC circuits and connecting platforms joining to multiple onshore connection points with their own reinforcement requirements. It enables significant connection of offshore windfarms and provides alternative to onshore reinforcment at a cheaper overall cost.	2023	Under Consideration	Investment on time	Investment on time
		782	Under Consideration (GB)	Under Consideration (GB)	Connection of Triton Knoll, Doggerbank & Hornsea GB Wind Farms and all associated works. This is in the region of 11GW of offshore generation.	2020	Under Consideration	Investment on time	Investment on time
90	**Swiss Roof**								
		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**								
		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	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

					Dumont), including a 380/150 kV traformator				
		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.
		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.

		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.
103	**Reinforcements Ring NL**								
		438	Eemshaven (NL)	Diemen (NL)	New 175-200km AC overhead line with capacity of 2x2650 MVA of 380kV. In the first phase a connection between Eemshaven Oude Schip and Vierverlaten will be built as well as an upgrade of the existing line Diemen - Lelystad - Ens	2018	Design & Permitting	Investment on time	Changes in plans of thermal plants at Eemshaven offers the opportunity to phase the grid expansions. The a first phase consists of a new 380 kV connection between Eemshaven-Oudeschip and Vierverlaten and the upgrade the circuits form Diemen-Lelystad-Ens
		439	Borssele (NL)	Tilburg (NL)	New 100-130km double-circuit 380kV OHL with 2x2650 MVA capacity.	2016	Design & Permitting	Investment on time	With a 380 kV substation at Rilland, the Zuid-West 380 kV project can be taken into service in two parts. The first part consists of the Borssele - Rilland line including substation Rilland and the second part consist of the Rilland – Tilburg line.

		440	Maasvlakte (NL)	Beverwijk (NL)	New 380 kV double-circuit mixed project (OHL+ underground cable) including approximately 20km of underground cable for 2650 MVA. The cable sections are a pilot project. The total length of cable at 380kV is frozen until more experience is gained.	2017	Under Construction	Delayed	Permitting procedures took longer than expected. The part from Maasvlakte to Bleiswijk has been commisssioned.
		441	Zwolle (NL)	Maasbracht (NL)	Upgrade of the capacity of the existing 300km double circuit 380kV OHL to reach a capacity of 2x2650 MVA along the Dutch Central ring (Hengelo-Zwolle-Ens Diemen-Krimpen-Geertruidenberg-Eindhoven-Maasbracht)	2019	Under Consideration	Investment on time	The investment is merged with the Ring Zuid project
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

106	**Ireland GB Interconnector**								
		809	Dunstown (IE)	Pentir (GB)	A new HVDC subsea connection between Ireland and Great Britain; this may be achieved by a direct link or by integrating an interconnector with a third party connection from Ireland to GB.	2025	Under Consideration	Investment on time	Joint studies between National Grid and EirGrid indicate a strong benefit for a second interconnector between Ireland and GB.
107	**Celtic Interconnector**								
		810	Great Island or Knockraha (IE)	La Martyre (FR)	A new HVDC subsea connection between Ireland and France	2025	Under Consideration	Investment on time	Feasibiliity studies are progressing
109	**East Coast Connections**								
		816	Northern Ireland (NI)	East Coast Offshore (NI)	'East Coast Off-shore' wind farm connecting to a 275 kV station to be determined. Multiple connection options are under consideration.	2020	Under Consideration	Delayed	Since the last TYNDP, the rights to develop the offshore site at County Down have been awarded. The developer has provided an indicative construction timeline, with completion now scheduled for 2020.
110	**Norway-Great Britain**								
		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
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
115	**Grid West**								
		470	Bellacorick (IE)	Cashla or Flagford (IE)	New 130km single circuit 400 kV OHL from north West Mayo to the EHV system.	2019	Design & Permitting	Investment on time	Consultants have been appointed; corridor options have been developed and evaluated; a report has been issued and consulted on with the public.
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
117	**Shannon Crossings**								
		467	Moneypoint (IE)	Kilpaddoge (IE)	A new 10km single circuit 220kV 500MVA (underground+subsea) cable constructed across the River Shannon Estuary from Moneypoint in Co. Clare to Tarbert or a new Kilpaddoge station in Co. Kerry.	2015	Design & Permitting	Delayed	Project delayed by delay in establishing the Kilpaddoge substation to which this cable will connect.
		468	Moneypoint (IE)	North Kerry (IE)	A new 27km single 400 kV circuit, consisting of a submarine cable from Moneypoint across the Shannon Estuary and an overhead line to a new 400 kV station in north Kerry	2020	Design & Permitting	Delayed	Investigating technology options in design stage
118	**RIDP II**								

		899	Coleraine	Kells	A new 275 kV double circuit from existing Kells 275 kV substation to a new 275 kV substation at Coleraine. The new 275 kV Coleraine substation will be developed adjacent to existing Coleraine 110 kV substation, thus establishing a 275/110 kV substation at Coleraine	2030	Planning	New Investment	Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study.
		900	Coleraine	Coolkeeragh	A new 275 kV single circuit from newly established 275 kV substation at Coleraine to existing 275 kV substation at Coolkeeragh.	2030	Planning	New Investment	Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study.
120	**2nd Offshore-Onshore Corridor**								
		933	Offshore Hub OR Stevin - TBD	Izegem - TBD	Further connection to inland: phase 2 Preliminary analysis shows the need to reinforce the 380kV network with a second offshore-onshore corridor in order to evacuate up to 4 GW of offshore wind. The solutions under study consist of multiple investment items. This investment item envisions the possibility of an AC OR DC solution going from an offshore hub OR onshore substation Stevin in Zeebrugge towards a further inland location. The reference solution presented here is an AC	2030	Under Consideration	New Investment	Additional offshore-onshore corridor needed in order to evacuate full potential of up to 4GW (compared to current target of 2,3 GW) of offshore wind in the Belgian part of the North Sea in visions 3 & 4.

					corridor towards Izegem. To be confirmed by further detailed studies in the coming years. The cost estimation does not take into account the offshore part of the corridor.				
		1053	Offshore Hub - TBD	Doel - TBD	1 GW connection to inland: phase 1 Preliminary analysis shows the need to reinforce the 380kV network with a second offshore-onshore corridor in order to evacuate up to 4 GW of offshore wind. The solutions under study consist of multiple investment items. This investment item envisions the possibility of a 1 GW DC solution between an offshore hub towards an inland location (substation Doel or further inland could be a possible location). Subject to further studies. The cost estimate does not take into account the construction of an eventual offshore hub.	2030	Under Consideration	New Investment	Additional offshore-onshore corridor needed in order to evacuate full potential of up to 4GW (compared to current target of 2,3 GW) of offshore wind in the Belgian part of the North Sea in visions 3 & 4.
121	**2nd Interco Belgium - UK (1GW)**								

		934	Kemsley (UK) for example - TBD	Doel/Zandvliet (BE) for example - TBD	NEMO 2: UK to BE 380kV inland This investment item envisions the possibility of a second 1GW HVDC connection, between UK (Kemsley) and a Belgian 380kV substation further inland in the Antwerp area (Doel, Zandvliet are indicative locations). Subject to further studies.	2030	Under Consideration	New Investment	Preliminary studies on vision 3&4 scenario's have indicated potential fur further regional welfare & RES integration increase by further increasing the interconnection capacity between Belgium & UK up to 2 GW.
126	**SE North-south reinforcements**								
		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 280km. 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 280km. Line capacity: 900 MW	2029	Under Consideration	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 220km. 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.	2024	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.
		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,	2030	Under Consideration	New Investment	new investment

					Goldshöfe, Raitersaich, Vöhringen				
		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
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.
		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.
153	**France-Alderney-Britain**								
		987	Cotentin Nord	Exeter	France-Alderney-Britain (FAB) is a new 220km-long HVDC subsea interconnection between Exeter (UK) and Cotentin Nord (France) with VSC converter station at both ends. Expected rated capacity is 2*700 MW.	2022	Planning	New Investment	Studies conducted after TYNDP2012 release have shown the economic viability of this interconnection and lead to develop this investment. Feasibility studies (marine surveys)are starting to find a suitable subsea route.
158	**Massif Central South**								
		597	La Gaudière (FR)	Rueyres (FR)	New 175-km 400kV double circuit OHL Gaudière-Rueyres substituting to the existing single circuit 400kV OHL	2023	Under Consideration	Investment on time	Studies conducted after TYNDP2012 release have led to better investment 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
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 subsea connection, testing the idea of connecting these markets.	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.
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.
168	**Spaak NL**								
		894	Sliedrecht area	Dodewaard	New Overhead line from Sliedrecht to Dodewaard of 2x2633 MVA in Wintrack, 65 km	2025	Under Consideration	New Investment	This new investment has been identified as a beneficial project in the NSCOGI study and is part of the national grid development plan
172	**ElecLink**								
		1005	Sellindge (UK)	Le Mandarins (FR)	Eleclink is a new FR – UK interconnection cable thought the channel Tunnel between Selindge (UK) and Mandarins (FR). Converter stations will be located on Eurotunnel concession at Folkestone and Coquelles. This HVDC interconnection is a PCI project (Project of common interest). It will increase by 1GW the interconnection capacity between UK and FR by 2016.	2016	Design & Permitting	New Investment	
173	**FR-BE phase 2**								

		1008	tbd(FR)	tbd(BE)	The following (combination of) options are envisioned and will be further studied: - Lonny-Achène-Gramme (reconductoring with High Temperature Low Sag conductors or HVDC) - Capelle-Courcelles (HVDC) - Warande-Zeebrugge/Alfa (HVDC)	2030	Under Consideration	New Investment	Preliminary analyses show the need for an additional reinforcement in visions 3 & 4 (2030) between France & Belgium , complementary to project # 23.
175	**Great Belt II**								
		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**								
		996	LV-Grobina	SE3	A new HVDC link between LV-SE3, only as alternative of interconnector DE-SE4	2030	Planning	New Investment	Market integration
		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
182	**BRITIB (GB-FR-ES)**								
		1111	Gatica	Indian Queens	Interconnection project between Indian Queens (Great Britain), Cordemais (France) and Gatica (Spain) in a multiterminal HVDC configuration with 3 sections of 1000 MW each, and a submarine route from Spain to Great Britain along the french coast.	2017	Under Consideration	New Investment	Project application to TYNDP 2014.
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
184	**PST Arkale**								
		594	Arkale (ES)		New PST in Arkale-Argia 220 kV interconnection line	2016	Planning	Investment on time	Draft NDP expected to be published during the preparation of TYNDP 2012 was not finally approved and published, so the investment is yet in a planning stage. If the new NDP is published by 2014, as expected, commissioning date would not be affected.
185	**Greenwire IE-GB**								
		1020	Dunstown	Pembroke	Greenwire Interconnetor spur 1, enables additional 500MW of interconnection between UK and Irish market	2018	Planning	New Investment	Opportunity to connect Irish RES to GB market
		1021	Woodland	Pentir	Greenwire Interconnetor spur 2, enables additional 1000MW of interconnection	2017	Planning	New Investment	Project application to TYNDP 2014.

					between UK and Irish market				
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
189	**Irish-Scottish Isles**								
		1025	Argyll hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	2030	Under Consideration	New Investment	The ISLES project will serve multiple offshore resources off the coasts of Scotland and Northern Ireland, and also facilitate a connection between GB and NI
		1027	Coolkeeragh hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	2030	Under Consideration	New Investment	The ISLES project will serve multiple offshore resources off the coasts of Scotland and Northern Ireland, and also facilitate a connection between GB and NI
		1028	Argyll	Coleraine	HVCD link between Argyll offshore hub and Coleraine offshore hub	2030	Under Consideration	New Investment	The ISLES project will serve multiple offshore resources off the coasts of Scotland and Northern Ireland, and also facilitate a connection between GB and NI
		1029	Coolkeeragh	Coolkeeragh hub	HVCD link between Coolkeeragh onshore and Coolkeeragh offshore hub	2030	Under Consideration	New Investment	The ISLES project will serve multiple offshore resources off the coasts of Scotland and Northern Ireland, and also facilitate a connection between GB and NI
		1030	Coleraine	Coleraine hub	HVCD link between Colerain onshore and Coleraine offshore hub	2030	Under Consideration	New Investment	The ISLES project will serve multiple offshore resources off the coasts of Scotland and Northern Ireland, and also facilitate a connection between GB and NI

		1031	Coleraine hub	Coolkeeragh hub	HVCD link between Coleraine offshore hub and Coolkeeragh offshore hub	2030	Under Consideration	New Investment	The ISLES project will serve multiple offshore resources off the coasts of Scotland and Northern Ireland, and also facilitate a connection between GB and NI
		1032	Hunterston	Coleraine hub	HVCD link between Hunterston (onshore) to Argyll offshore hub	2030	Under Consideration	New Investment	The ISLES project will serve multiple offshore resources off the coasts of Scotland and Northern Ireland, and also facilitate a connection between GB and NI
		1024	Cruachan	Argyll hub	HVCD link between Cruachan (onshore) to Argyll offshore hub	2030	Under Consideration	New Investment	Project application to TYNDP 2014.
		1026	Coleraine hub		A new dedicated offshore HVDC hub platform to allow connection of offshore renewable generation and interconnection capacity.	2030	Under Consideration	New Investment	Project application to TYNDP 2014.
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 140km. 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 150km. 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 170km. 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**								
		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 310km. 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 220km. 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	
198	**Area of Lake Constance**								
		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) (/Sigmarszell)	Point Neuravensburg – Point Sigmarszell/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).	2020	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.
		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.
199	**Lake Geneva South**								
		1051	CORNIER (FR)	CHAVALON (CH)	Upgrade of the double circuit 225 kV line between Cornier (France) and Riddes and Saint Triphon (Switzerland) to a single circuit 400 kV line between Cornier and Chavalon (Switzerland). In order to take most benefit from this, the existing 400 kV Genissiat substation will be connected in/out to the	2025	Under Consideration	New Investment	grid studies conducted after TYNDP2012 release allowed to define the investment

					existing line Cornier-Montagny.				
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	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.

					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 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 additionnal 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
		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
		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
214	**Interco Iceland-UK**								
		1082	tbd	tbd	Interco Iceland-UK	2030	Under Consideration	New Investment	
216	**Massif Central North**								
		999	Marmagne	Rueyres	Erection of a new 400-kV double circuit line substituting an existing 400-kV single circuit line.	2030	Under Consideration	Investment on time	This long term investment is only needed for scenarios with high RES development in the area, especially wind and hydro; additional studies are needed for better investment definition.
225	**ALEGRO 2**								
		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.

228	**Marex**								
		1113	Glinsk 400kV	Connah's Quay 400kV	1500 MW HVDC VSC cable	2018	Planning	New Investment	Project application for TYNDP 2014.
		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
		961	Muhlbach	Scheer	New 400kV line substituting to existing 225kV line in Alsace area. Several solutions are under consideration and some restructuration of the 225 kV grid may be needed in the area. This investment is only needed in vision 4.	2030	Under Consideration	New Investment	This investment is needed only in vision4; triggered by high north-west to south-east flows in eastern France (from Lorraine and northern border to Alsace, southern Germany and Switzerland)
		962	Vigy	Marleinheim	Operation at 400kV of the second circuit of a 112-km existing 400 kV line currently operated at 225kV, with some restructuration of the 225-kV grid in the area.	2030	Under Consideration	New Investment	This investment is needed only in vision4; triggered by high north-west to south-east flows in eastern France (from Lorraine and northern border to Alsace, southern Germany ans Switzerland)
		963	Vigy	Bezaumont	Operation at 400 kV of the second circuit of a 40-km existing 400 kV line currently operated at 225 kV.	2030	Under Consideration	New Investment	This investment is needed only in vision4; triggered by high north-west to south-east flows in eastern France (from Lorraine and northern border to Alsace, southern Germany ans Switzerland)

		964	Creney	Vielmoulin	Upgrade of an existing single-circuit 400 kV line in Bourgogne. Accurate scope of the investment should be defined taking into account congestion in specific scenarios (visions 3 & 4) and refurbishment needed on existing assets in the area.	2030	Under Consideration	New Investment	Increase of grid capacity is needed only in visions 3 & 4, triggered by high north-west to south-east flows in eastern France; also possible needs for refurbishment of existing assets in the area.
		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	Commissioning date for different substations varies from 2015 to 2023 depending on local increase of RES or commissioning of power plants. The investment includes the old investments 204 and 205.
		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

		980	Rossignol		New 400kV substation east of Paris and associated connections to existing grid. This investment is needed only in visions 3 & 4, in order to balance flows on the north-eastern Paris 400-kV ring.	2030	Under Consideration	New Investment	new investment needed in the long run for visions 3 & 4 to balnce flows on the north-eastern Paris 400-kV ring.
		981	Chesnoy (FR)	Cirolliers (FR)	Reconductoring Chesnoy-Cirolliers existing 400kV OHL with high temperature conductors in order to strengthen the south-western part of Parsi 400-kV ring. This long term investment is needed only in visions 3&4.	2030	Under Consideration	New Investment	This long term investment is needed only in visions 3 & 4 in order to strentgthen the south-western part of Paris 400-kV ring.
		982	Chaingy (FR)	Dambron (FR)	New 26-km double circuit 400kV line in Loiret department, substituting to two existing 225kV lines. this investment is needed in order to cope with south-north flows to Paris area.	2030	Under Consideration	New Investment	recent studies showed the need to strengthen the grid in the area in order to cope with south-north flows to Paris area.
		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
		1078	Muhlbach		Two 400 kV phase-shifters will be installed in an existing substation in order to mitigate the flows when decommissioning Fessenheim nuclear power station.	2016	Design & Permitting	New Investment	These PST are part of the grid restructuration following the decommissioning of Fessenheim nuclear power plant.
		1079	Alsace		Installation of 320 MVARs of capacitors and 2 reactances of 64-MVAR in Alsace for voltage support after decommissioning Fessenheim nuclear power station.	2016	Design & Permitting	New Investment	The investment is triggered by the decommissioning of Fessenheim nuclear power station.

		1080	Scheer		in-out connection of Scheer 400kV existing substation to the existing line Bezaumont-Muhlbach. This investment is needed for securing the area after the decomissioning of Fessenheim power station.	2017	Design & Permitting	New Investment	this investment is needed after Fessenheim nuclear power station decommisioning.
		1081	Muhlbach	Scheer	Ampacity increase of existing 400 kV Muhlbach-Scheer line	2016	Design & Permitting	New Investment	This investement is needed after the decommisioning of Fessenheim power station.
		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	Progress 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
		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.
		1098	Creney (FR)	Mery-sur-Seine (FR)	Reconductoring an existing 25-km single circuit 400 kV line in Bourgogne area.	2030	Under Consideration	New Investment	Accurate scope of the investment to be defined taking into account congestion in specific scenario (visions 3 & 4) and refurbishment needed on existing asset.
		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
		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
		983	tbd	tbd	Restructuration/development of the 400kV grid south of Paris area, needed for visions 3 & 4. Several solutions are under consideration inlvolving either new axis or reconductoring of existing assets.	2030	Under Consideration	New Investment	Recent studies for visions 3 & 4 have shown the need for strengthening the southern part of the Paris 400 kV ring, either by creating a new line or by increasing the capacity of the existing assets.
		814	Oriel (IE)	Oriel Wind Farm (IE)	Oriel off-shore wind farm connecting to a new Oriel 220 kV station located on the Louth - Woodland 220 kV circuit	2016	Planning	Investment on time	This investment has removed from Project 109 because of the new geographical requirements for project/clusters. Investment is driven by wind farm developer who states that it is on time.

		815	Carrickmines (IE)	Kish Bank Wind Farm (IE)	Kish Bank off-shore wind farm connecting to the existing Carrickmines 220 kV station	2015	Planning	Investment on time	This investment has removed from Project 109 because of the new geographical requirements for project/clusters. Investment is driven by wind farm developer who states that it is on time.
		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
		42	Lonny (FR)	Vesle (FR)	Reconstruction of the existing 70km single circuit 400kV OHL as double circuit OHL.	2016	Design & Permitting	Investment on time	-
		44	Havre (FR)	Rougemontier (FR)	Reconductoring of existing 54km double circuit 400kV OHL to increase its capacity in order to integrate new generation.	2018	Under Construction	Investment on time	the investment progresses according to the pace of new generation installation in the area.
		596	Cergy (FR)	Terrier (FR)	Upgrade of an existing 35-km 225 kV line to 400-kV between Cergy and Persan (north-western Paris area) and connection to Terrier via an existing 400kV line.	2018	Design & Permitting	Investment on time	In TYNDP2012, project consisted in a new 400kV line between Cergy and Terrier but further found out upgrade and restructuration of existing assets as the most feasible solution.
		598	La Gaudière (FR)	Bouches du Rhone area (FR)	New 220-km subsea HVDC link between Marseille area and Languedoc.	2020	Design & Permitting	Delayed	Investment is delayed by 2 years due to longer than expected permitting process regarding converter stations location; also cable qualification longer than expected.
		51	Biancon (FR)	La Bocca (FR)	Part of the PACA "Safety net" project: construction of a new AC 220kV underground cable Biançon - La Bocca.	2015	Under Construction	Investment on time	Investment progresses as planned.

		599	Biancon (FR)	Frejus (FR)	Part of the PACA "safety net" project: new 24-km 220-kV AC underground cable Biancon - Fréjus	2015	Under Construction	Investment on time	Investment progresses as planned.
		600	Trans (FR)	Boutre (FR)	Part of the PACA "safety net" project: new 65-km 220-kV AC underground cable Boutre-Trans	2015	Under Construction	Investment on time	Investment progresses as planned.
		53	Coulange (FR)	Le Chaffard (FR)	Reconductoring (with ACCS / ACCR) of two existing double circuit 400kV OHL (Coulange - Pivoz-Cordier - Le Chaffard and Coulange - Beaumont-Monteux - Le Chaffard). Total length of both lines: 275km	2016	Under Construction	Investment on time	Investment progresses as planned.
		222	Silz (AT)	Zell-Ziller (AT)	Upgrade of the existing 220kV-double circuit- OHL Zell-Ziller - Silz. Line length: 42km.				
		602	Avelin (FR)	Mastaing (FR)	Operation at 400 kV of existing line currently operated at 220 kV	2017	Design & Permitting	Investment on time	investment progresses as planned
		603	Avelin (FR)	Gavrelle (FR)	An existing 30-km 400-kV single circuit OHL in Lille area will be substituted by a new double-circuit 400kV OHL.	2017	Design & Permitting	Investment on time	Progresses as planned.
		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	This investment 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
		823	Sud-Aveyron (FR)		New 400-kV substation connected to existing 400-kV grid in Massif Central area and equipped with 400/225 transformers	2018	Design & Permitting	Delayed	some delay in the permitting process due to in-situ technical studies postponement
		825	Somme (FR)		New 400-kV substation connected to existing 400-kV network and equipped with transformers to 220 kV or high voltage networks in order to connec new on-shore wind generation.	2015	Under Construction	Investment on time	investment progresses as planned.
		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
		182	Kriftel (DE)	Obererlenbach (DE)	New 400 kV double circuit OHL Kriftel - Obererlebenbach in existing OHL corridor.	2018	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 commissioned in 2014. Last sections are planned to be commissioned 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	Progress 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. Several 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
		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	Progress 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
		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	
		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	
		465	LAOIS-KILKENNY (IE)		A new 500 MVA 400/110kV substation connected into the Moneypoint-Dunstown 400kV line and the Athy-Portlaoise 110kV line, and with two 400/110kV 250 MVA transformers. This project also comprises a new 110kV line from the new 400/110 kV substation to Ballyragget 38kV station and upgrading of Ballyragget station and the Ballyragget-Kilkenny 38kV line from 38kV to 110kV substation.	2015	Design & Permitting	Delayed	The project was submitted for planning consent in January 2013; the consultation and pre-planning stage was longer than anticipated.

		423	Skaidi (NO)	Varangerbotn (NO)	New 230 km single circuit 400kV OHL.	2027	Planning	Rescheduled	Postponed due to uncertainty regarding demand timeframe
		748	Bramford (GB)	Sizewell C (GB)	Reconductor the existing circuit which runs from Bramford - Sizewell with a higher rated conductor.	2027	Planning	Rescheduled	Delayed due to a foreseen slower uptake in offshore wind than was originally anticipated in the TYNDP 2010.
		749	Norwich Main (GB)	Lowestoft	This is a potential new circuit in the East Anglia area to conenct significant volumes of wind. The work may include the tee-in of the Lowestoft circuit to the current Norwich-Bramford circuit.	2024	Planning	Investment on time	Investment on time
		750	Walpole (GB)	Bramford (GB)	Reconductor the existing circuit which runs from Bramford - Norwich Main with a higher rated conductor.	2022	Under Construction	Investment on time	Investment on time
		430	Revsing (DK)	Landerupgård (DK)	New 27km single circuit 400kV line via cable with capacity of approx. 1200 MW.	2021	Planning	Rescheduled	Commissioning 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.

		756	Tilbury (GB)	Elstree (GB)	Uprate Elstree - Warley - Tilbury from 275kV to 400kV.	2024	Planning	Rescheduled	Delayed due to anticipated changes in the local generation background.
		758	West Weybridge (GB)	Beddington (GB)	Uprate the 275kV overhead line route between West Weybridge - Chessington - Beddington to 400kV.	2028	Planning	Rescheduled	Delayed due to anticipated changes in the local generation background.
		761	Gravir (GB)	Beauly (GB)	Western Isles link (subsea section). New 450MW HVDC link, +/- 150kV. Total length 156km - subsea section 80km.	2018	Design & Permitting	Delayed	Project is subject to a study by the Scottish and UK Governments of transmission tariffs for island connections.
		762	Gravir (GB)	Beauly (GB)	Western Isles link - onshore section. New 450MW HVDC link, +/- 150kV. Total length 156km - onshore underground cable 76km.	2018	Design & Permitting	Delayed	Project is subject to a study by Scottish and UK Governments of transmission tariffs for island connections.
		763	Spittal and Kergord (both GB)	Blackhillock (GB)	Caithness to Moray 1200MW HVDC link joined in Caithness by a 600MW HVDC leg from Shetland when required by windfarm development on Shetland. Total route length ~395km.	2018	Design & Permitting	Delayed	Planned scheme re-configured to omit offshore HVDC bussing point. Scope change triggered re-tender and additional route surveys.
		765	Beauly (GB)	Kintore (GB)	Reconductor existing 275kV overhead line route.	2015	Under Construction	Delayed	Requirement to co-ordinate outages with Beauly-Denny works (Investment id 455)
		766	Blackhillock (GB)	Kincardine (GB)	Reinsulate existing 275kV route for 400kV operation and establish three new 400kV substations en-route.	2018	Design & Permitting	Delayed	2018 reflects the current view of when the additional capacity is required.
		455	Beauly (GB)	Denny (GB)	New double circuit 400kV OHL (220km) with new terminal substations and substation extensions en route.	2015	Under Consideration	Delayed	Delay to substation works at southern end, Denny.

		457	Anglo-Scottish (GB)		Installation of series compensation in the Harker - Hutton, Eccles - Stella West and Strathaven - Harker circuits (x2 225MVAr MSCs are to be installed at Harker, x1 at Hutton, x2 at Stella West and x1 at Cockenzie). In addition, the Strathaven - Smeaton circuits are to be uprated to 400kV and the cables at Torness are to be uprated also.	2015	Design & Permitting	Investment on time	Investment on time
		460	Pentir (GB)	Trawsfynydd (GB)	Reconductor the existing 132kV circuit for operation at 400kV. Reconfiguration and extension of Pentir 400kV substation. Increase the capacity of the cable link crossing the Glaslyn Estuary to be equivalent to the overhead line.	2020	Planning	Delayed	Delayed due to anticipated changes in the local generation background.
		770	Wylfa (GB)	Pentir (GB)	Construction of a new Wylfa - Pentir 400kV transmission route, which includes the extension of the Pentir 400kV substation and modifications to the Wylfa 400kV substation. This work is to accomodate significant new wind and nuclear development.	2023	Planning	Rescheduled	Delayed due to anticipated changes in the local generation background.
		771	Coleraine (NI)	Tunes Wind (NI)	North coast off-shore wind farm. Multiple connection options are under consideration.	2030	Under Consideration	Rescheduled	Previous assumed connection date of 2020 has slipped back to 2030, due to unsuitability of site for present offshore wind technology.
		772	Moneypoint (IE)		New 400/220kV transformer at Moneypoint station.	2016	Design & Permitting	Delayed	Delayed. This investment was not in the last TYNDP and should not be in this one.

		777	Carrickmines (IE)	Dunstown (IE)	A new 45km single circuit 400kV OHL from Dunstown 400 kV station to a new 400 kV station in the vicinity of Carrickmines 220 kV station.	2035	Under Consideration	Rescheduled	Driver for this investment is under review
		778	Carrickmines (IE)		New 400 kV station in the vicinity of Carrickmines 220 kV station.	2035	Under Consideration	Rescheduled	The driver of this investment is under review
		789	offshore wind farms (FR)	several French substations (FR)	AC 225-kV subsea cables and substations works for connecting to shore French offshore windfarms in order to comply with the 2020 objective.	2020	Design & Permitting	Investment on time	Investment will develop step by step according to the pace of offshore wind generation installation; two calls for tenders have already been issued.
		790	Calan (FR)	Plaine-Haute (FR)	Part of "Brittany safety net" : new 80km single circuit 220kV underground cable between existing stations Calan and Plaine Haute, with T-connection in Mur de Bretagne (existing HV substation where 220-kV voltage will be implemented)	2017	Design & Permitting	Investment on time	Investment progresses as planned.
		791	Mur de Bretagne (FR)		New 220 kV phase shifter in Mur de Bretagne, part of the "Brittany safety net".	2017	Design & Permitting	Investment on time	In TYNDP 2012 this investment was included in the 89.A24 investment.
		792	Brennilis (FR)		New 220 kV phase shifter in Brennilis ; part of "Brittany safety net".	2014	Design & Permitting	Expected earlier than planned previously	The investment develops in time : in TYNDP 2012 several investments were merged in 89.A24; 2017 was the commisioning date of the last piece of investment.
		794	Plaine-Haute (FR)		New transformer 400/220kV in existing substation ; part of "Brittany safety net".	2015	Design & Permitting	Expected earlier than planned previously	In TYNDP2012, this investment was included in investment 89.A24 and only the date of the last piece of investment was given.
		874	Samnanger (NO)	Sauda (NO)	Voltage upgrade of existing 300kV line.	2021	Under Consideration	Investment on time	market

12.1.3 List of commissioned investments from TYNDP and RgIPs 2012 within the region

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
45	17. 45	Taute (FR)	Oudon (FR)	"Cotentin-Maine "Project : new 163km double circuit 400kV OHL connected to existing network via two new substations in Cotentin and Maine regions.	2013	Commissioned	Commissioned	-
48	18. 48	Gaudière (FR)	Rueyres (FR)	Reconductoring with ACCS	2012	Commissioned	Commissioned	investment commisioned as expected.
180	180	Mengede (DE)	Kruckel (DE)	Installation of a second circuit 380kV OHL from Mengede to Kruckel	2012	Commissioned	Commissioned	Investment is commissioned.
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	Project is completed and now in service. Could be removed from TYNDP projects list.
54	21. 54	Cornier (FR)	Piossasco (IT)	Replacement of conductors (by ACCS) on existing grid	2013	Commissioned	Commissioned	Investment commissioned on time.
41	41	Fruges (FR)		New 400-kV substation connected to existing grid	2013	Commissioned	Commissioned	investment commisioned as planned
410	410	Kristiansand (NO)		Spare transformer for the HVDC Skagerak interconnection transformer.	2013	Commissioned	Commissioned	new interconnectors
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	Investment is commissioned.
52	52	Feuillane (FR)	Realtor	Operation at 400 kV of existing 220-kV line	2012	Commissioned	Commissioned	Works are completed, as the line was already designed for operation at 400-kV ; the line will be commissiond at 400kV after some operational measures.

61	61	Moulaine (FR)	Belval (LU)	Connection of SOTEL to the French grid	2013	Commissioned	Commissioned	The permitting process came to an end in Luxembourg so that the investment was completed and commissioned.The French part was already built when TYNDP2012 was released.
764	77. 451a	Dounreay (GB)	Beauly (GB)	String a second 275kV OHL circuit on existing towers.	2013	Commissioned	Commissioned	Commissioned January 2013
456	77. 456	Harker (GB)	Quernmore (GB)	Reconductor Harker - Hutton - Quernmore	2014	Commissioned	Commissioned	Investment on time
461	80. 461	Woodland (IE)	Deeside (GB)	A new 260 km HVDC (200 kV DC) underground and subsea connection between Ireland and Britain with 500MW capacity. On the Irish side, a 45km direct current underground cable will be built to the Woodland substation where the VSC converter station will be pl	2012	Commissioned	Commissioned	The project was commissioned in late 2012.
793	89. A24	Brittany (FR)		Installation of more than 1000 MVARs of capacitors and SVC.	2013	Commissioned	Commissioned	In TYNDP2012, this investment was included in Brittany saftey net (89.A24); the commissioning date was that of the last piece of investment.
46	5. 46	Baixas (FR)	Gaudière (FR)	Reconductoring of existing line	2013	Commissioned	Commissioned	Investment commisioned on time.
166	42. 166	Offshore Wind park Riffgat (DE)	Emden /Borßum(DE)	New AC-cable connection	2014	Commissioned	Commissioned	

12.1.4 List of cancelled investments from TYNDP and RgIPs 2012 within the region

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
595	17. A18	tbd (FR)	tbd (FR)	New network reinforcement between Haute Normandy and the south of Paris area. Length about 160 km.	-	Cancelled	Cancelled	After more detailed studies,investment n°983 proved more efficient than the solution initially envisaged.
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.
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).
824	41	Marne-Sud (FR)		New 400-kV substation connected to existing grid	-	Cancelled	Cancelled	Studies showed that the current perspective of new RES generation installation in the area can be accomodated via lower voltage grid development and does not need the creation of a new 400 kV substation.
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

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.
773	84. 471	Maynooth (IE)		New 400 kV station near or at Maynooth 220 kV station.	-	Cancelled	Cancelled	Studies indicate that this station is unlikely to be required within the period of the TYNDP
775	84. A31	Finglas / Huntstown (IE)		New 400 kV station in the vicinity of Huntstown and Finglas 220 kV stations.	-	Cancelled	Cancelled	System studies indicate that this investment is unlikely to be required within the period of the TYNDP
774	84. A31	Finglas / Huntstown (IE)	Woodland (IE)	A new 25km single circuit 400 kV from Woodland 400 kV station to a new 400 kV station in the vicinity of Huntstown and Finglas 220 kV stations.	-	Cancelled	Cancelled	System studies indicate that this investment is unlikely to be required within the period of the TYNDP
776	84. A32	Dunstown (IE)	Maynooth (IE)	A new 40km single circuit 400kV OHL circuit from Dunstown 400 kV station to a new 400 kV station in the vicinity of Maynooth 220 kV station.	-	Cancelled	Cancelled	Investment has been incorporated into investment 84.471, which is a circuit in series with this circuit - the intermediate station (inv. 773) is unlikely to progress within the period of this TYNDP
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
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

12.1.5 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	S2	b6 technical resilience	b7 flexibility	scenario	SoS (MWh/yr)	SEW (Meuros/yr)	RES avoided spillage (MWh/yr)	Losses variation (MWh/yr)	CO2 emissions variation (kT/yr)
221	Storage faciliy at Larne in Northern Ireland. Project consists of both storage and generation facilities.	268	NA	NA	2	2	Scenario Vision 1 - 2030	-	[0;10]	[27000;33000]	0	[-44;-36]
							Scenario Vision 2 - 2030	-	0	[14000;17000]	0	[-27;-22]
							Scenario Vision 3 - 2030	-	[0;10]	[90000;110000]	0	[-71;-58]
							Scenario Vision 4 - 2030	-	[0;10]	[81000;99000]	0	[-38;-31]

12.2 Key concepts and definitions

12.2.1 ENTSO-E

The European Network of Transmission System Operators for Electricity (ENTSO-E) was established on a voluntary basis on 19 December 2008 and became fully operational on 1 July 2009, in anticipation of the requirements of the 3rd Package which came into force on 3 March 2011.

Today there are 41 TSOs from 34 European countries are members of ENTSO-E. The working structure of the association consists of Working and Regional Groups, coordinated by four Committees (System Development, System Operations, Markets and R&D), supervised by a management Board and the Assembly of ENTSO-E, and supported by the Secretariat, the Legal and Regulatory Group, and Expert Groups.

The main purposes of ENTSO-E are:

– to pursue the co-operation of the European TSOs both on the pan-European and regional level; and

– to have an active and important role in the European rule setting process in compliance with EU legislation.

Table 12.1 ENTSO-E Countries and Member TSOs

Country	**Company**	**North**	**Baltic**	**CCE**	**CSE**	**CCS**	**CSW**
Austria	Austrian Power Grid AG			🟦		🟦	
	Vorarlberger Übertragungsnetz GmbH			🟦		🟦	
Belgium	Elia System Operator SA	🟦					
Bosnia and Herzegovina	Nezavisni operator sustava u Bosni i Hercegovini				🟦		
Bulgaria	Electroenergien Sistemen Operator EAD				🟦		
Croatia	Croatian Transmission System Operator Ltd.			🟦	🟦		
Cyprus	Cyprus Transmission System Operator				🟦		
Czech Republic	ČEPS a.s.			🟦			
Denmark	Energinet.dk	🟦	🟦				
Estonia	Elering AS		🟦				
Finland	Fingrid OyJ		🟦				
France	Réseau de Transport d'Electricité	🟦				🟦	🟦
FYR of Macedonia	Macedonian Transmission System Operator AD				🟦		
Germany	50Hertz Transmission GmbH		🟦	🟦			
	Amprion GmbH	🟦				🟦	
	TransnetBW GmbH	🟦				🟦	
	TenneT TSO GmbH	🟦		🟦		🟦	
Greece	Independent Power Transmission Operator S.A.				🟦		
Hungary	MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság			🟦	🟦		
Iceland	Landsnet hf						
Ireland	EirGrid plc	🟦					
Italy	Terna - Rete Elettrica Nazionale SpA				🟦	🟦	

Latvia	AS Augstsprieguma tīkls		🟦				
Lithuania	Litgrid AB		🟦				
Luxembourg	Creos Luxembourg S.A.	🟦					
Montenegro	Crnogorski elektroprenosni sistem AD				🟦		
Netherlands	TenneT TSO B.V.	🟦					
Norway	Statnett SF	🟦	🟦				
Poland	PSE Operator S.A.		🟦	🟦			
Portugal	Rede Eléctrica Nacional, S.A.						🟦
Romania	C.N. Transelectrica S.A.			🟦	🟦		
Serbia	JP Elektromreža Srbije				🟦		
Slovak Republic	Slovenska elektrizacna prenosova sustava, a.s.			🟦			
Slovenia	ELES, d.o.o.			🟦	🟦	🟦	
Spain	Red Eléctrica de España: S.A.						🟦
Sweden	Svenska Kraftnät		🟦				
Switzerland	Swissgrid ag					🟦	
United Kingdom	National Grid Electricity Transmission Plc	🟦					
	Scottish Hydro Electric Transmission Plc	🟦					
	Scottish Power Transmission plc	🟦					
	System Operator for Northern Ireland Ltd	🟦					

For more information, please refer to www.entsoe.eu.

12.2.2 Legal requirements for TYNDP (EC 714/2009 and EU 347/2013)

Regulation EC 714/2009

One key requirements of the 3rd Package, especially Regulation EC 714/2009, forms the legislative driver for the production of the “2014 Ten Year Network Development Plan” suite of documents (the “TYNDP 2014 package”) is under:

- **Art 8.3 (b) of Regulation**

  ENTSO-E shall adopt a non-binding Community-wide 10 year network development plan, including a European generation adequacy outlook, every two years.

- **Art 8.4**

  The European generation adequacy outlook shall cover the overall adequacy of the electricity system to supply current and projected demands for electricity for the next five-year period as well as for the period between five and 15 years from the date of the outlook. The European generation adequacy outlook shall build on national generation adequacy outlooks prepared by each individual transmission operator.

- **Art 8.10**

  ENTSO-E shall adopt and publish a network development plan every two years. The network development plan shall:

- include the modelling of the integrated network, scenario development, a European generation adequacy outlook and an assessment of the resilience of the system
.
- Build on national investment plans, taking into account regional plans, and if appropriate Community aspects of network planning, including the guidelines for trans-European energy networks; it shall be subject to a cost benefit analysis established as set out in Article 11 of the regulation Eu No 347/2013.

- Build on the reasonable needs of different system users and integrate long-term commitments from investors referred to in Article 8 (tendering procedures), article 13 (ISO) and article 22 (network development) of the Directive;

- Identify investment gaps, notably with respect to cross-border capacities. A review of barriers to the increase of cross-border capacities arising from different approval procedures or practices may be annexed to the network development plan.

Regulation EU 347/2013

- **Art 3.6**

  Projects of Common Interest included on the Union list pursuant to paragraph 4 of this Article shall become an integral part of the relevant national 10-year network development plans under Article 22 of Directives 2009/72/EC and 2009/73/EC and other national infrastructure plans concerned, as appropriate. Those projects shall be conferred the highest possible priority within each of those plans.

- **Art 11.1**

  The European Network of Transmission System Operators (ENTSO) for Electricity shall publish and submit to Member States, the Commission and the Agency their respective methodologies, including on network and market modelling, for a harmonised energy system-wide cost-benefit analysis at Union level for projects of common interest falling under the categories set out in Annex II.1 (a) to (d) and Annex II.2. Those methodologies shall be applied for the preparation of each subsequent 10-year network development plan developed by the ENTSO for Electricity or the ENTSO for Gas pursuant to Article 8 of Regulation (EC) No 714/2009 and Article 8 of Regulation (EC) No 715/2009. The methodologies shall be drawn up in line with the principles laid down in Annex V and be consistent with the rules and indicators set out in Annex IV. Prior to submitting their respective methodologies, the ENTSO for Electricity shall conduct an extensive consultation process involving at least the organisations representing all relevant stakeholders — and, if deemed appropriate, the stakeholders themselves — national regulatory authorities and other national authorities.

12.2.3 Scenarios (Visions) and Cases

As introduced in TYNDP 2010, § 4.1.2, network planning makes use of two different levels of details to describe the hypotheses, both of which are often referred to as “scenarios” (and thus become sources of confusion):

– A **scenario**: general economic conditions (economic growth, prices of primary fuels and CO_2); general level of load (with underlying uses of electricity, resulting for example in typical shape of load curve and sensitivity to temperature); generation fleet (number of units of every type, and respective size), network consistency. The TYNDP 2014 covers four scenarios, known as the 2030 Visions developed by ENTSO-E TSOs in collaboration with stakeholders, through the Long-Term Network Development Stakeholder Group and further informed via public consultation. The Visions are not forecasts of the future but provide a credible range within which the pathway to 2050 could be anticipated to be realised with a high level of certainty. A **case study**: i.e. represent a particular situation that may occur within the framework of a scenario, featuring:

- one specific point-in-time (e.g. winter / summer, peak hours / low load conditions),
- a realisation of random phenomena, generally linked to climatic conditions (such as wind conditions, hydro inflows, temperature, etc.) or availability of plants (forced and planned);
- A corresponding merit-order dispatch of all generating units resulting from the assumptions above.

A scenario can thus be described quite synthetically, and debated. Cases correspond however to the relevant situations that network planers study to assess likely investments needs and the efficiency of any measure to solve them.

12.2.4 Investment needs typology

As introduced in the chapter 4, **Investment needs** are every concern ahead on the regional grid and of European significance, and which are likely to trigger investment in the Transmission System in order to restore the grid ability to fulfil the duties and services expected from this infrastructure.

The investment needs are sorted in the following categories:

- **Demand growth**: large cities or regions, where the security of supply can be at risk despite a sufficient generation capacity overall, i.e.: at risk specifically because of lacking transmission means.
- **Future generation evacuation**: places where new generation facilities asked (or are likely to ask) for connection, be they large power plants and/or distributed generation, RES or not, and the existing network does not assure an adequate evacuation and integration into the system. In the present TYNDP 2012 package, RES and conventional generation have been distinguished to provide a clearer picture.
- **Existing generation evacuation**: places where existing generation cannot be evacuated reliably in all situations because of a change in surrounding power flow patterns.
- **Generation decommissioning**: places where large power plants are decommissioned, modifying the surrounding power flow patterns, or causing local voltage level concerns.
- **Insufficient cross-border capacity**, i.e. structural market congestion between price zones 29. Two subset of structural congestion are specifically identified:
  - **Change in exchange patterns**: grid section, the transfer capability of which may appear no more appropriate to accommodate power exchanges, that is new (or recent) congestion.
  - **Isolated systems to be connected**: typically islands to be connected to the mainland.
- **Reliable grid operation**: substations, where risks of current and voltage limits violation require upgrade of HV equipment to withstand now likely high short circuit currents, to manage reactive power issues, transient stability issues, etc. in steady state and fault situations.
- **Ageing/obsolescence of existing network equipment**: asset requiring replacement or heavy refurbishment in order to maintain the grid transfer capability at its present standards, but possibly address new environmental concerns (e.g. higher standards against climatic conditions).

Isolation of systems, demand growth, commissioning and decommissioning of generation, ageing/obsolescence of existing network equipment are **primary drivers**, i.e. exogenous causes for grid development. Other needs (change in exchange patterns, existing generation evacuation, insufficient cross-border capacity, reliable grid operation) are assessed only once the primary drivers have been established.

12.2.5 Investment items, projects, projects of pan-European Significance

A **Project** in the TYNDP 2014 could be represented by a cluster of several **Investment items that have to be realised in total to achieve a desired effect**. The clustering is performed according to the CBA clustering rules[23]. Every row of the table in appendix 1 to the TYNDP or Regional Investment Plan report corresponds to one investment item. The basic rule for the clustering is that **an investment item belongs to a project if a single project does not achieve the desirable effect. A group of investments are clustered when they deliver a common measurable goal are located in the same area or along the same corridor and are contained within a general plan for that area or corridor.** .

A project can be limited to one investment item only.

An investment item can contribute to two projects. In this case it is depicted only once, in one of the projects; and only referred to in the other project (no technical description, status, etc. are repeated).

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;
  - 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.

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

Projects of pan-European significance are candidate projects for the Project of Common Interest

foreseen by the future EIP.

12.2.6 Boundaries, bulk power flows, grid transfer capability

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[23] Please refer to the Cost Benefits Analysis methodology: https://www.entsoe.eu/major-projects/ten-year-network-development-plan/cba-methodology/

A Boundary is one section of the grid between one area and another (price zone, area within a country or a TSO), or several sections of the grid sharing the same concern, across which it appears relevant for TSOs to assess grid transfer capability values (in order to auction capacity, to advertise the possibility of new generation connection upstream, or to communicate on securing load growth for several years downstream). A boundary, across which a grid transfer capability assessed, is hence oriented, i.e. relates to a specific direction of power flows (for an international border A-B, one boundary A>B and another boundary B>A can be defined. The PL>DE+CZ+SK is a boundary; CZ>PL is another).

A boundary may remain stable (border between states or price zones), or vary from one horizon or scenario to another. It may be internal to a country or a price zone.

A **Bulk power flow** is the typical power flow triggering grid development across a boundary.

The **Grid Transfer Capability (GTC)** is the ability of the grid to transport electricity across a boundary, i.e. from one area (price zone, area within a country or a TSO) to another. It depends on the considered state of consumption, generation and exchange, as well as the topology and availability of the grid, and account for security rules (such as the N-1 rule). It is expressed in MW, and represents maximum transfer capabilities between two areas calculated under certain conditions.

The Grid Transfer Capability is oriented, which means that across a boundary, there may be two different values.

The Grid Transfer Capability compares rather directly with the NTC when the ry separates prices zones if the transmission reliability margin is neglected; or, roughly again, with the amount of generation or load that can be accommodated.

12.3 Abbreviations

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

12.4 Imprint