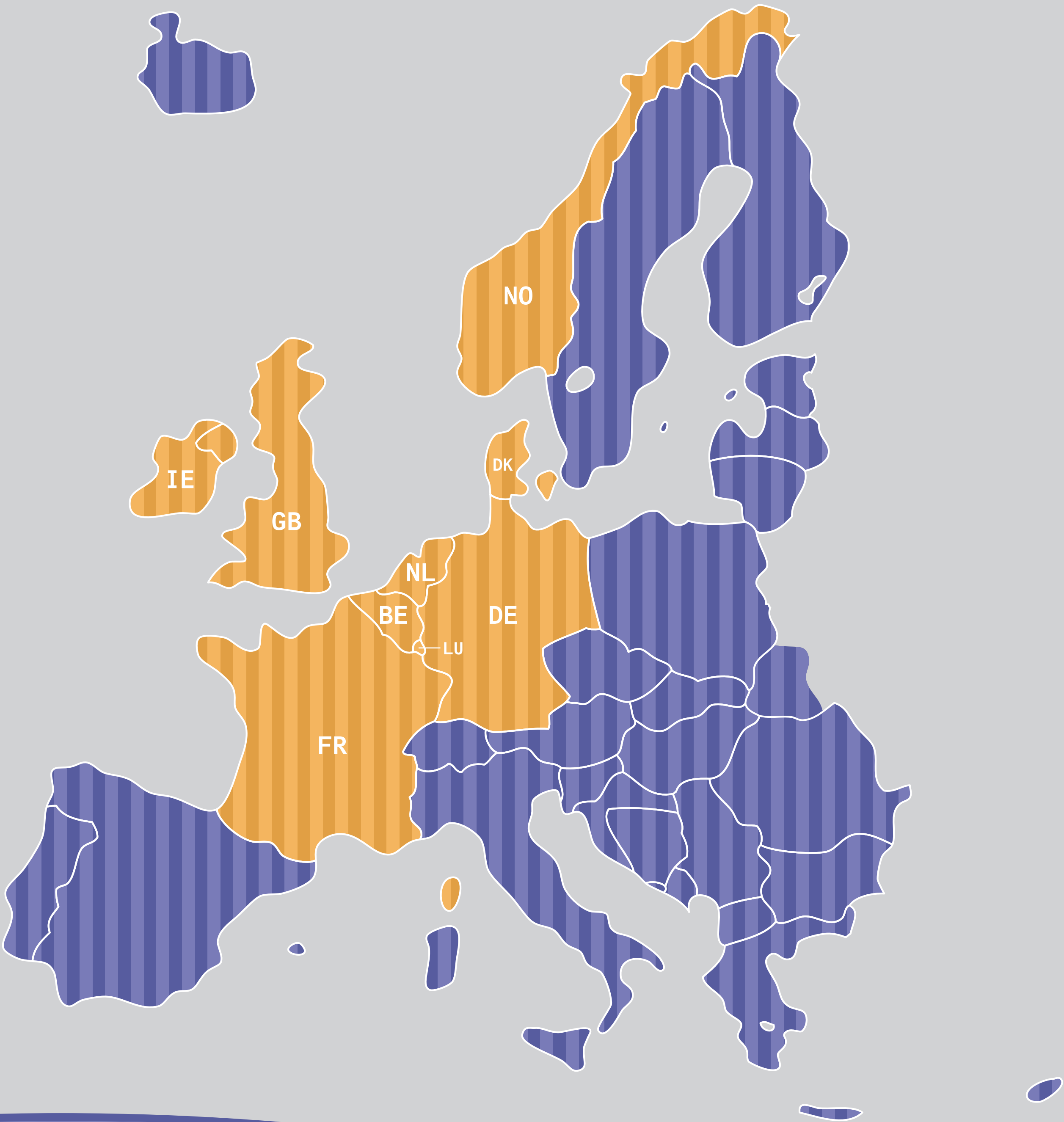
Regional Investment Plan North Sea

Final



European Network of
Transmission System Operators
for Electricity

entsoe

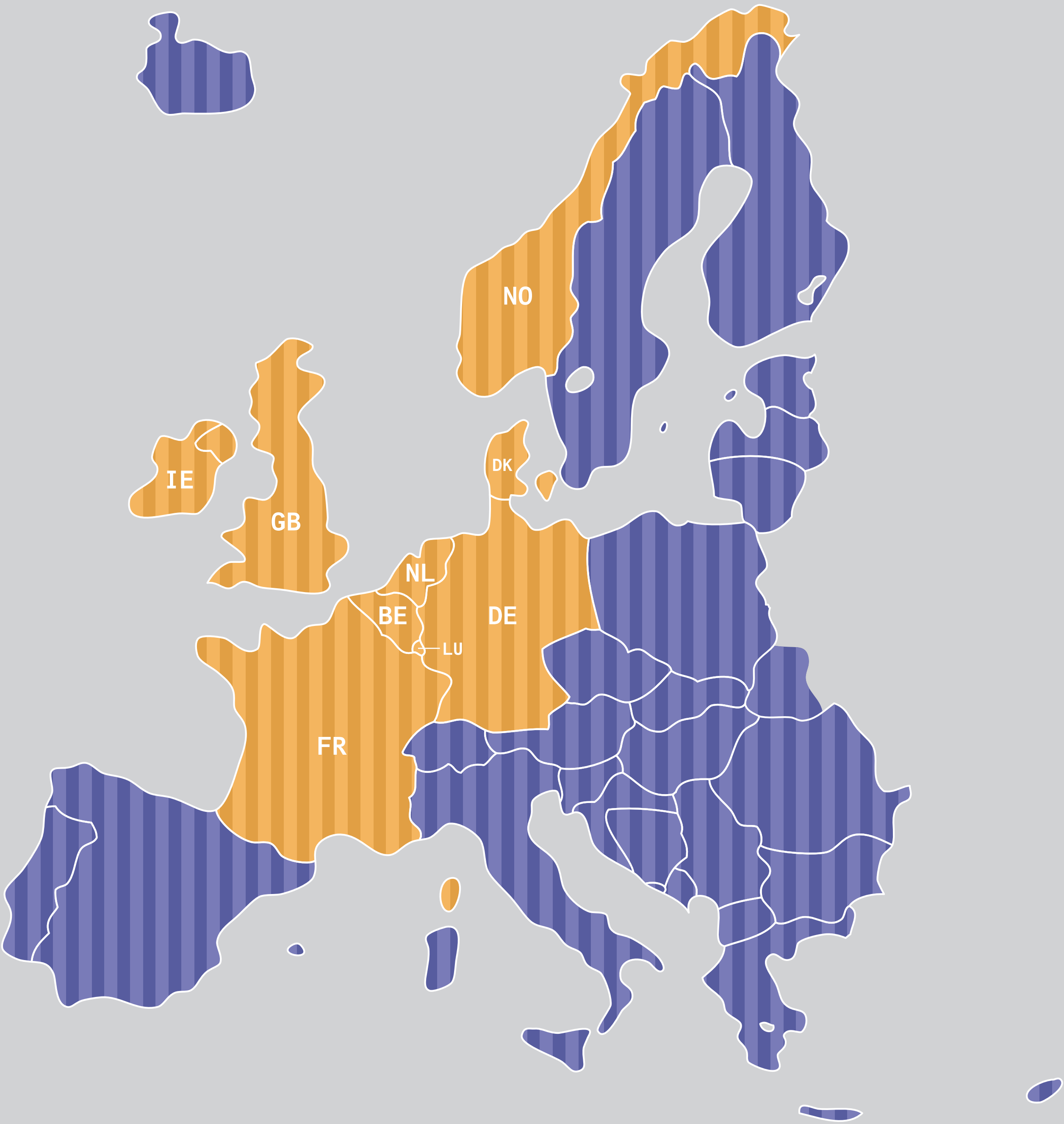
Regional Investment Plan North Sea

Final

5 July 2012

Content

1 Executive Summary



The 3rd Legislative Package for the Internal Market in Electricity entered into force on 3 March 2011. It promotes cooperation within the European Electricity Industry, the development of the Electricity Infrastructure both within and between Member States, and looks at Cross-border Exchanges of Electricity between the Member States.

In this regard, the TSOs of the Regional Group North Sea within ENTSO-E present this Regional Investment Plan 2012 – 2022. The North Sea Region covers Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, Norway, and UK.

Investment drivers

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

– the preservation of security of supply and the completion of the integrated European electricity market, taking into account some policy decisions (for example, the ongoing impact of the Nuclear Phase Out in Germany), by securing the current exchange capacities between countries and increasing capacities by building new interconnections;

– the large-scale connection and increased integration of renewable energy sources;

– the connection and integration of the new conventional power plants planned by the generation operators in their expansion strategy or to replace the ageing plants in place;

– the support of the load growth in some areas in a reliable way.

Scenarios 2020

TSOs of the North Sea Region have studied two different scenarios both for the year 2020. This year has been chosen because it is a target year for the European Energy Policy objectives, which do not currently extend beyond this date. The scenarios represent different possible futures of the main variables involved in the behavior of the markets and thus, the design of the systems.

A first scenario has been referred to as the **EU 2020,** and represents a context in which all objectives of the European 20-20-20 targets are met (20 % RES share of gross energy consumption, 20 % reduction of GHG, and 20 % increase in energy efficiency).

In this scenario, the national demand growths are too low to take into account the positive impact of efficiency measures. Moreover, the World Energy Outlook of the International Energy Agency (IEA) has been chosen as a reference for gas and coal prices. It assumes an artificial high cost of the

CO_2 allowances to create a merit order with gas before coal, consequently allowing the fulfillment of the EU environmental objectives ("top-down-scenario").

A second scenario has been referred to as **Scenario Best Estimate,** or **Scenario B,** and represents the TSOs' best estimate on how the future might look, taking practical experience into account concerning for example lead times of developments. This "bottom-up" scenario may not entirely cope with the European objectives.

In Scenario B, the demand growth rates are higher than in EU2020. The prices of CO_2 emissions used are the central forecasts of the IEA's World Energy Outlook and result in lower variable generation cost for most coal plants in Europe compared to EU2020. The installation of power from RES is the central forecast of the TSOs, and is generally (but not always) lower than the national targets.

In addition to these two scenarios, **a sensitivity analysis** was made based upon Scenario B with the new German Nuclear Phase Out plans announced in spring 2011, during the analysis phase.

The regional group has performed common market studies on both scenarios. These studies have pointed out that:

- The seas surrounding the region provide huge potential for renewable energy resources. By 2020, it is expected that 35 – 42 GW of offshore wind generation will be connected to the grid in the region. In addition there is a significant amount of RES generation onshore, in line with the projections in the governments' National Renewable Energy Action Plans. While the amount of offshore wind generation capacity has the potential to increase substantially beyond this figure, the governments have not set any renewable energy targets beyond 2020, which makes planning beyond 2020 uncertain.
- In 2020, with the foreseen investments, the region can largely deal with the higher penetration of RES with only limited curtailment for some RES, under the assumption that there are no national (also called "internal") grid constraints.
- Using the IEA fuel and CO_2 price forecasts, as well as the higher demand particularly in Germany and France, in Scenario B, coal and lignite plants will operate as base load plants. Enhancing the grid will expand their market area, trade potential and reduce the positive effects of more RES integration on CO_2 reduction.
- The Nuclear Phase Out has a negative effect on the CO_2 emissions, as nuclear energy is substituted by CO_2 producing units. However, the change in merit order of gas and coal between the scenarios has a much higher impact than Nuclear Phase Out.

Investment needs

By 2020, the changes in generation mix 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.

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 in Norway. The existing and new interconnectors connecting the Nordic system with the Continent and GB will be beneficial for trade and balancing flows.

Within Continental Europe, bulk power flows from Denmark West and Northern Germany into Southern Germany are already dominant and will increase. Moreover, 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.

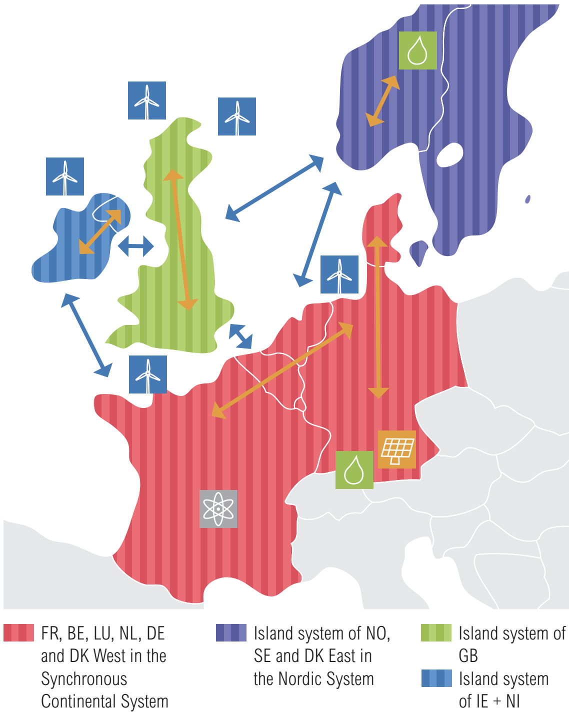


Figure 1:
North Sea Region Major Power Flows

Where physical flows may exceed the physical capacity of the existing grids, additional projects will be investigated to reinforce the networks in these areas.

Investments, transmission adequacy and resilience

In response to those investment needs, the Regional Investment Plan 2012 – 2022 for the North Sea Region includes details of 56 projects of European Significance in addition to other National projects supporting network development. Around 75 % of the individual investments in these projects were in the pilot TYNDP 2010 – 2020. According to the TSOs' assessments a significant number of them are subject to risk of delays mainly due to the difficulties encountered in the authorization processes. The TSOs are, however, committed to delivery of this plan and to facilitating the region in meeting the EU targets for 2020.

Offshore Grid development

Wind energy potential in the Northern Seas is very significant. 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.

It is therefore essential that these finite resources are best managed by a co-ordinated offshore grid development plan to connect the offshore wind parks and to interconnect the neighboring countries in a market trade and security of supply perspective. Only through an integrated, coordinated approach will targets be effectively met. In this respect, ENTSO-E proposes a pragmatic stepwise approach.

In a first stage, local coordination should ensure that clusters of offshore wind farms are connected to and integrated with the onshore systems. By delivering this essential first step the 2020 targets will be achieved. In a second stage, the evolution of a wider integrated offshore grid is expected to be beneficial in meeting longer-term targets by facilitating RES connections and cross-border trade. This can only be achieved through international coordination.

The ten governments of the North Seas countries (Ireland, UK, France, Belgium, Luxembourg, Netherlands, Germany, Denmark, Sweden and Norway) signed a Memorandum of Understanding aimed at providing a coordinated, strategic development path for an offshore transmission network in the Northern Seas. The ENTSO-E work considering the development of an integrated North Seas Grid for 2030 is now being taken forward within the North Seas Countries' Offshore Grid Initiative[1)].

Key Success Factors

Permit Granting Procedures: RG NS Project Monitoring emphasises that a number of TYNDP 2010 projects are subjected to commissioning delays. If energy and climate objectives are to be achieved, a smooth authorization processes is necessary. On this aspect, the Energy Infrastructure Package moves in a correct direction by setting up the one stop shop principle and by stating that the duration of the permit granting process shall not exceed three years.

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1) http://ec.europa.eu/energy/renewables/grid/doc/north_sea_countries_offshore_grid_initiative_mou.pdf

Regulation: Regulatory framework evolution is a prerequisite to the further development of a pan-regional off (on-) shore network. Main issues:

- Support Schemes consistency;
- Treatment of the injected renewable energy;
- Balancing of systems subject to massive RES integration;
- Cost allocation based on, among other things, cost and benefit analysis;
- Possibility given to realise anticipatory investments.

Financing: Regional investments of European significance in RG NS for the next 10 years amount to 75 € billion. Given the fact that these investments are a small element of the TSO's aggregated investment portfolio it is crucial that the current regulatory framework leads to adequate and stable returns for all involved stakeholders in order to be able to attract investors required for financing the investments.

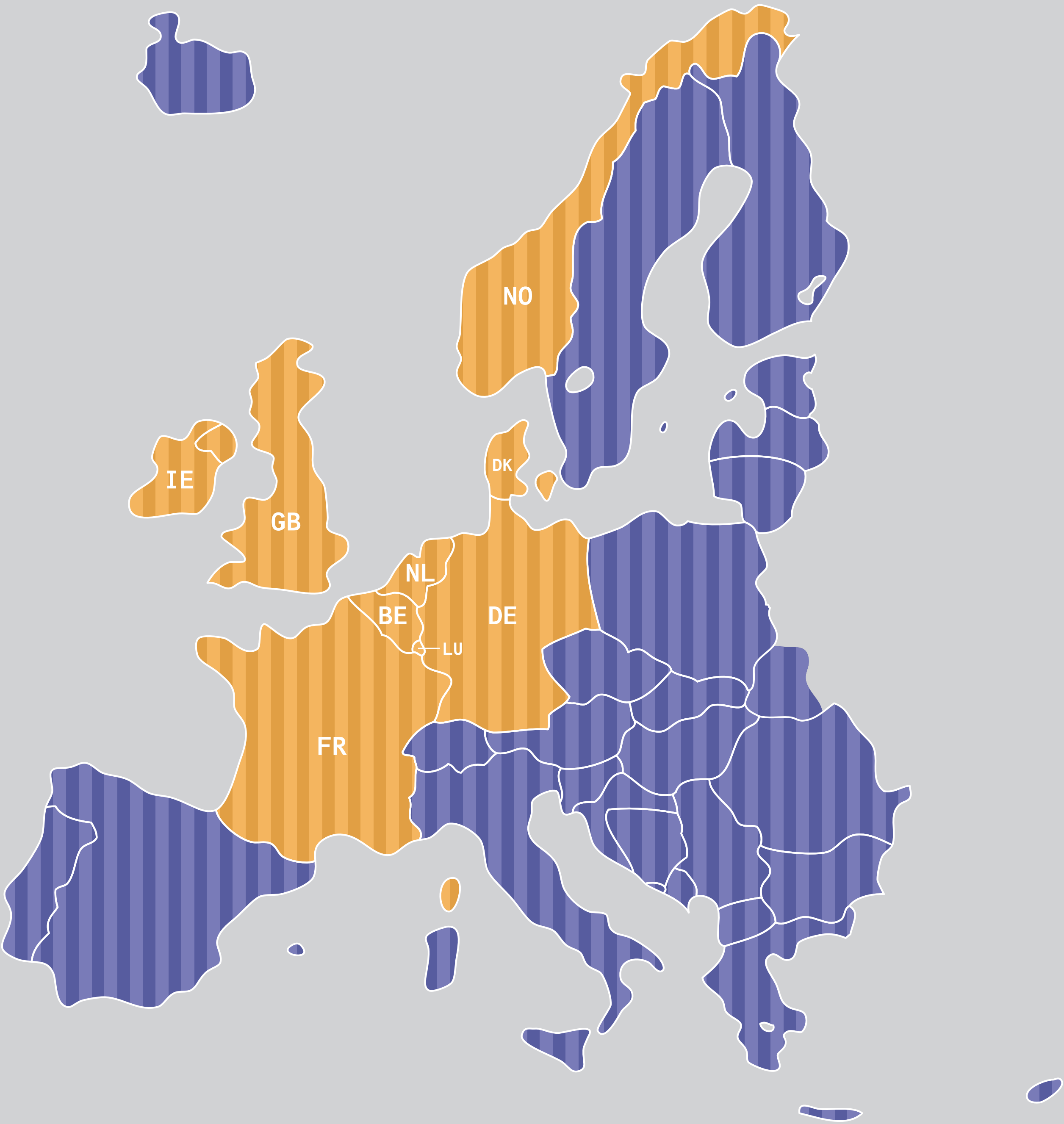
Conclusion

The analysis undertaken shows that the completion of the 56 projects identified for the North Sea region will provide sufficient grid adequacy to meet the needs presented by the EU 2020 scenarios, which indicate that 42 GW offshore and a comparable amount of onshore wind generation will get connected by 2020. In addition, the planned interconnections will provide adequate capacity to maintain low levels of constraints. It must be noted however that it is very likely that the long term scenarios will change over the course of the coming years, and so in some cases additional investments will be required. At the 2030 time horizon, the focus of the North Seas Countries' Offshore Grid Initiative will be on possible offshore grid designs facilitating higher RES volumes, market integration and security of supply. The current Regional Investment Plan is an important step towards the realization of such an offshore grid.

Going forward, lessons need to be learned regarding how to improve the speed of permitting processes and to settle a stable and favorable regulatory regime; both of which are key factors to further develop an offshore grid in the North Sea.

The TSOs are facing great challenges in realizing the 56 projects mentioned in this Regional investment plan as part of the TSOs' overall investment portfolio.

2 Introduction to RG NS Regional Investment Plan



2.1 Expectations of the 3rd Legislative Package

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

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

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

An explanation of how the Ten Year Network Development Plan (TYNDP) package meets these requirements is contained in Section 2.3.

2.2 ENTSO-E

ENTSO-E[2)] was established on a voluntary basis on the 19 December 2008 and became fully operational on the 1 July 2009, in anticipation of the entry into force of the 3rd Package on the 3 March 2011.

Today, 41 TSOs from 34 European countries are members of ENTSO-E. The working structure of the association consists of Working and Regional Groups, coordinated by four Committees (System Development, System Operations, Markets and Research & Development), supervised by a management Board and the Assembly of ENTSO-E, and supported by the Secre-

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

2) ENTSO-E = European Network of Transmission System Operators for Electricity

tariat, the Legal and Regulatory Group, and Expert Groups.

The main purposes of ENTSO-E are:

- to pursue the cooperation 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.

2.3 Documents in the TYNDP Package

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

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

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

1. **Ten Year Network Development Plan 2012:** The TYNDP focuses specifically on the projects of pan-European significance detailed within each Regional Investment Plan, covering those with significant contributions to enabling Renewable Energy Supply connections, facilitating cross-border flows and meeting security of supply in large areas of demand. Further information on the content, methodology and selection criteria can be found in the TYNDP document itself.
2. **Regional Investment Plans 2012:** (six individual regional documents) The Regional Investment Plans overlap between the National Development Plans that TSOs are bound to publish to their regulatory authority (under Article 22 of Directive 2009/72/EC) and the TYNDP document outlined above. Each Regional Investment Plan provides a regional approach to the specific drivers for grid development and the planned projects to face these European and regional needs.
3. **Scenario Outlook and Adequacy Forecast 2012:** The Scenario Outlook & Adequacy Forecast (SO & AF) assesses the future system adequacy at a mid- to long-term time horizon. It provides an overview of generation adequacy analyses for all of ENTSO-E, its regions as well as

for individual countries, including an assessment of the role of the transmission capacities and security of supply on a regional basis.

More information about the history and evolution of the Ten Year Network Development Plan can be found in the TYNDP 2012 document.

2.4 Regional Groups

As described in Section 2.2, cooperation of the European TSOs both at the Pan-European and regional level in order to undertake effective planning is the main requirement of the 3rd package, and therefore one of ENTSO-E's key purposes. To achieve this ENTSO-E is split into six regional groups for grid planning and system development tasks. The Member States belonging to each group are shown in Figure 2.

ENTSO-E considers the regional approach to be the most appropriate framework for grid development in Europe, and contains numerous instances of overlapping to ensure overall consistency of the **Regional Investment Plans.**

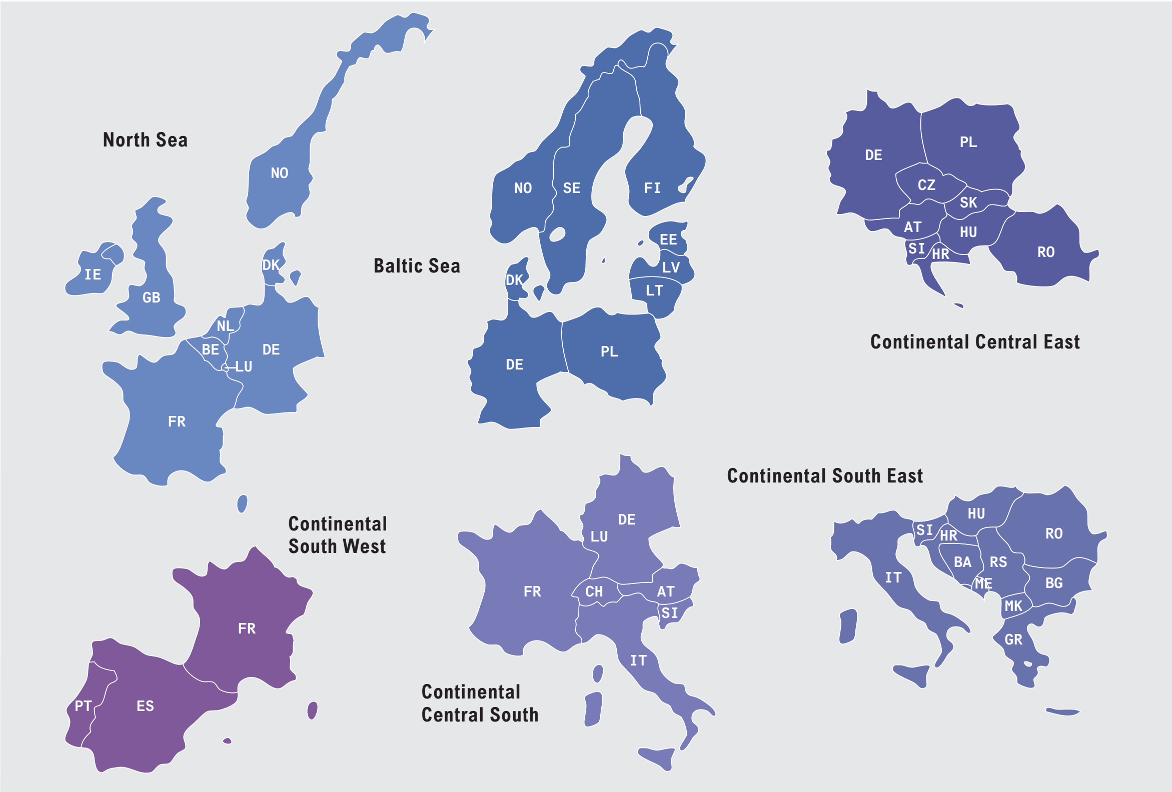


Figure 2:
ENTSO-E Regions (System Development Committee)

2.5 How to Read the RG NS Regional Investment Plan

The present document is focused on the North Sea Region (RG NS) which embraces Belgium, Denmark, France, Luxembourg, Netherlands, Ireland, Germany, Norway and UK.

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

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

Chapter 5 describes the scenarios considered while developing the Regional Investment Plan, looking at the common scenarios at ENTSO-E level contributing to the TYNDP 2012 but also highlighting any specific regional scenarios.

Chapter 6 presents the forecast evolution of power flows and transmission capacity across the Region for the ten year period of this plan, looking at the main drivers for system evolution and the consequences these will have.

Chapter 7 focuses on the Projects of European significance and Regional projects of interest identified to meet the investment needs presented in Chapter 6, split up into medium-term (2012 to 2016 inclusive) and long-term (2017-2022) projects.

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

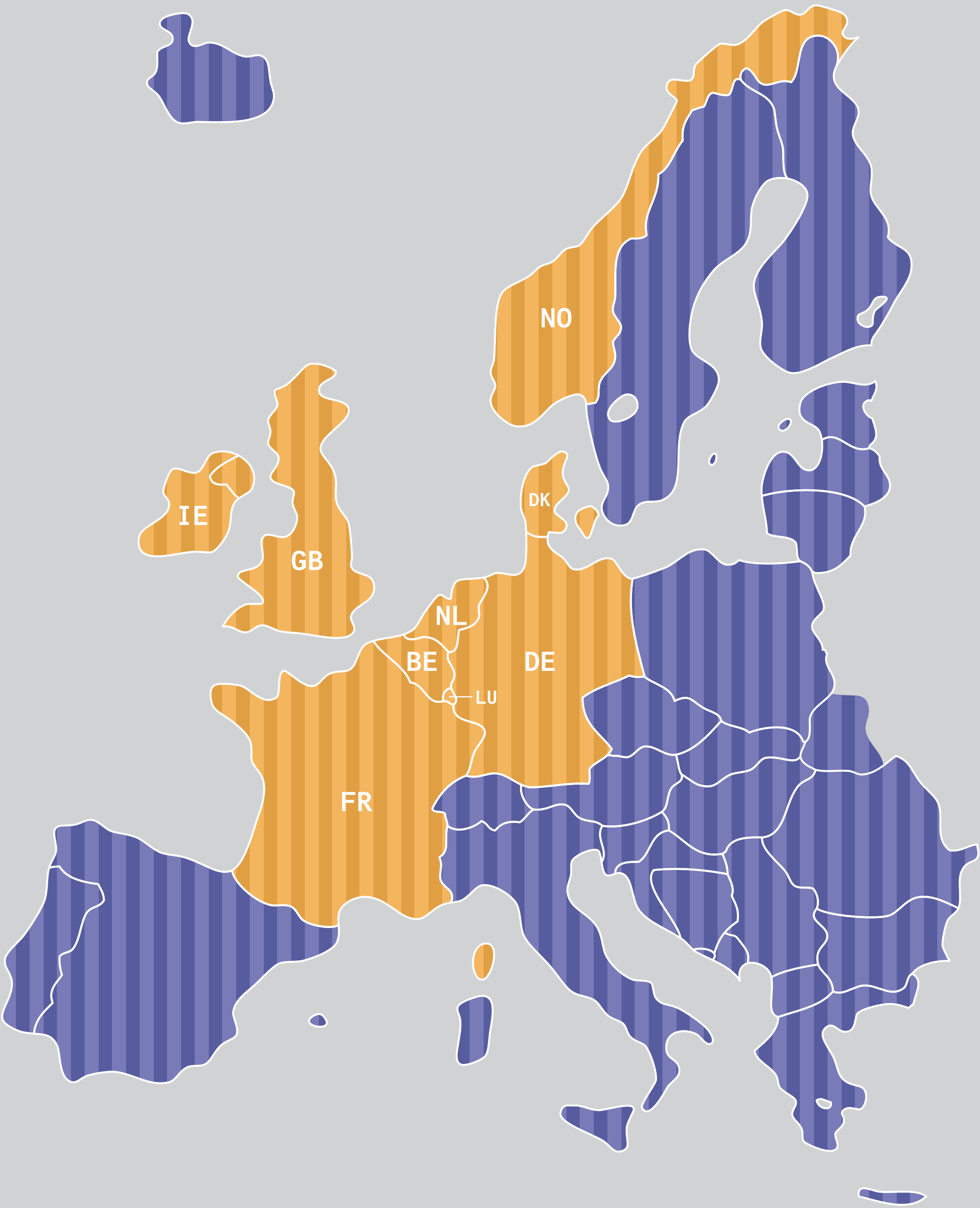
Chapter 9 underlines the process of environmental assessment utilized in the course of constructing the Regional Investment Plan and presents key statistics.

Chapter 10 revisits the resilience principles highlighted in the TYNDP 2012 and justifies the planned investments. It also highlights and describes the adverse scenarios which may occur in the region and which may require special attention and possible future investment.

Chapter 11 focuses on the specific issues relating to the development of an offshore grid in the northern seas.

Finally, the appendices provide further details regarding the North Sea region projects and on the grid analysis carried out for this Plan.

3 Assessment of the TYNDP 2010



TYNDP 2012 includes 56 projects in the North Sea region, comprising 286 individual investments within the countries of the North Sea region, and interconnections between the countries of the region, or between these countries and neighboring regions. Approximately 27 % of the investments are new to this plan, that is, they did not feature in the TYNDP 2010.

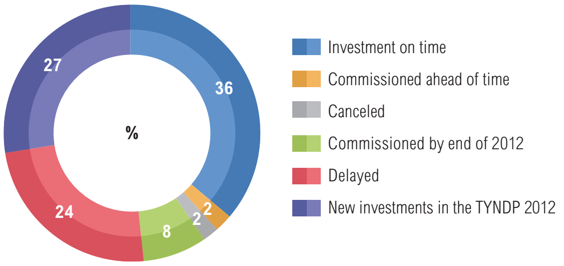


Figure 3:
Status of RG NS TYNDP 2012 projects

This chapter presents an overview of the changes to those investments which were in TYNDP 2010. The main changes and reasons for the changes are outlined, with a focus on the major investments for the North Sea Region. Of the investments which were presented in the TYNDP 2010, approximately 50 % remain on schedule. However some investments have changed in terms of expected commissioning date, status or details. In addition, a small number have been removed from the plan or cancelled.

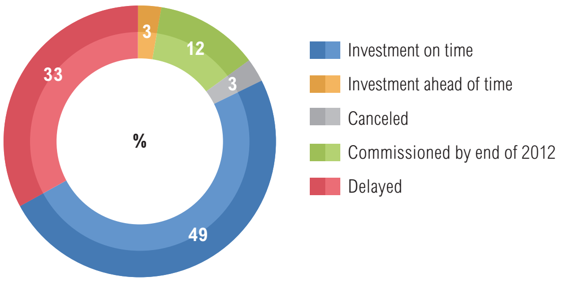


Figure 4:
Status of RG NS TYNDP 2010 projects

From the overview of the major changes of the investments in respect to TYNDP 2010 it can be concluded that the most susceptible to change is the commissioning date. 33 % of these investments have later commissioning dates than previously scheduled due to permitting difficulties, scoping changes or delays in implementation of other investments. Four investments (3 %) are ahead of schedule as a result of high RES penetration and a greater urgency in investment need. Despite problems other projects are facing, 24 grid investments in the North Sea Region were completed or are due to be completed and put into operation by the end of 2012.

More detailed monitoring data on every investment is available in Appendix A.

3.1 Completed Investments

Eleven investments, including three new interconnectors, have been completed within the North Sea region since the TYNDP 2010 was issued. The following are most relevant to the region.

Investment	Name	Comment
437	BritNed (GB-NL)	1000 MW HVDC interconnector commissioned in 2011
434	Great Belt (DK)	600 MW HVDC link between DKW-DKE commissioned in 2010
59	Lorraine–Ardennes (FR-BE)	Moulaine (FR) – Aubange (BE) 220 kV second circuit commissioned in 2010
39	Avelin–Warande (FR)	Reconductoring of the 400 kV existing double circuit, commissioned in 2011
43	IFA converters (FR)	Thyristors in the AC/DC convertor at Mandarins (FR) expected to be replaced in 2012
466	Srananagh Project (IE)	Flagford-Srananagh 220 kV line expected to be completed in early 2012

3.2 Delays in Commissioning Date

The scheduled commissioning dates of eight interconnector projects and a number of important national investments in projects of European significance have been delayed. The delays relate to problems with permitting, interactions with other investments or changes in the scope of the investments, and will impact negatively on market integration and connection of renewable generation sources.

A large portion of German onshore investments are delayed, largely due to permitting issues, for example changes to the legal framework, local public resistance, delays in permitting processes, and so on. For the most part the delays do not change the classification of the project from mid-term to long-term.

Project. Investment	Name	Comment
Delays in permitting procedures		
103.145	Doetinchem (NL) / Niederrhein (DE)	interconnector project expected to be commissioned after 2013
-.61	Moulaine (FR) – Belval (LU)	investment delayed from 2010 to a later year
81.462, -.464	North-South 400 kV interconnector (IE – NI)	400 kV Interconnector is delayed to 2016; a 2010 draft review of the project proposes to postpone plans for the intermediate Moyhill substation at this time.
24.445	Lillo, Zandvliet, Mercator (BE)	Due to a delay in the permitting procedure for the Lillo Zandvliet part of the BRABO project, two 150 kV cables will be laid earlier than previously foreseen to secure the supply in the Antwerpen harbour.
103.438	Vicinity of Eemshaven (NL)	Connecting the generation locations to the Dutch 380 kV central ring delayed by 2 years (to 2018).
103.439	Vicinity of Borssele (NL)	Connecting the generation locations in the vicinity of Borssele to the Dutch 380 kV central ring (expected date 2016).
103.440	Randstad project (NL)	Connection from the generation locations to the Dutch 380 kV central ring (expected date 2016).
17.45	Cotentin-Maine (FR)	Investment faces tough local opposition that could delay it by a couple of months. The permitting phase is even more difficult for overhead lines.

Other Delays		
36.141	Kriegers Flak CGS (DE–DK)	Combined Grid Solution (CGS) delayed by 1,5 years. Project depends on offshore wind farms (OWF). DE part under construction while DK part delayed due to lack of political decision concerning OWF. CGS Expected by end of 2017.
110.424	NSN interconnector (NO–GB)	Urgent need for reinforcements (NO) before new interconnectors can be added. Delay of interconnector (NO–GB) until 2018 – 2021.
37.142	Nordlink/ NorGer (NO–DE)	Urgent need for reinforcements (NO) before new interconnectors can be added. Delay of interconnector (NO–DE) until 2018 – 2021.
38.425	NorNed 2, (NO–NL)	NorNed 2 is now unlikely to be realized during this planning period but is included in the TYNDP calculations and therefore on the project list. NorNed 2 is not included in the current Norwegian national grid development plan.
74.443	Nemo (GB–BE)	135 km subsea interconnector delayed by one year to 2018. Investment depends on necessary onshore grid reinforcements (GB), which cannot be realized by 2016 due to the permitting procedures.
83.467	Moneypoint to Kilpaddoge (IE)	Delayed from 2012 to 2014 due to re-development of Moneypoint 400 kV station and change of cable termination to new planned Kilpaddoge 220 kV station.
17.44	Havre- Rougemontier (FR)	Investment (FR) is needed for integrating new generation in Le Havre area. As generation development is slower than previously assumed, the investment has been postponed from 2015 to 2018.
25.62	IFA2 (GB-FR)	This HVDC subsea interconnector was only at a very preliminary stage at the time the TYNDP2010 was issued. Ongoing feasibility studies have led to reassess the expected commissioning date to 2020.

3.3 Earlier Scheduled Commissioning Date

Four of the TYNDP 2010 investments are ahead of schedule.

Project. Investment	Name	Comment
5. 46	Baixas (FR) - Gaudière (FR)	More detailed feasibility studies have lead to optimized operating modes, therefore the commissioning date could be brought forward by a couple of months.
24. 60a	Lillo (BE) - Mercator (BE)	The Lillo-Mercator part of the BRABO project will be delivered one year earlier (2017) to enable the connection of a new power plant.
72. 435	Endrup (DK) - Revsing (DK)	Upgrade of 50 km double-circuit 400 kV OHL to reach a capacity of approx. 2000 MW. Now expected to be two years earlier.
74. 450	Sellindge - Dungeness (GB)	Reconductoring existing double circuit 400 kV OHL, four years earlier.

3.4 Canceled Investments

A small number of investments have been canceled or put on-hold since the TYNDP 2010.

Investment	Name	Comment
Implementation of the investment became obsolete due to the implementation of another investment		
424b to 424i	GB East Coast	Projects removed to reflect work in progress to optimize onshore / offshore design strategy given the potential for more than 20 GW of renewable offshore generation capacity in this area.
451	Rowdown (GB)	Installation of new quad boosters is no longer considered necessary; a new strategy involving other developments in and around London, as described by the new London project (76), will meet the system requirements.
456b, 456c	Harker, Quernmore and Padiham (GB)	These two projects are no longer necessary due to changes in the generation background and the adoption of alternative projects within the Anglo-Scottish region.
Changes in Anticipated Needs		
448	Thames Estuary (GB)	Changes in scenario backgrounds mean that the initially proposed new 400 kV circuit is no longer necessary.
	Øresund (DK-SE)	A 400 kV cable connection upgrade, namely the replacement of ageing 400 kV & 132 kV submarine cables, (DKE - SE) is in bilateral negotiation.
431	Tjele-Trige (DK)	Investment is related to either a new offshore wind power plant or upgrading the HVDC connections to Sweden. Both are not expected within the timeframe of the TYNDP 2012.

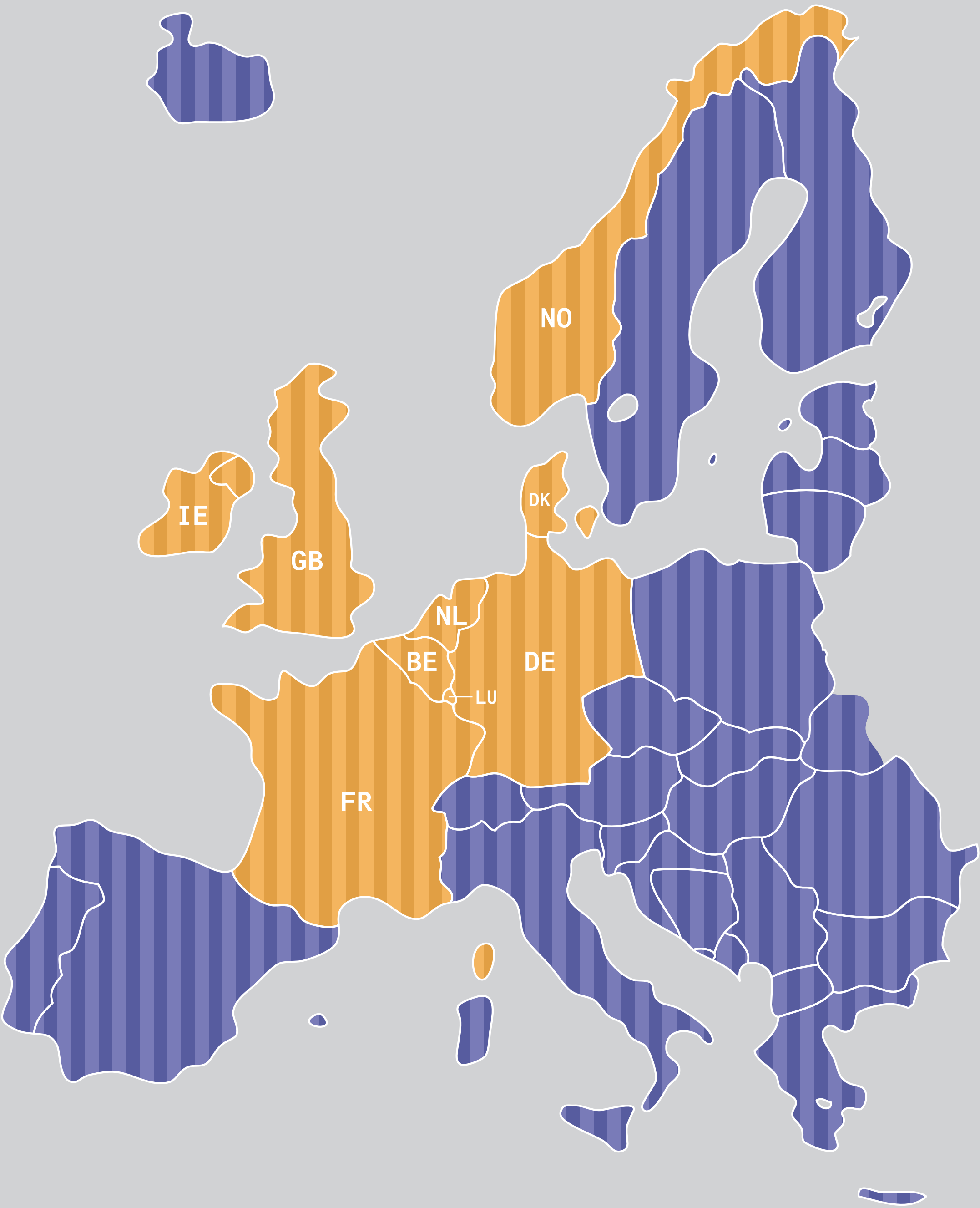
3.5 Changes in Scope of Investments

The consistency of the scope has changed for a number of investments which were in the pilot TYNDP 2010.

Project. Investment	Name	Comment
Changes due to results of relevant studies		
79.459b	Wylfa – Mid Wales now to -Pembroke (GB)	Route change has potential to reduce onshore consenting challenge with potential for additional benefits through coordinating offshore transmission assets with the onshore system.
72.436	Idomlund- Tjele now to Endrup- (DKW)	400kV cable route change offers better grid-connection possibilities for future large-scale offshore wind farms and reinforces the back-bone structure in DKW, connected to the system upgrade between DKW and DE.
Project to accommodate additional investment need		
40.446	Interconnector (BE-LU)	Project originally planned as two new 220 kV underground cables - scope might change due to RES development and possible overloads and loop flows, possible delay to 2020.
77.453	East Coast HVDC link (GB)	As the offshore cables for this project are expected to pass close to offshore wind generation, options are being considered which incorporate the offshore generation connection and wider system reinforcement.
77.456	Harker to Hutton to Quernmore (GB)	Project replacing the conductors on the Anglo-Scottish link is being extended to Quernmore to permit higher currents with the insertion of series compensation on the longer circuit sections to improve system stability limits.

Moved from Project of European Significance to Project of Regional or National Significance		
465	Laois-Kilkenny (IE)	400/110 kV project (formerly Loughteeog) on schedule but removed from TYNDP 2012 because evaluation against the criteria for project of European significance is marginal.
40	Avelin and Mastaing (FR)	Installation of a 3rd busbar in Avelin and connection of Mastaing to an existing 400 kV circuit. Investment does not meet the criteria for project of European significance. These investments have been commissioned.
41	Fruges, Sud-Aveyron – Marne-Sud, Somme (FR)	New 400 kV substations connected to existing 400 kV network and equipped with transformers to 220 kV or high voltage networks. Investment does not meet the criteria for project of European significance.
429	Ferslev – Vester Hassing (DK)	20 km single circuit 400 kV / 800 MW cable. Investment does not meet the criteria for project of European significance.

4 Specific RG Methodology and Assumptions



4.1 Common Approach for all Regions of ENTSO-E

The regional analyses carried out in support of this plan have two main purposes. Firstly they provide an assessment of the adequacy of the planned grid and in doing so identify grid bottlenecks in the regions and requirements or opportunities for further grid investments.

The term "bottlenecks" covers two types of problems which can be present in a transmission grid:

- existing (congestion) problems due to the power flows resulting from the market exchanges. Even when these are limited to NTC values;
- future problems limiting the capabilities to integrate renewable energy sources, to connect new power plants, or to support local load growth.

This chapter describes the methodology which was applied to identify those bottlenecks.

In addition to the identification of bottlenecks, the analyses provide an evaluation of the benefits of the planned grid investments. The indicators that have been evaluated for each project include:

- Increase in Grid Capacity
- Savings in Social and Welfare Costs
- Increased Renewable Energy connections
- Efficiency (Reduction in Losses)
- Reduction in CO_2
- Technical Resilience
- Flexibility
- Social and Environmental Indicator

The common scenarios described in Chapter 5 were built by ENTSO-E as a basis for the analysis for the TYNDP and the regional plans. During the process of preparing the TYNDP and the regional plans, a Pan European Market Database (PEMD) has been developed containing scenario supply and demand data as well as common data such as fuel prices. This common data is the basis for regional analyses, both market model analysis and network analysis.

4.2 Methodology Used by RG NS to Identify Bottlenecks

The methodology used by the RG NS to identify the bottlenecks involves first carrying out market analysis to determine the range of generation and load patterns across the region. The information derived from the results of the market analysis is then brought into grid studies which assess the grid power flows that would result from these generation and load patterns.

The methodology involves a five step approach, as illustrated in Figure 5 and described in more detail below.

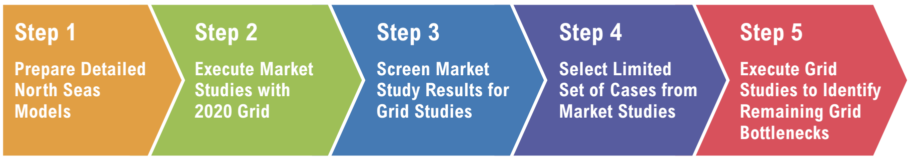


Figure 5:
RG NS Methodology for calculation of Bottlenecks

In a regionally interconnected transmission grid bottlenecks can be caused in one part of the system due to activities in another part of the region. In this regard, they are linked in a supra-national or regional way, and not just caused by national or bilateral cross-border constraints.

In order to detect these regional bottlenecks, one must develop a common view by performing grid calculations in a more regional way than only within bilateral studies between TSOs. A regional view on the behavior of the market and the grid will demonstrate all possible bottlenecks and their limitations and as such are complementary to the bilateral studies already performed between TSOs.

As a starting point for these studies a set of representative planning cases (snapshots) is identified covering a wide range of situations in the study area. These situations will depend on the hypotheses regarding generation, demand and exchanges but also on the localization of the different generating units and load distributed in the area.

To perform grid calculations on a large area such as the complete RG NS transmission grid, the choice of the planning cases is less straight forward than in bilateral studies but is decisive for the outcome. Because of this, year-round market simulations representing all possible situations are performed before the grid calculations. The year-round results are then used as an input for the common grid calculations.

Indeed, due to the complexity and the uncertainty of the future generation (both volume and location) and due to different challenges/ tasks of the grid in different areas of the region, a limited set of planning cases is not sufficiently representative. A single planning case cannot reflect these different challenges since they are caused by different factors. Additionally, by definition, planning cases do not take into account the probability of a bottleneck occurring. Therefore, the scope of the approach has been expanded to include an extended set of planning cases.

Step 1:
Preparation of model for market calculations

RG NS used three market simulation tools in parallel (Promod, Antares and PowrSym4). The results of these three simulation tools were compared in depth enabling RG NS to verify the results and to increase the quality of the market analysis.

ENTSO-E's Pan European Market Database (PEMD) provides a market model of the whole of Europe which ensures consistency across all regional groups of ENTSO-E. RG NS supplemented this with a more detailed regional database to more accurately reflect regional specifics (shaded blue in Figure 6). The Swedish electricity system has also been modeled in detail in view of its participation in the North Seas Countries' Offshore Grid Initiative (NSCOGI).

The PEMD has been used by RG NS to model the European power system outside the North Sea Region as follows:

1. Generation and load data for neighboring countries, shaded yellow in the map in Figure 6, were included in the RG NS market model in detail similar to the PEMD to address market behavior across the boundaries with the North Sea region;
2. The market beyond the neighboring countries has been modeled by fixed hourly commercial flows between the neighboring countries and those beyond. These commercial power flows have been derived for each scenario from the PEMD Europe wide market analysis.

Within the simulated perimeter (shaded blue and yellow in Figure 6) the power systems have been modeled in greater detail than in the PEMD. Each country is modeled as one market node, neglecting the internal bottlenecks, except for Denmark and Luxembourg where, due to the grid design, the market areas are split. These nodes are connected with each other with specified cross-border transfer capacities.

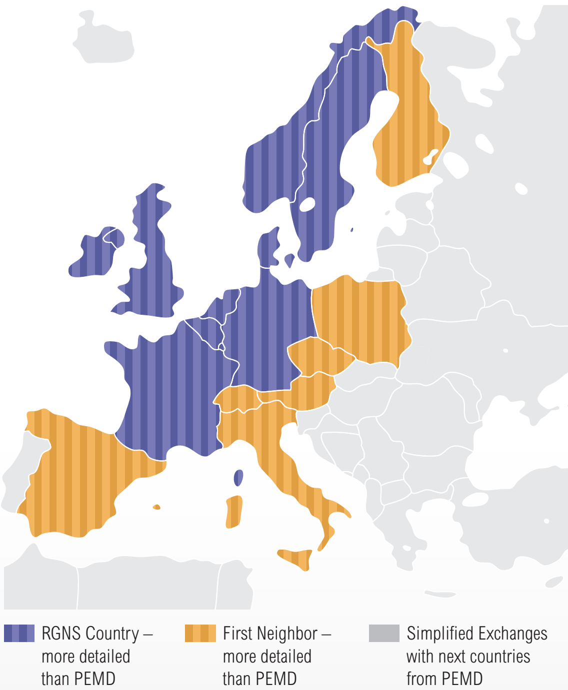


Figure 6:
Perimeter(s) in market modeling within RG NS

Other characteristics of the market analysis are:

- A perfect functioning of the markets is assumed;
- The different behaviors of reservoir based hydro, run of river production facilities and pumped water storage are modeled;
- No price driven demand-side management or political policies are modeled;
- A coherent set of correlated historic wind power time series have been used; these series have been up-scaled to match the capacities for the 2020 scenarios;
- Thermal plants within each country have been grouped into categories according to fuel type, age, must-run obligation, and so on, to obtain a realistic model of the generation portfolio within the RG NS perimeter. The operational flexibility (up-time, minimum down-time, ramp rates etc.) of the units and the must-run obligations for each of these categories are modeled according to their current market behavior or known obligations;
- Unit commitment and dispatching was based upon production costs including CO_2 costs. Capital costs, revenues and other imperfections in market behavior, namely different fuel contracts are not modeled;
- Net Transfer Capacities (NTCs) between market nodes are based on an assessment of the capacities of the planned grid in 2015 and 2020.

Step 2: Executing the market studies

The market modeling tool simulates the electricity market behavior for a one year period in hourly time steps. Given the load demand and the market input parameters the production cost are minimized. This provides hourly production values for each category and hourly commercial exchanges between the market nodes within the perimeter. The hourly balances for each country or system can be derived from these results.

Step 3: Screening of market model results for adoption in grid model

The NTCs set the limit for commercial exchanges between market nodes in the market model. As the DC links are controllable, the physical flows cannot exceed the NTCs. However, additional capacity requirements can be identified by remaining price differences between both ends.

In contrast, the physical flows in the AC interconnected grid will, more often than not, differ from market flows as the physical flows follow the path of the lowest resistance. This might cause congestions in the AC grid. Such congestions are identified by load-flow calculations.

The year-round physical cross border flows are calculated with an approximate method, known as PTDF (Power Transfer Distribution Factors) method. This methodology results in power flow values for each hour for each border and can show where and when the border is congested.

Step 4: Identification of the planning cases

Representative planning cases are those that are considered relevant to assess the need for grid reinforcement and/or grid optimization.

With the physical transmission capacity of each border and the time series of physical cross-border flows of step 3, the criticality and frequency of occurrence of the congestion on the borders could be estimated. On that basis, it was possible to evaluate which points in time should be assessed in further detail. Statistically relevant points in time were selected giving a set of 29 planning cases for further grid calculations. Additional cases with sub-regional relevance were also taken forward by individual TSOs.

The selected 29 common planning cases allowed for the consideration of:

- High loading of the AC interconnectors,
- High transit flows,
- High and low load,
- Multiple generation patterns, and
- Maximum flows in both directions on the DC interconnectors.

Step 5: Identification of remaining bottlenecks

With the results of step 4, a detailed load flow simulation for the selected planning cases is performed. In this step, the dispatch (as given per generation category in the market simulations) is assigned to individual power plants. Flows are calculated for all the individual transmission lines, both within countries as well as cross-border connections.

The analysis performed by the TSOs shows where the reliability criteria are not met. Grid extensions can then be studied and proposed. Detailed information on the methodology can be found in ENTSO-E's planning standards [TYNDP 2012 Appendix 3].

If the requirement for additional transmission capacity is identified to meet these remaining bottlenecks, further joint studies will need to be undertaken between all the TSOs involved. It is important to note that efficient grid design will not result in every congestion being resolved, and assessment of projects therefore takes into account other factors, such as economic efficiency, security of supply, public acceptability and so on.

4.3 Methodology to Calculate Project Indicators

The methodology used by the North Sea Regional Group to evaluate the project benefit indicators is illustrated in Figure 7. The benefits assessed in the market studies process are those provided by **long-term cross-border reinforcements,** which increase the transmission capacity between two countries. To evaluate them, the two grid situations (with or without all of the long-term reinforcements) are compared – thus, the comparison gives the **benefits provided by all long-term RG NS projects taken together.**

A comparison of the results provides an evaluation of a number of the benefits, namely social and economic welfare indicator and CO_2 emissions reduction.

Other project indicators were evaluated based on common methodology provided by ENTSO-E [TYNDP 2012 Appendix 3.

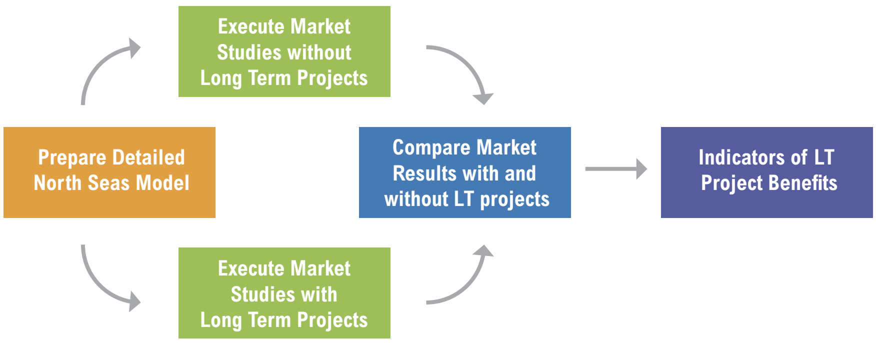
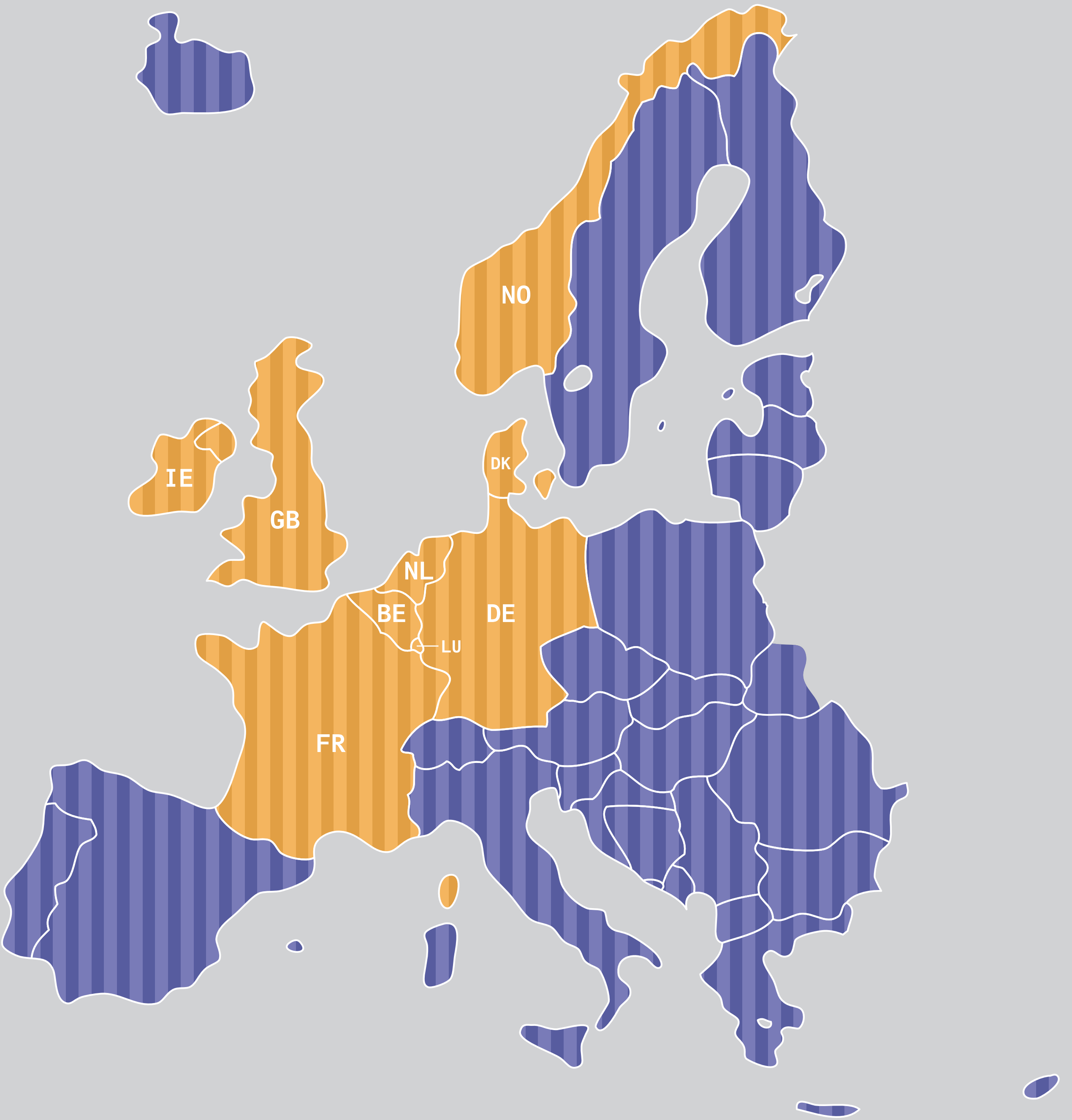


Figure 7:
Methodology to evaluate project benefit indicators

5 Scenarios



5.1 Description of the Scenarios

5.1.1 Qualitative Description of Scenarios

Two different scenarios and a sensitivity case have been simulated for the whole region for the year 2020. The year 2020 has been chosen as the European 20-20-20 objectives are set for this year. Common European objectives for the period after 2020 would be beneficial for grid planning purposes, due to long lead times.

The two scenarios and the sensitivity analysis represent a range of possibilities driving the behavior of the power system and thus, the markets.

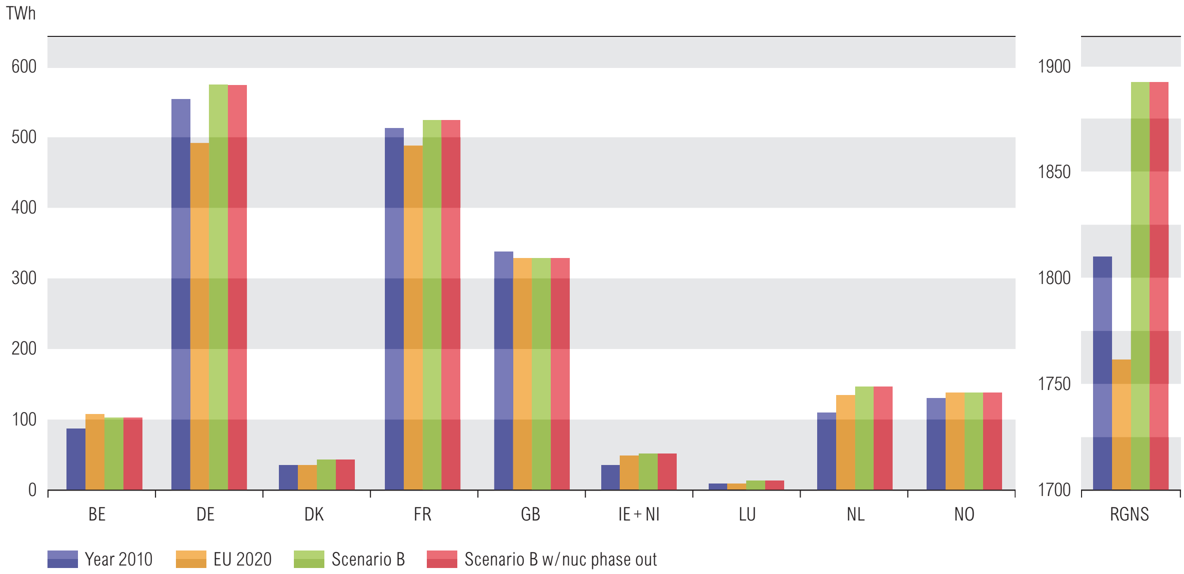
- Scenario **EU2020**
  - Based on national Renewable Energy Action Plans
  - 20-20-20 objectives are met at EU-Level
  - Lower demand growth
  - More Wind and Solar
  - Gas before Coal in the merit order to meet CO_2 targets
- **Scenario B**
  - Based on TSOs' best estimates
  - 20-20-20 objectives are not necessarily met at EU-Level
  - Higher demand growth
  - Less Wind and Solar
  - Coal before gas
- Thirdly, a sensitivity analysis focused on the Nuclear Phase Out plan of Germany announced in 2011. This analysis is based on Scenario B; the nuclear units that have been shut down in this sensitivity analysis have not been replaced by any other generation means.

For each of the scenarios, data has been shared in a standard format among TSOs using ENTSO-E's Pan-European Market Database (PEMD) to allow consistent modeling of all European regions. To improve accuracy of the regional model, the North Sea region collected detailed data, that is, to improve representation of complex hydro systems and particular thermal constraints.

In scenario "EU2020" and Scenario B (with and without Nuclear Phase Out), additional information was collected relating to the "must-run" constraints of specific units. These are meant to represent operational constraints forcing the need to run a specific plant outside of the merit order, because of security criteria which are not modeled in the simulation tools. These “must-run” constraints force the use of some coal generation even in the EU2020 Scenario. Seasonal values of transfer capacities between neighbouring systems have been used.

5.1.2 Quantitative Description of Scenarios

On a regional level the EU2020 scenario foresees a 120 TWh lower demand compared to Scenario B. This is mainly due to lower electricity demands in Germany and France, which reflect the impact of efficiency measures adopted (Figure 8).



	BE	DE	DK	FR	GB	IE+NI	LU	NL	NO	RG NS
	89	547	36	513	336	36	7	116	130	**1810**
	106	494	36	490	329	42	7	132	134	**1770**
	102	569	39	522	329	43	9	140	134	**1887**
	102	569	39	522	329	43	9	140	134	**1887**

Figure 8:
Annual demand for 2010 (Reference: Statistical Yearbook 2010) and in 2020

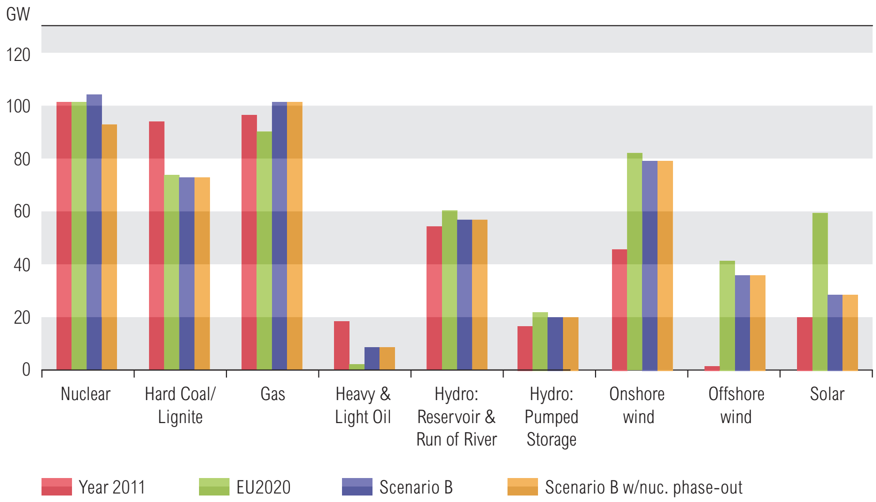


Figure 9:
Aggregated installed capacities in 2011 (Reference: SO & AF 2011) and 2020

While the scenarios for 2020 do not differ much, that is, by 33 GW, with respect to aggregated installed capacities, the installed wind and solar capacities are foreseen to grow considerably over the coming decade (see Figure 9).

The aggregated amount of installed wind power for 2020 is only slightly higher in the EU2020 scenario than is expected in Scenario B. A more significant difference of 30 GW is observed for the aggregated installed photovoltaic power. Although solar power has a relatively low utilization factor, the difference is mainly accounted for by Germany and thus can have a big local impact.

The installed capacity of nuclear plants is the only difference between Scenario B and Scenario B with Nuclear Phase Out. By the year 2020, Germany anticipates having only 8.1 GW of nuclear power remaining of the original Scenario B capacity (18.8 GW). The remaining 8.1 GW will be decommissioned in 2021 and 2022.

The market analysis focuses on the impact of grid development given the scenarios described above. Grid development is reflected in the increase of available transfer capacities between market areas. For each scenario the market analysis is performed with the transfer capacities as planned in 2015 and in 2020, both with 2020 generation / load data. Grid reinforcement projects up to 2015 are considered as firm. This approach makes it possible to evaluate the long-term projects.

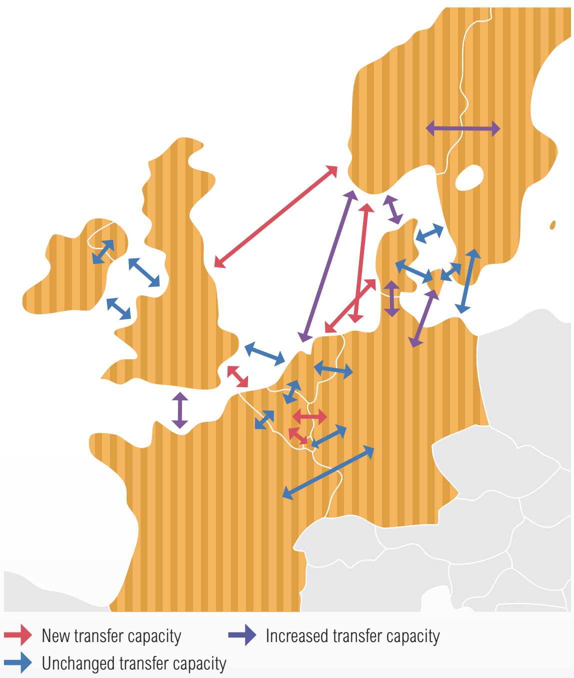


Figure 10:
Additional transfer capacities between 2015 and 2020

Figure 10 gives an overview of the differences between 2015 and 2020 transfer capacities. An increase of transfer capacity is due to new (red lines) or increased (purple lines) interconnection between markets. Not all projects mentioned in the TYNDP have been taken into account when determining the 2020 transfer capacities. Some projects have been added and some removed after market and load flow analysis took place. The two additional interconnectors from Ireland identified as a result of the analysis in this plan were not taken into account, nor was the Kriegers Flak CGS. On the other hand, NorNed2 was taken into account but is now not expected to be constructed within the plan period.

5.2 Regional Group Specific Scenarios

With the exception of the scenarios mentioned above in Section 5.1, no specific regional scenarios have been assessed within Regional Group North Sea.

5.3 Results of the Market Analysis

The output of the market analysis can be divided into the following topics:

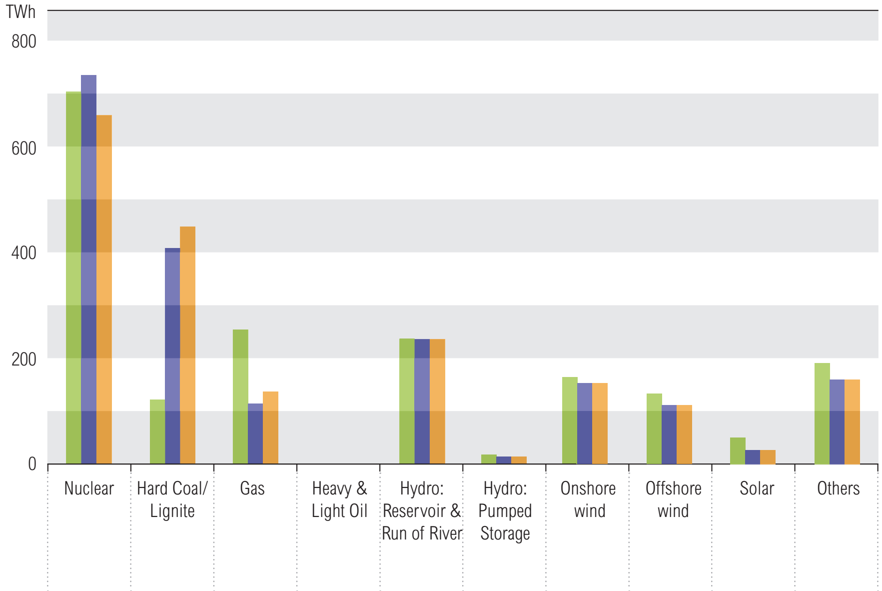
- fuel mix,
- curtailment of excessive production,
- import and export positions,
- CO_2 emissions,
- production costs.

While the simulation produces hourly results, only year-round volumes are presented in this section to support the market analyses. The hourly results have been used for planning case selection and grid analyses.

The main observations and conclusions on the above mentioned topic are described in this section.

5.3.1 Fuel Mix

As expected, the shift in merit order between the scenarios is clearly visible in the regional output of coal/lignite and gas units (see Figure 11). Available renewable energy is almost completely integrated into the system for all scenarios, due to its zero marginal costs. The shutdown of nuclear units increases the energy production of coal and gas plants and reduces the net export to countries outside the North Sea Region.



	Nuclear	Hard Coal/ Lignite	Gas	Heavy & Light Oil	Hydro: Reservoir & Run of River	Hydro: Pumped Storage	Onshore wind	Offshore wind	Solar	Others
EU2020	705	120	259	0	230	21	172	133	55	190
Scenario B	740	413	116	0	229	16	165	112	27	160
Scenario B w/nuc. phase-out	658	449	140	0	229	16	165	112	27	160

EU2020 Scenario B Scenario B w/nuc. phase-out

Figure 11:
Aggregated Fuel Mix Grid 2020

5.3.2 Curtailment of Excessive Production

Curtailment is defined by the excess of energy produced compared to the demand and export opportunities. Scenario EU2020 realises 85 TWh more RES-E than Scenario B, yet this leads only to 0.7 TWh more generation curtailment. For 2020, the level is less than 0.1% of the demand for most countries, except for Ireland and Northern Ireland where it is approximately 2% of the demand.

The interconnection capacity foreseen by 2020 seems sufficient to integrate the RES-E objectives given by the National Renewable Energy Action Plans (EU2020 scenario). Although internal grid constraints are not modeled in the market simulations they have been assessed in the grid analysis on the

29 common planning cases. No significant internal grid congestions that would lead to curtailment of production have been identified.

5.3.3 Import/Export Positions

The year round power exchange patterns for 2020 for the EU2020 scenarios are given in Figure 12. For 2020 substantial changes in net export balances are foreseen. The absolute net exchange level of the region in 2020 is anticipated to be 94TWh which is 2 to 3 times higher than in 2010.

The regional net export balance for Scenario B is around 69 TWh, which is 25 TWh lower than under Scenario EU2020. The difference is explained by the substantially lower demand and higher RES in France in the EU2020 scenario, allowing for more export of French nuclear energy, both within as well as outside the region.

In all scenarios the regional net export balance would be even higher (about 6 TWh, not shown) if no grid reinforcements were to be taken into account (2020 generation/load with 2015 transfer capacities). The additional interconnections with Great Britain up to 2020 leads to a doubling of the import position of GB when comparing net exchanges resulting from 2020 transfer capacities with 2015 transfer capacities. Relatively expensive production plants in Great Britain are replaced by cheaper energy from within the region, which leads to an overall decrease of net export from the region.

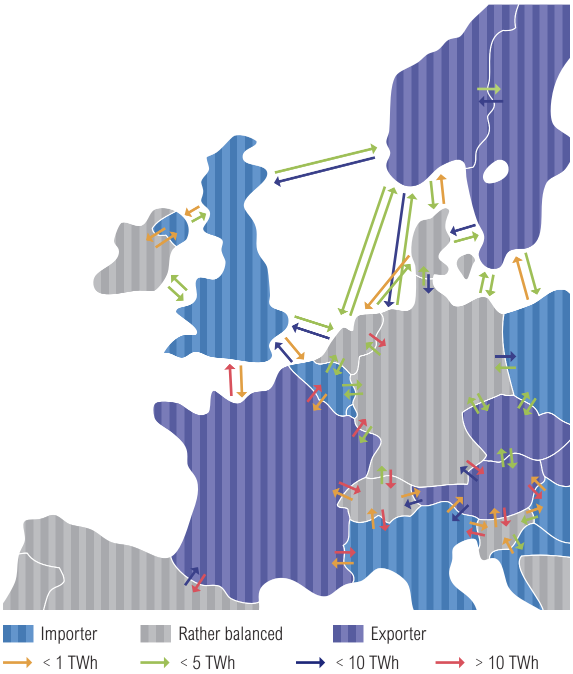


Figure 12:
Power Exchange Patterns in 2020

Furthermore, the political decision for a Nuclear Phase Out has a significant impact on the market. Specifically, Germany shifts to a net importer when taking account of the Nuclear Phase Out plans in Scenario B. Nuclear production is substituted by a net increase of regional production and net decrease of the regional export position.

5.3.4 CO_2 Emissions

The impact of "gas before coal/lignite" merit order is most noticeable in the anticipated emissions of CO_2, see Figure 13. The CO_2 emissions in the EU2020 scenario are around half compared to Scenario B emissions. Because of the substitution of nuclear energy by coal-fired, lignite-fired & gas-fired generation, the Nuclear Phase Out has a negative impact on the CO_2 emissions.

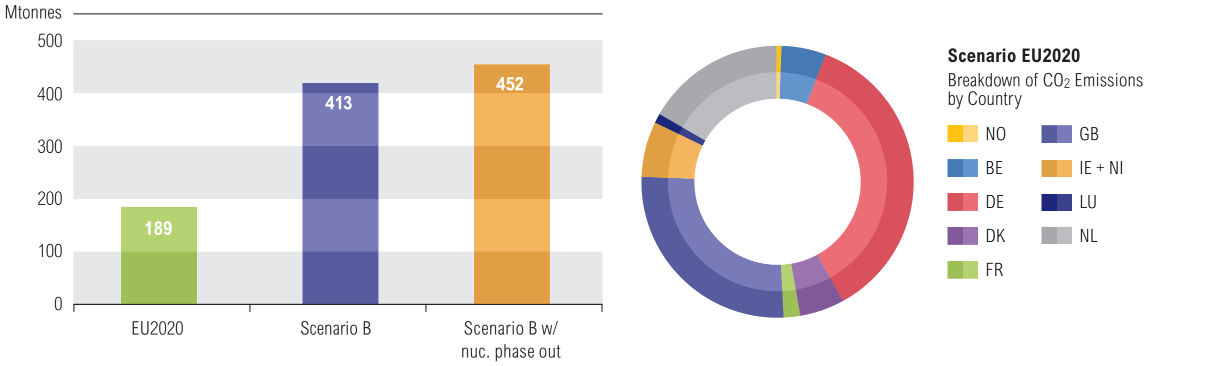


Figure 13:
CO_2 Emissions 2020 Grid and Breakdown of CO_2 Emissions by Country for Scenario EU2020

Grid development only has a marginal effect on the regional CO_2 emissions.

5.3.5 Production Costs

The resulting variable production costs for 2020 are given in Figure 14. The variable production costs in EU2020 are greater compared to Scenario B as a result of the higher CO_2 price in the EU2020 scenario.

With the expansion of the grid, the variable production costs will be reduced.

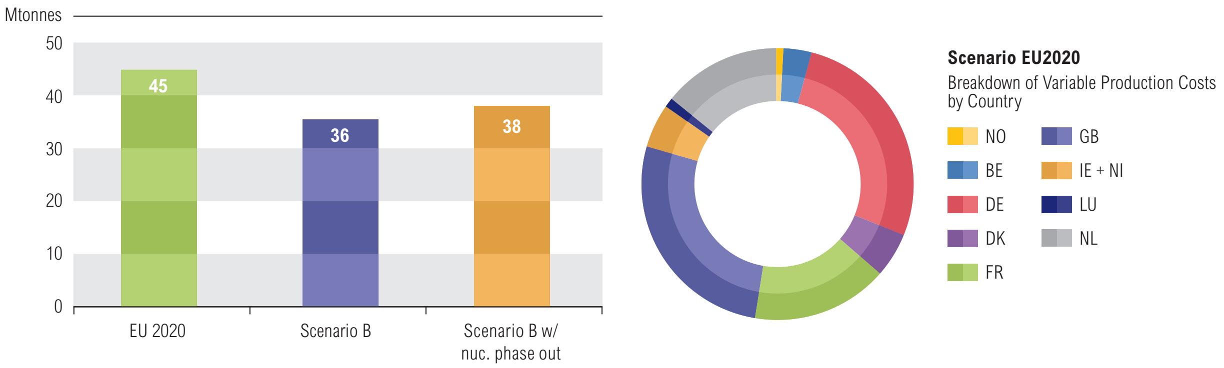


Figure 14:
Variable Production Costs 2020 Grid (B€/year) and Breakdown of Variable Production Costs by Country for Scenario EU2020

A sensitivity analysis with enhanced transfer capacity values shows a further convergence of marginal costs within the region and eliminates curtailment of excessive power.

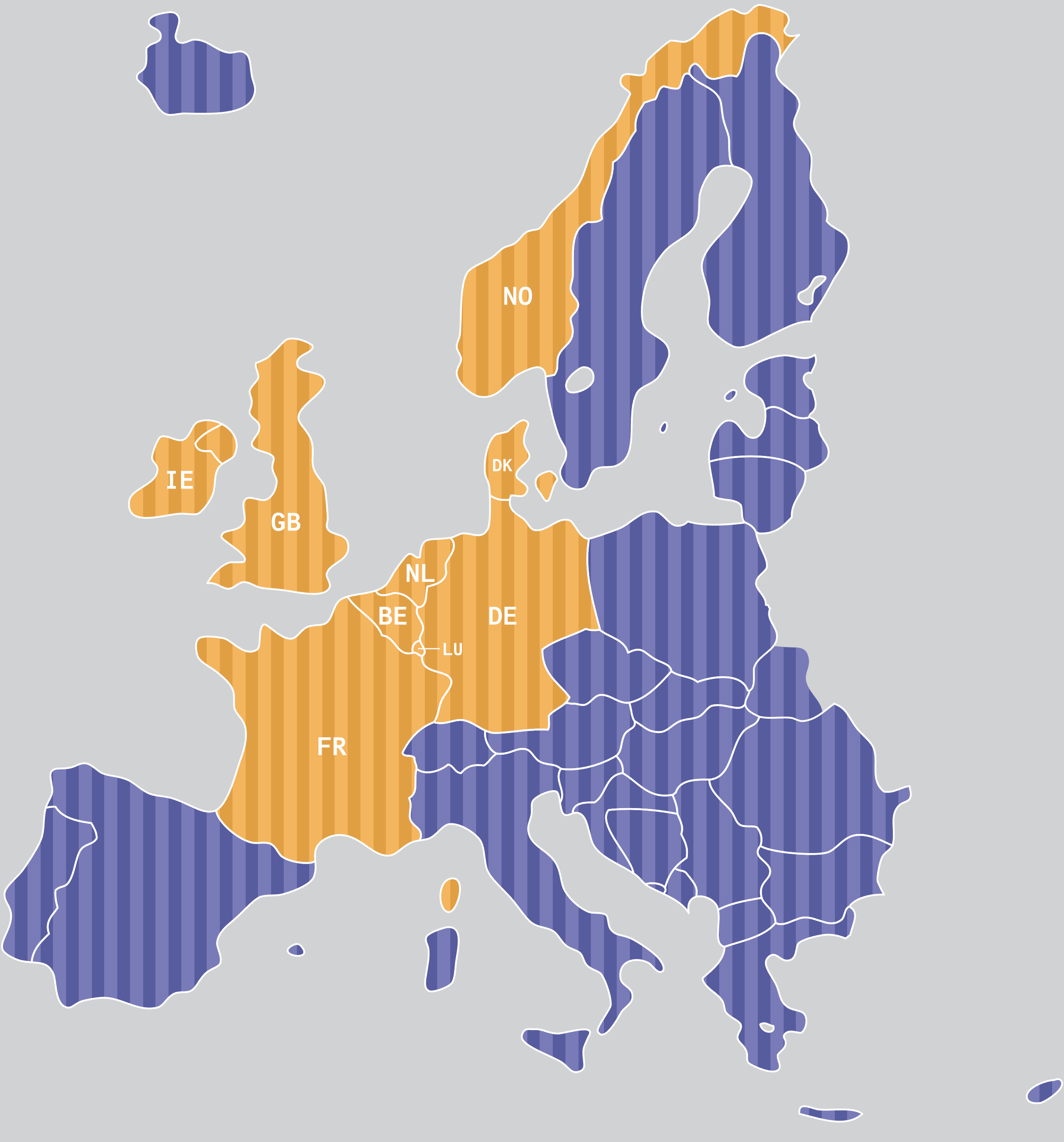
Generation Adequacy Indicators

The Scenario Outlook and Adequacy Forecast (SO & AF) report provides an assessment of the adequacy of the projected installed generation to meet the forecast demand. The main conclusions of the report for the 2020 situation are as follows:

- Considering a theoretical case where interconnections are ignored, many countries would not meet generation adequacy standards, indicating that they will rely at times on power flows from generation in neighboring systems to meet their demands;
- The analysed cases with the transfer capacities as planned in 2015 and in 2020 show that there will be sufficient generation and interconnection capacity installed to meet the forecast demands of every country in 2020, as measured by adequacy indicators (Loss of Load Expectation and Expected Energy Not Supplied);

More details of the adequacy analyses are provided in the SO & AF report.

6 Investment Needs



The North Sea region comprises nine countries in four separate synchronous systems: i) Great Britain, ii) Ireland, iii) Norway and Denmark East in the Nordic system, and iv) France, Belgium, Luxembourg, the Netherlands, Germany and Denmark West in the continental system.

6.1 Present Situation

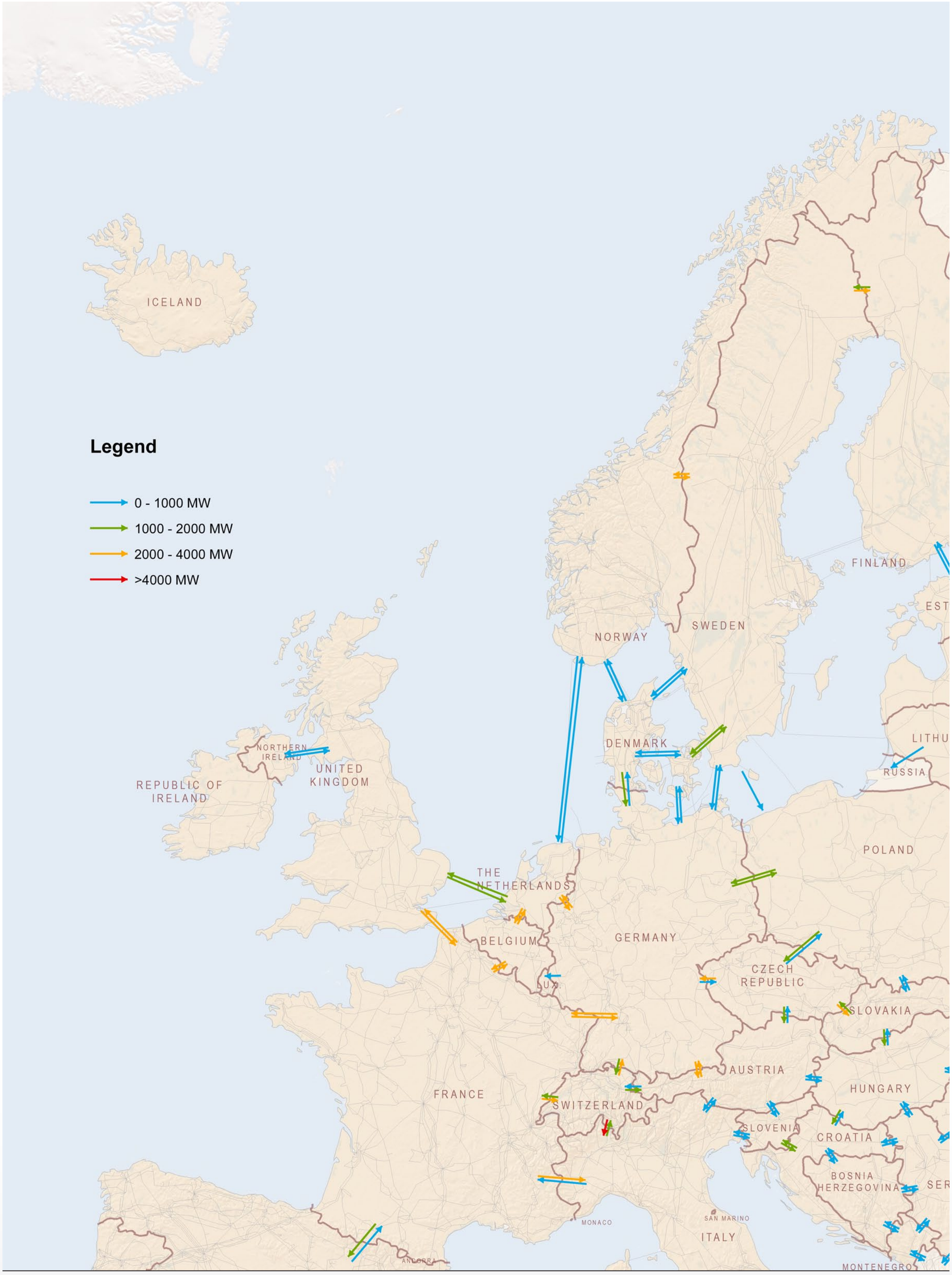


Figure 15:
NTC Winter 2010/11

Power flows in the North Sea region are currently characterized by significant **transit flows** particularly through the synchronous systems, driven by market exchanges. Since the electricity grids in these systems are meshed, physical flows do not necessarily follow commercial flows and thus part of the AC interconnection capacity may be absorbed by transit flows.

The market exchanges are driven by cyclic day/night price differentials between northern hydro systems and continental thermal systems. Additionally they are impacted by high localized concentrations of wind generation, fluctuations in market players' deployment of their production assets in several constituent areas in neighboring countries, and the availability of the interconnectors.

The region has seen significant **changes to its generation mix** particularly in the development of renewable energy sources. The system reinforcements necessary to provide full access to these new sources of generation may take a number of years to deliver, emphasizing already congested areas within the region, particularly in high wind output areas. Additionally, since the closure of the first set of nuclear power plants in Germany, new flows within the region have been experienced. This phenomenon will increase as more plant closures will follow.

Between the four synchronous systems within the region, the relatively **low level of interconnection limits the ability to rely on neighboring systems for security of supply/balancing and necessarily restricts** access to other markets.

6.2 Drivers of System Evolution

Over the plan period, the drivers for system evolution within the North Sea region are aligned to the three pillars of European energy policy areas:

- completion of the internal energy market for electricity;
- carbon reduction and RES targets;
- security of supply.

Moreover, a fourth driver of Member State policy decisions is observed within the North Sea region, namely the ongoing impact of the Nuclear Phase Out in Germany[1)].

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1) NB: compared to the version submitted for consultation, the final version of the Regional Investment Plan 2012 has been updated with the most recent information related to the German national development plan which is in the consultation process. (Provisional data was introduced in the version of the Regional Investment Plan submitted for consultation and the final plan needed only to be marginally adapted).

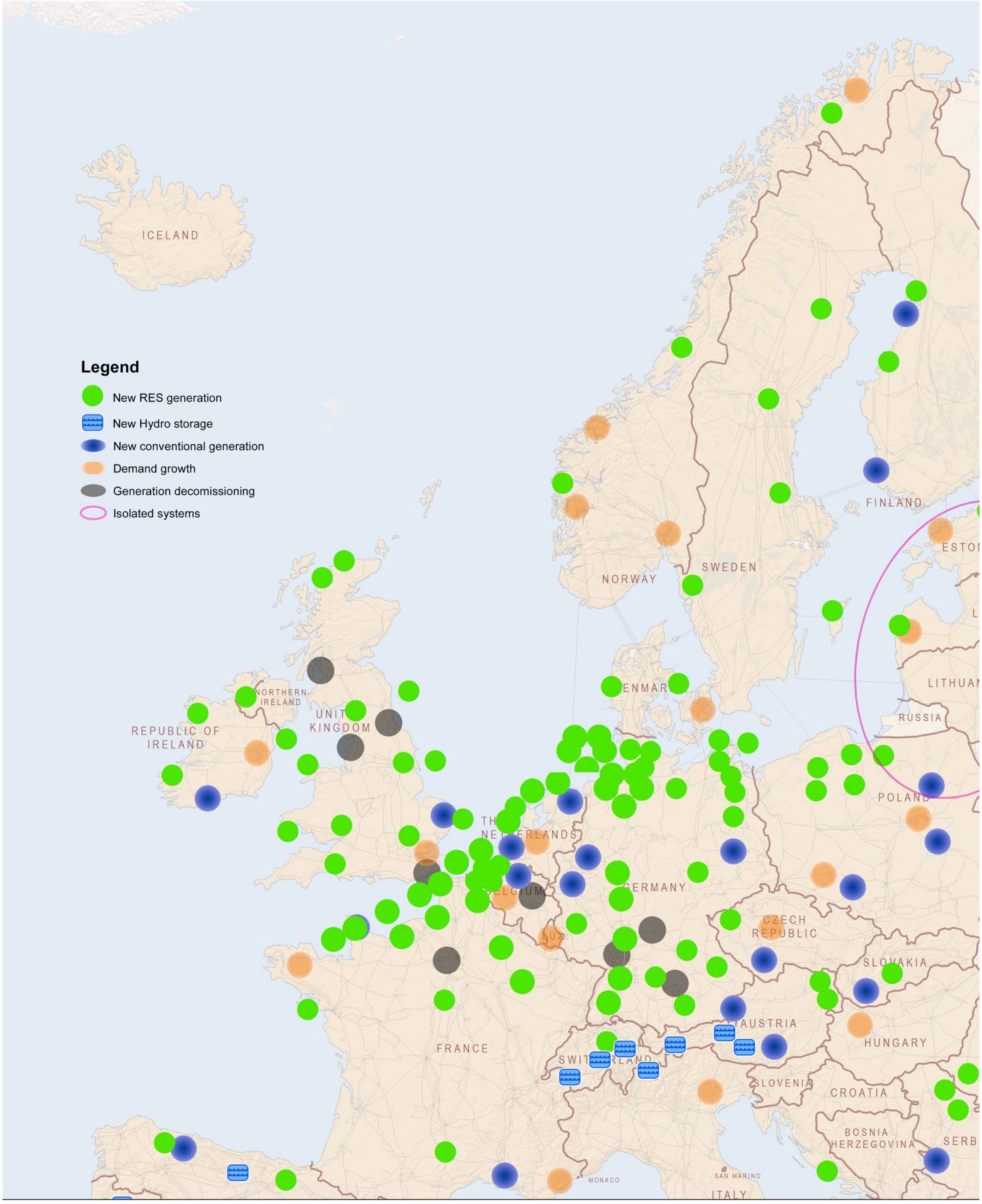


Figure 16:
Grid Development Drivers

6.2.1 Completion of the Internal Energy Market for Electricity

In order to deliver a strong and efficient energy market in Europe it is necessary to secure and increase NTCs between countries and increase domestic system capacity. This will require the connections between the four synchronous systems to be upgraded and new interconnections to be created. In addition, there are associated reinforcements to the local networks that need to be undertaken as otherwise congestion at the borders will affect functionality and efficiency of the internal energy market.

An existing feature of the North Sea region which will have an increasing impact on power flows going forward is the hydro capacity from the Nordic countries, amounting to almost 50% of Europe's hydro generation capacity. This is already an important driver for interconnectors between Norway and mainland Europe as well as Great Britain, as easily adjustable hydropower can act as storage for increasing variable RES production.

6.2.2 Further Increases in the Connection of Renewable and Low Carbon Generation

In order to fulfil both European and national renewable targets, many RES projects are expected to be initiated within the North Sea region throughout and beyond this plan period. Many of these new forms of RES generation, namely wind and solar facilities, are located in rural areas where the transmission grids have historically been less developed. TSOs within the region therefore face major challenges in extending and reinforcing their grids to connect new onshore RES and resolving the associated bottlenecks by increasing GTCs of the domestic systems in these rural areas.

These challenges are greater for offshore generation where significant volumes of RES are expected to need connection from increasing distances away from the onshore transmission grids. Large volumes of offshore RES, particularly offshore wind, are expected in eastern Ireland, Belgium, northwest France, the north coast of Germany, the Baltic coasts of Germany and Denmark and all of the coastal areas of Great Britain.

Differences in national targets and incentives, combined with the various availabilities of renewable sources across North West Europe will lead to a greater penetration of RES technologies in certain areas when compared to others. This significantly increases the power exchange opportunities across the North Sea region, particularly between the northern part of the region (Scandinavia, northern Germany, GB and Ireland) and the southern part (the Netherlands, Belgium, southern Germany and France). These potential flows are highly dependent on prevailing weather conditions and therefore require greater grid flexibility.

In some countries in the region, particularly GB, new nuclear generation will play a significant role in achieving mid- to long-term carbon reduction targets. Increasing nuclear capacity results in flows which exceed the capability of the existing grids.

The integration of RES and other forms of low carbon generation highlights the need to reinforce the transmission grids between and within the countries of the North Sea region.

6.2.3 Security of Supply

There are two aspects to Security of supply: i) the availability of primary energy resources to generate sufficient electricity to meet demand and ii) the ability of the grid to reliably transport power from sources of generation to demand centers.

An appropriate power grid is necessary in order to access and share the various primary energy resources available in the region, particularly hydro in the Nordic countries, on and offshore wind in the northern countries, solar in the south and thermal across the region.

Generation decommissioning, large penetration of volatile generation, namely wind and solar facilities and demand growth, will have an important impact on security of supply to specific areas within the region and are therefore a key driver of grid development.

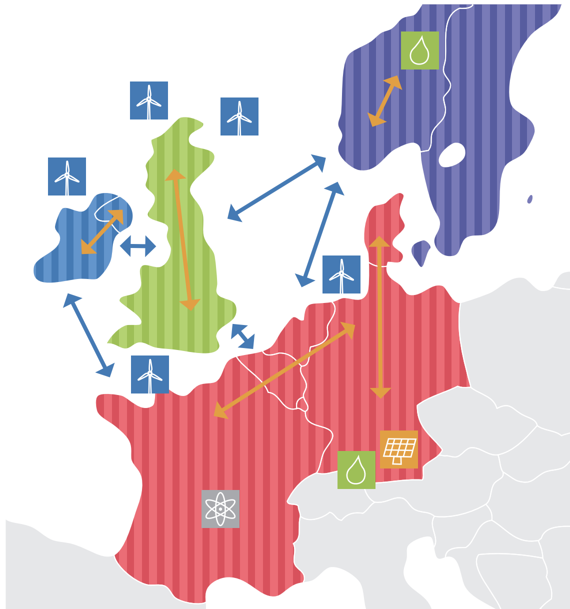
6.2.4 Policy Decisions

Political decisions by Member States can have a significant impact on power flows through the region. The most significant of these is the latest legislative developments in Germany requiring the last of its nuclear power plants to be shut by 2022. This will therefore continue to have a significant and increasing impact on national and international transit flows.

6.3 Bulk Power Flows in 2020

The drivers identified above are reflected in the bulk power flow corridors anticipated by 2020. Figure 17 represents the four separate synchronous systems of Ireland and Great Britain and the regional elements of the Nordic and Continental systems.

The **Island 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, evacuating variable wind to areas with less wind generation capacity, or experiencing different wind conditions will be necessary. Conversely, in low wind conditions, having access to other markets for balance and security of supply will be critical. Significant flows between the islanded systems and to continental Europe and Norway are therefore expected.



FR, BE, LU, NL, DE and DK West in the Synchronous Continental System

Island system of NO, SE and DK East in the Nordic System

Island system of GB

Island system of IE + NI

Figure 17:
2020 Power Corridors

The **Nordic region** is dominated by hydro generation. Trade opportunities between the Nordic hydropower system and thermal power systems in Denmark and the Netherlands have already driven a degree of interconnectivity, but flows to and from this region will continue to increase through new interconnectors to the continent and GB going forward.

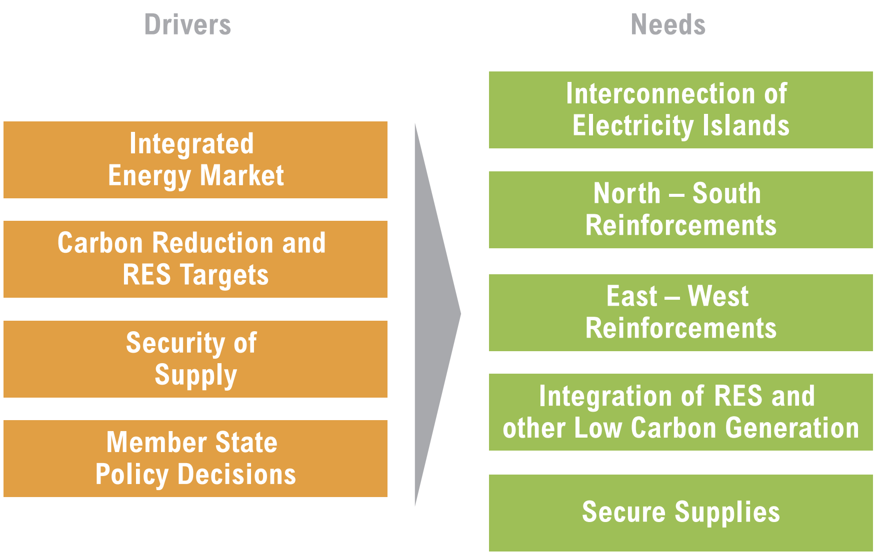
Within the **Continental Europe** system, bulk power flows along the North South corridor from the Nordic system into southern Germany are already dominant. These transit flows continue to be driven by the price difference between the thermal based Continental and hydro based Nordic prices. Additionally wind power in the region, mainly located in Denmark and Northern Germany has an impact: on non-windy days, electricity produced by Norwegian hydro power will flow southbound through the interconnectors into Denmark and into Germany. On windy days, wind in northern Germany potentially flows both south into southern Germany, while the Danish wind energy is expected to flow to Norway. The Danish West transmission system continues to serve as a significant link between the Continental and Nordic systems.

Within Germany, the increasing geographical imbalance between generation and consumption, as well as the long distances separating generation and demand centers require additional grid reinforcement along the North South corridor. These long distances, as well as the need to improve the grid's dynamic and static voltage stability favor the use of HVDC technology.

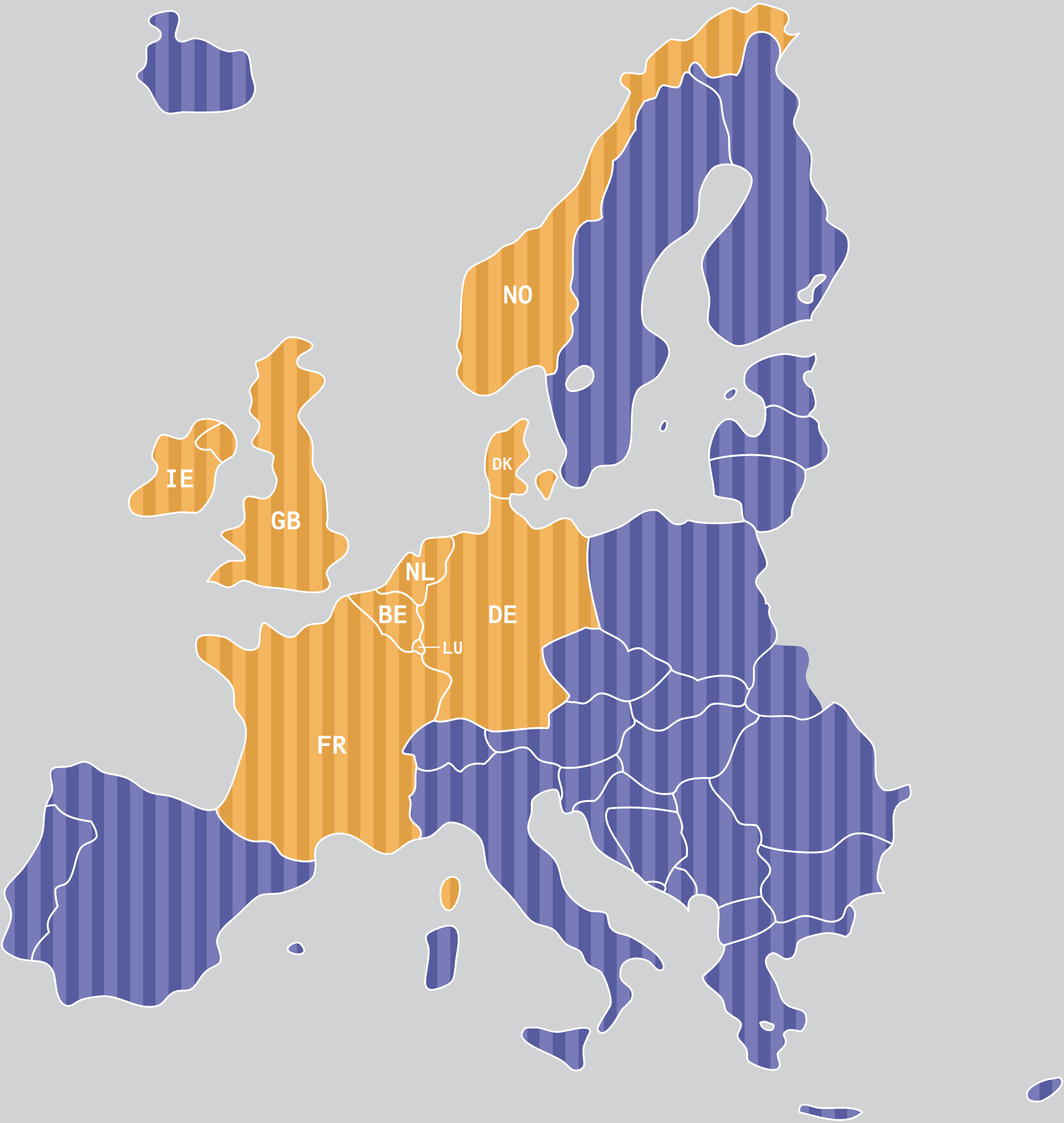
Expected new generation in northern France and along the coast of Normandy, both conventional and RES, including offshore wind, will increase the flows towards the Paris area and the centre of the country.

The foreseen changes in the energy mixes will give rise to a major evolution of East West bulk flows between northern Germany, the Netherlands, Belgium and France, stressing the interconnections between those countries. The direction of these flows is largely dependent on the wind conditions in Germany.

Chapter 7 sets out the investments proposed to meet the needs identified in this chapter, as summarized below:



7 Investments



The main drivers for investments in the North Sea region are described in Chapter 6. As a result of these drivers, projects are now being developed for market integration, RES and conventional generation integration and security of supply. The projects presented in this plan are those of Pan-European significance. In addition, all the TSOs have a number of other investments of National importance that are planned or in consideration. These investments are included in the relevant National development plans, but not in any of the statistics and figures of this plan.

7.1 Criteria for Including Projects

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

- The main equipment is at least 220 kV if it is an overhead line AC or at least 150 kV otherwise and is, at least partially, located in one of the 32 countries represented in TYNDP.
- Altogether, these assets contribute to a grid transfer capability increase across a network boundary within the ENTSO-E interconnected network (e.g. additional NTC between two market areas) or at its borders (i.e. increasing the import and/or export capability of ENTSO-E countries vis-à-vis others).
- An estimate of the abovementioned grid transfer capability increase is explicitly provided in MW in the application.
- The grid transfer capability increase meets at least one of the following minimums:
  - At least 500 MW of additional NTC; or
  - Connecting or securing output of at least 1 GW/1000 km^2 of generation; or
  - Securing load growth for at least 10 years for an area representing consumption greater than 3 TWh/yr.

7.2 Projects of pan-European Significance

In the sections below a general description of the projects for the whole North Sea region is presented, refering to the most important issues to which the new investments contribute. Appendix 1 contains a high level presentation of these projects. The total cost of all projects of European Significance in the North Sea region is 75 €bn.

7.2.1 Mid-Term (2012 – 2016)

Figure 18 illustrates the projects which are expected to be delivered in the North Sea region in the first five-year period of the ten year plan, that is, between 2012 and 2016. They have been selected to address the needs identified in Chapter 6.

In the descriptions below in 7.2.1 and 7.2.2, projects have been categorized by the main need that they address. However, it should be noted that a principle aim of efficient grid development is to select project solutions that serve multiple needs. As such, the projects in this plan will provide additional benefits not specified in this chapter.

The interconnection of electrical islands, as described below, will increase a) the liquidity of markets, b) the capability for RES-integrated power supply and c) security and diversity of supply across the region. The plan, in its totality will enable greater market integration and create a larger market for the region's renewable energy generation and energy storage.

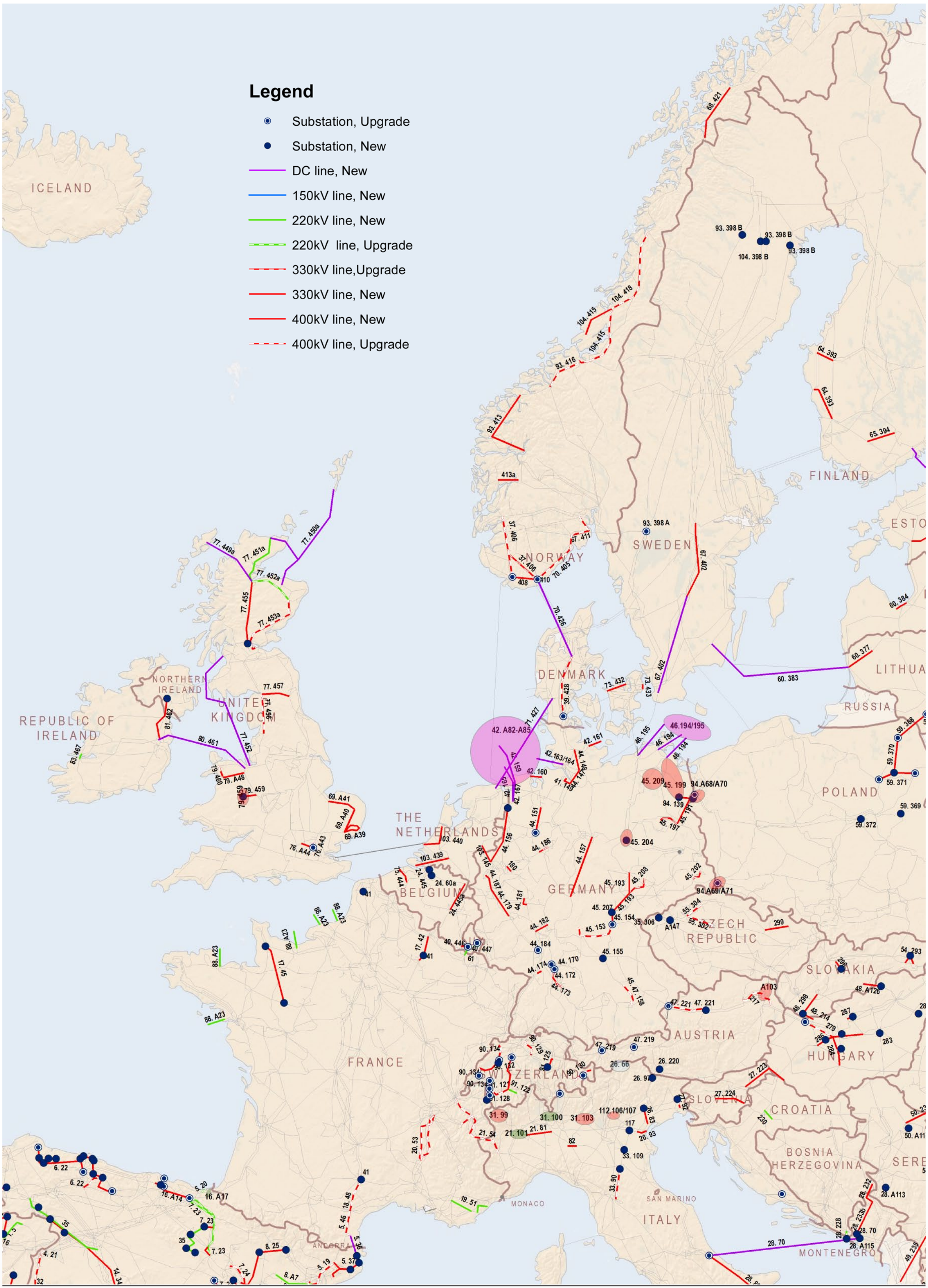


Figure 18:
Map of Medium Term Projects in the North Sea Region

7.2.1.1 Interconnection of electrical islands (MT)

Within the first period of this plan, two interconnectors between the "island" systems will be completed. Together with the recently completed BritNed project, they represent a significant increase in capacity between the four synchronous areas of the North Sea region.

- Project 70 – Skagerrak 4 – a 700 MW VSC-HVDC link between Denmark West and Norway, expected to be commissioned in 2014.
- Project 80 – The East West Interconnector Project – a new 500 MW VSC-HVDC 200 kV interconnector between Woodland (IE) and Deeside (GB) is expected to be completed in the second half of 2012. It has been awarded a grant from the European Energy Program for Recovery (EEPR) of the European Commission.

7.2.1.2 Strengthening of the East - West axis (MT)

Two interconnectors and a number of internal grid projects will, when completed, strengthen the East - West axis:

- Project 24 – Reinforcement of the 380 kV grid between Gramme and Van Eyck (BE) consisting of a second 380 kV circuit and an additional 380 kV substation in Van Eyck. The project is scheduled for completion in 2014 and is required to cope with the evolution of international flows and to connect new power plants in the area.
- Project 71 – Cobra – a 700 MW HVDC 320 kV link between Denmark West and the Netherlands is expected to be brought into commercial operation by 2016. The project will investigate the possibility to connect new offshore wind farms to the cable, thus possibly making it the first step towards a North Sea offshore grid. It has been awarded a grant from the EEPR.

7.2.1.3 North to south reinforcements (MT)

Due to increasing RES generation meeting the goals of European countries, particularly Germany, new connections between areas with high installed capacities of RES and areas with high consumption and storage capabilities are necessary.

For this reason the development of new north-south and northeast-southwest electricity transmission capacity in Germany is necessary. For the midterm time horizon the necessary grid development in Germany is covered by common projects in the western and eastern corridor (Projects 44 and 45).

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

The German East corridor begins in the North-East of Germany, an area with high RES generation (planned and existing), conventional generation and connections with Scandinavia (planned and existing).

Both corridors end in the South of Germany, an area with high consumptions and connections to Austria and Switzerland (for transit to Italy and pumped storage in the Alps).

7.2.1.4 Integration of RES and other low carbon generation (MT)

In the medium-term, a number of projects facilitating the connection and access of RES, are expected to be commissioned.

- Project 75 – Stevin – in order to connect approximately 2160 MW wind farms in the North Sea close to Belgium, a new double-circuit 380 kV line by 2014 is necessary between the shore (Zeebrugge) and the existing 380 kV grid (Zomergem). This onshore development could be coupled with the development of an optimized offshore grid consisting of two offshore platforms which would form part of the meshed transmission system.
- Project 83 – Moneypoint-Kilpaddoge – a 220 kV cable across the Shannon estuary (IE), expected to be commissioned in 2014. It is required to provide grid capacity for wind generation in Kerry.

7.2.1.5 Other market integration projects (MT)

- Project 81 – The North South 400 kV Interconnector – a new 400 kV circuit between Ireland and Northern Ireland, expected to be commissioned in 2016, will strengthen the links between the Ireland and Northern Ireland systems.

7.2.2 Long-Term (2017 – 2022)

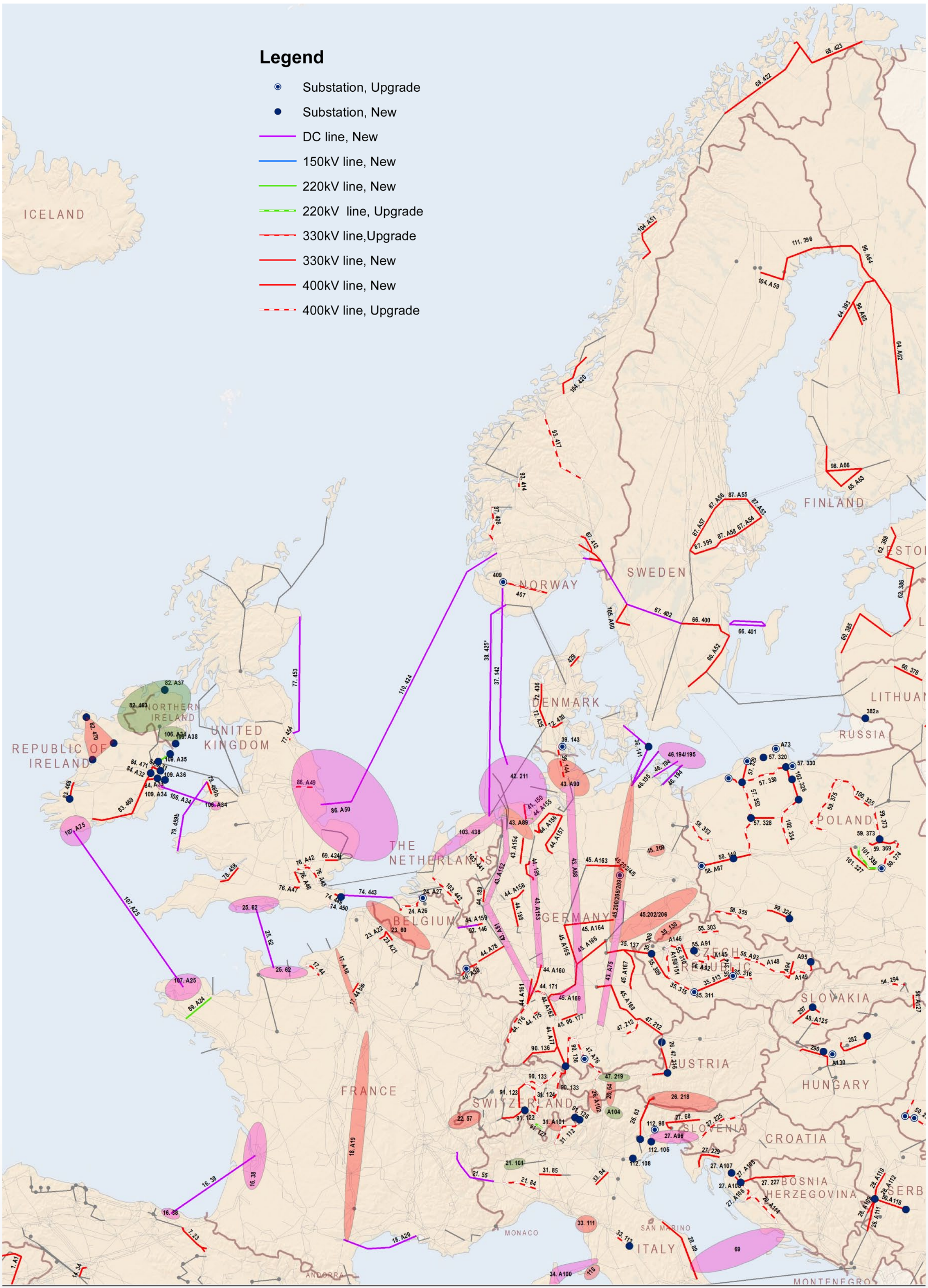


Figure 19:
Map of Long Term Projects in the North Sea Region

7.2.2.1 Interconnection of electrical islands (LT)

This period will see a significant number of new HVDC sub-sea interconnectors being completed. These new links will further integrate the synchronous systems of Ireland, Great Britain, the Nordic region and the continental system.

The plan includes new HVDC links between Ireland and Great Britain and between Great Britain and Norway, creating an East-West link across the three synchronous islands.

- Project 106 – Sensitivity studies on the reference RgIP scenarios indicate that there is an economic opportunity for greater interconnection between Ireland and GB.
- Project 110 – a 700 km HVDC connection between Norway and GB is planned to be commissioned in the period between 2018/21. The interconnector will probably be operated at 500 kV with a capacity of approximately 1000-1400 MW.

The plan also includes a number of new links from the synchronous islands to mainland Europe.

- Project 25 – IFA2 – a new 1000 MW HVDC interconnector between France and GB is progressing. A seabed survey is being investigated. Commissioning is planned for about 2020.
- Project 38 – NorNed 2 is now not likely be realised during this planning period but is included in the TYNDP calculations and therefore on the project list. NorNed 2 is not included in the current Norwegian national grid development plan.
- Project 37 – a HVDC link approximately 1000-1400 MW is planned from Norway to Germany. The commissioning date is planned to be in the period 2018-2021. All planned interconnectors to Norway require substantial internal AC grid reinforcements. These are primarily related to voltage upgrades from 300 kV to 420 kV in the South of Norway
- Project 74 – NEMO – a 1000 MW HVDC interconnector between Zeebrugge (BE) and Richborough (GB) is under consideration. The new interconnection could be achieved by 2018.
- Project 107 – Sensitivity studies on the reference RgIP scenarios indicate that there is an economic opportunity for greater interconnection between Ireland and France.

A number of projects internal to one of the national grids are required to facilitate the greater interconnectivity of the synchronous islands to mainland Europe.

- Project 74 – The upgrade of the south east transmission system of GB involves the addition of a new 400 kV circuit route from Canterbury to Richborough and the reconductoring of the Dungeness to Sellindge circuits.

7.2.2.2 North to south reinforcements (LT)

There are three major projects planned to strengthen the North–South Corridor (from Denmark to Southern Germany).

- Project 36 – Kriegers Flak CGS is considered to be a pilot project to build, utilise and demonstrate a multi-vendor, multi-terminal HVDC VSC offshore system interconnecting different countries and integrating offshore wind power. It has been awarded a grant from the EEPR.
- Project 39 – The upgrading of the 400 kV back-bone transmission system in Denmark West and the 400 kV connections to Germany, when commissioned in 2017, will increase the grid transfer capacity from DK-W to DE by 1000 MW and from DE to DK-W by 1550 MW.
- Project 72 – The plan includes a project to upgrade the 400 kV transmission system in Denmark West. When completed in 2020, the project will increase GTC by 950 MW.

7.2.2.3 Strengthening the East-West axis (LT)

This plan includes a significant number of new projects designed to reduce congestion on the East-West axis, expected to be completed in the longer-term. The projects will facilitate increased market trade, provide capacity for renewable energy sources and increase security of supply to the countries along the axis.

- Project 23 – the doubling of the 400 kV Gavrelle-Avelin axis, associated with the operation upgrade of Avelin-Mastaing from 225 kV to 400 kV. All of these investments are scheduled for 2017. These projects are coupled with the reinforcement of the France-Belgium Border, currently the subject of a joint study and will improve the security of the area.
- Project 24 – a number of investments in Antwerpen, between Ghent and Antwerpen, delivered between 2016 and 2020 will complement the medium-term reinforcement of the 380 kV grid between Gramme and Van Eyck (BE).
- Project 40 – will reinforce the internal network of LU. In the medium-term this will involve closing a 220 kV mesh around the capital of Luxembourg town and the installation of a phase shift transformer. In the longer-term, an additional double circuit line would be built between Bascharage (LU) and Aubange (BE) at either 220 kV or 400 kV.
- Project 92 – a 1000 MW HVDC interconnector between Germany and Belgium and associated internal investments in Belgium. The capacity could be extended to about 1600 MW depending on further investigations.

- Project 103 – consists of several new 380 kV double-circuits from centralized generation locations toward the Dutch central ring and interconnection between Netherlands and Germany. Commissioning of individual investments starts in the medium-term and is completed in the long-term.

7.2.2.4 RES and other low carbon-related projects (LT)

There are 12 projects planned to connect and evacuate power from renewable generation plants. While there are major investments planned in Ireland and Great Britain for onshore wind farm connections, most of the 12 projects are for the connection of offshore wind parks.

- Projects 42 and 46 – There are two major projects planned for the North of Germany, to connect and evacuate up to 10 GW in offshore wind generation.
- Project 43 – The foreseen RES generation in northern Germany will increase the geographical imbalance between generation and consumption, increasing the distances between generation and consumption regions requiring grid extension inside Germany as well as to the MT projects for the West and East Corridor. The needs for transportation over long distances as well as the need to improve grid stability regarding dynamic and static voltage would favor HVDC technology.

  For this reason, the German TSOs are considering several DC-connections, allowing the North–South and Northeast–Southwest power flows and enhancing the grid stability. Due to the significant change of the German energy scenarios and policies (finalized in December 2011) and the upcoming grid development plan 2012 (NEP), modifications / additions to the project plans are expected.
- Project 69 is a new project planned to accommodate the expected growth in offshore wind and nuclear generation around Norfolk/East Anglia (GB), above what was considered for the TYNDP 2010.
- Project 77 will significantly reinforce the grid between Scotland and England accommodating increasing RES generation in Scotland. A new 2000 MW HVDC offshore cable reinforcement along the West coast is on track for 2015 completion.
- Project 78 – a new Hinkley Point–Seabank circuit (GB) associated with the connection of new nuclear generation.
- Project 79 – a new 400kV circuit route and substation to connect new wind farms in mid Wales, expected 2016, a HVDC reinforcement circuit from Wylfa to Pembroke, expected 2020; and an upgrade of the Trawsfynydd to Treuden-T circuit with a larger conductor.

- Projects 82, 83 and 109 – consists of Grid West, Grid Link, RIDP and Moneypoint to North Kerry investments and connections of offshore wind generation off the North and East coasts of Northern Ireland and off the East coast of Ireland (Oriel and Kish Banks). The projects are expected to be completed by 2020.
- Project 86 on the East coast of GB will consist of multiple offshore HVDC and AC circuits and connecting offshore platforms to multiple onshore connection sites (and associated reinforcement requirements).
- Project 88 – RTE is planning construction of several subsea cables to connect offshore wind farms to the main grid in France.
- Project 17, consisting of five 400 kV investments, including Cotentin-Maine and the reconstruction of the Lonny-Vesle axis, needed for accommodating larger and more volatile North South power flows from Normandy to Champagne, triggered especially by the development of new generation sources (along the Channel coasts, from Picardie to Champagne and further north abroad) that would naturally flow to large consumption areas: Paris area, but also more broadly from Brittany to Reims.

7.2.2.5 Security of supply projects (LT)

While demand growth is generally low across the region, a number of areas were identified as requiring reinforcement for security of supply.

- Project 24 – BRABO – consideration for a new double-circuit 380 kV line between Zandvliet and Lillo and later from Lillo to Kallo and Mercator (both planned by 2017).
- Project 76 – The upgrading of three main 275 kV circuit routes in London to 400 kV and the rating upgrade of existing circuits.
- Project 84 – The "Dublin Ring" project (IE) consists of four new 400 kV circuits in a ring around the Dublin city.
- Project 89 – The Brittany "safety net" project involves construction of a 100 km AC 220 kV cable to secure Brittany's supply (this investment is part of a programme including also connection of new generation, both RES and conventional, (call for tenders currently in progress) and energy efficiency measures.

7.2.3 3rd Party Promoted Projects

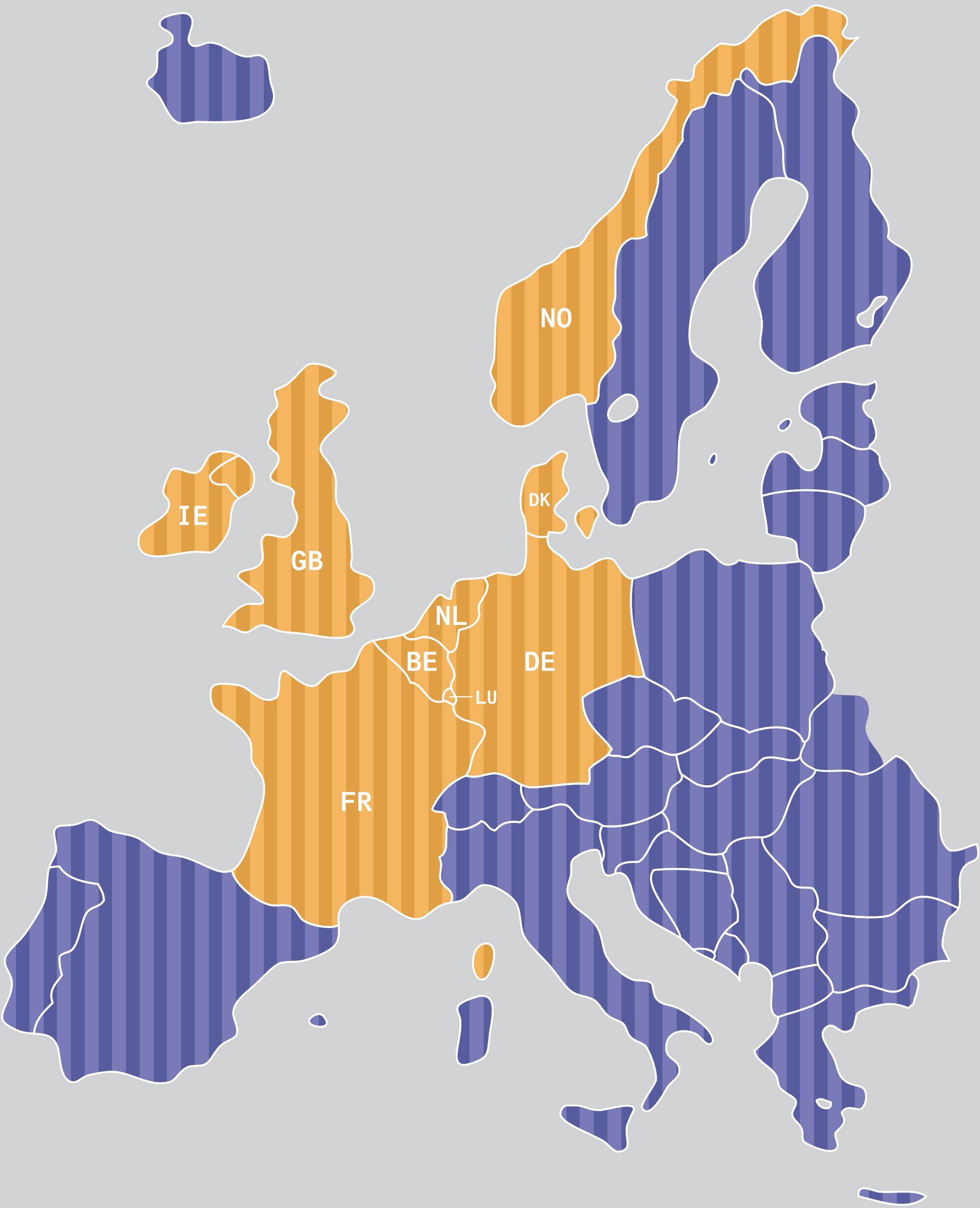
In order to deliver the most comprehensive and up-to-date outlook of the electricity grid by 2020 and beyond, ENTSO-E, based on the stakeholders' feedback to the 2010 pilot TYDNP, elaborated and made available in February 2011 a procedure for the inclusion of the third party projects in the 2012 release of the TYNDP[1]: As a result, ENTSOE- received five submissions (three of which were in the North Sea Region):

Country A	Country B	Technology	Technical description	Regulatory and legal criteria fulfillment	Brief benefits for the project
GB	NO	HVDC	Yes	No	"The project is market driven. The additional benefit is the possibility to balance the high RES (especially wind in the UK with the storage capacity in NO)".
GB	ES	HVDC	Yes	No	"The project is market driven. The project will facilitate the development of renewables in Spain and Britain and will contribute to security of supply in these member states by providing a source of back-up power. It will also be an economic source of balancing power and should enable the most efficient sharing of energy resources amongst the two member states".
GB	FR	HVDC	Yes	No	"The project is market driven. This new HVDC interconnection will increase the existing cross border capacity by 55%. The interconnector will also provide wider access to diverse natural resources and low emission plant and hence also create less dependency on fossil fuels renewable source of energy and potential link to wind farms etc".

None of these projects demonstrated evidence of a transmission licence or an exemption for such licence granted by the relevant national regulatory authorities and EC, as required by the ENTSO-E guidelines. The non-discrimination principle (especially with regard to similar projects that may not have applied for inclusion for this reason), makes it inappropriate for these projects to be incorporated in the table of projects of the TYNDP 2012 package.

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

8 Transmission Adequacy



Transmission adequacy shows how adequate the transmission system is in the future in the analyzed scenarios, based on the assumption that the presented projects are already commissioned. It answers the question "are the problems arising from the scenarios fully solved after the projects are built?". The analyses performed for this plan, which were based on the assumptions in Chapter 5, have not identified a need for new projects in the North Sea Region additional to those presented in the plan. The planned projects should solve much of the congestion in the Region, identified in Chapter 6, for some years.

- the interconnection between Great Britain and mainland Europe should be considerably increased by planned projects between GB and BE, NO and FR, on top of the recently commissioned BritNed; the same is true for Ireland assuming the conceptual projects with GB and France currently under investigation are realized;
- the IE-NI border should not expect any significant congestion;
- onshore and offshore wind in the North Seas will be accommodated in Great Britain, Ireland, France, Belgium, Germany;
- new conventional generation will be integrated in Great Britain, Ireland, Germany , Belgium and the Netherlands;
- the supply of major load areas such as London, Dublin, Antwerp and Zeebrugge will be secured;

However, residual congestion in some rare situations or a need for further investigation remains in some areas:

- Additional reinforcement may be needed in southern Norway, especially in the western and eastern Corridors, to accommodate new interconnections between southern Norway and DE, NL and GB;
- Since the German government decided by law to achieve accelerated Nuclear Phase Out by 2022, there is a high probability that additional investments will be needed in the German western and eastern corridors. A reasonable risk has risen that new investment needs and therefore grid developments will appear in the next version of the TYNDP;
- Belgium North border and Luxembourg borders are subject to possible congestion depending on the value and direction of the major power flows. For Luxembourg, the long-term structure of the interconnection with neighboring countries is still under investigation;
- Market and grid simulations have shown possible residual congestion at the borders between France and Belgium and Germany; investigations are in progress to assess the need for additional projects;
- Some additional projects on top of those presented in the plan may be needed for accommodating the North-to-South flows in northern France due to cross-border exchanges added to new generation in North and North-western France flowing to large consumption areas, especially the Paris region;

– Load supply of Brittany could be at risk during cold periods if all three mitigation measures are not implemented (i) generation development (RES and conventional)[1]; (ii) electrical energy savings that would limit the load increase; and (iii) grid development.

It is important to note that if the assumptions associated with the commissioning of the projects presented in Appendix A or the scenarios as set out in Chapter 5 change, the need for additional investment may change.

Figure 20 presents the transmission adequacy assessment for the North Sea Region. Three categories have been considered in the transmission adequacy showing that needs are solved in every situation, in almost every situation or that the need is not completely solved.

1. Light purple:
   Unlikely that with all projects in the plans, in the span of scenarios considered in the plans, further measure is reported related to the boundary;
2. Purple:
   Possibly, with all projects in the plans, in the span of scenarios considered in the plans, certain rare developments could trigger further measures on the boundary although sufficient transmission capability is provided for the vast majority of the situations ;
3. Dark purple:
   Most **likely** that in the span of scenarios considered in the plans, additional measures are needed on top of all projects in the plans to cope with congestion on the boundary.

1) Calls for tenders for offshore wind and a new CCGT currently in progress

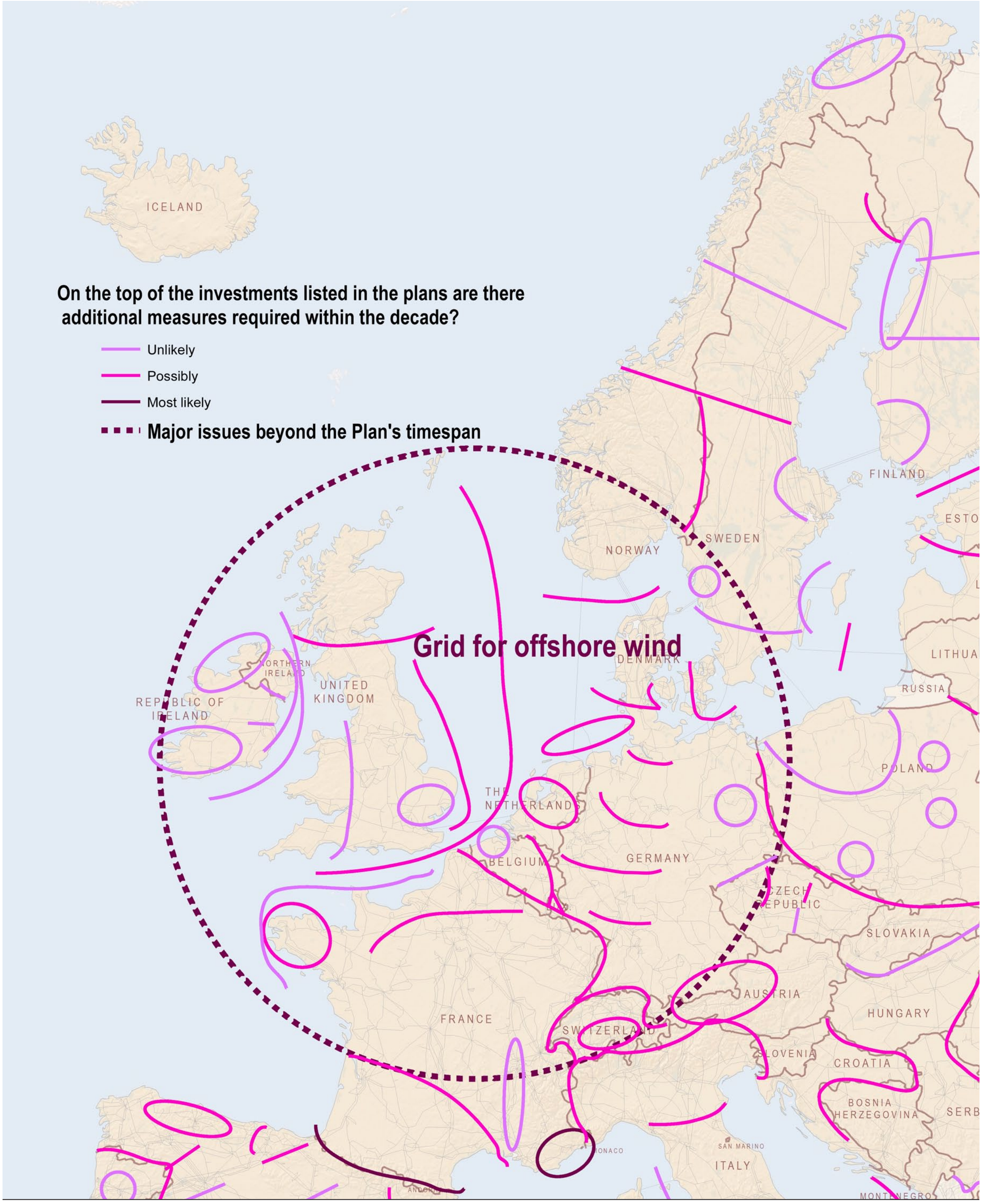
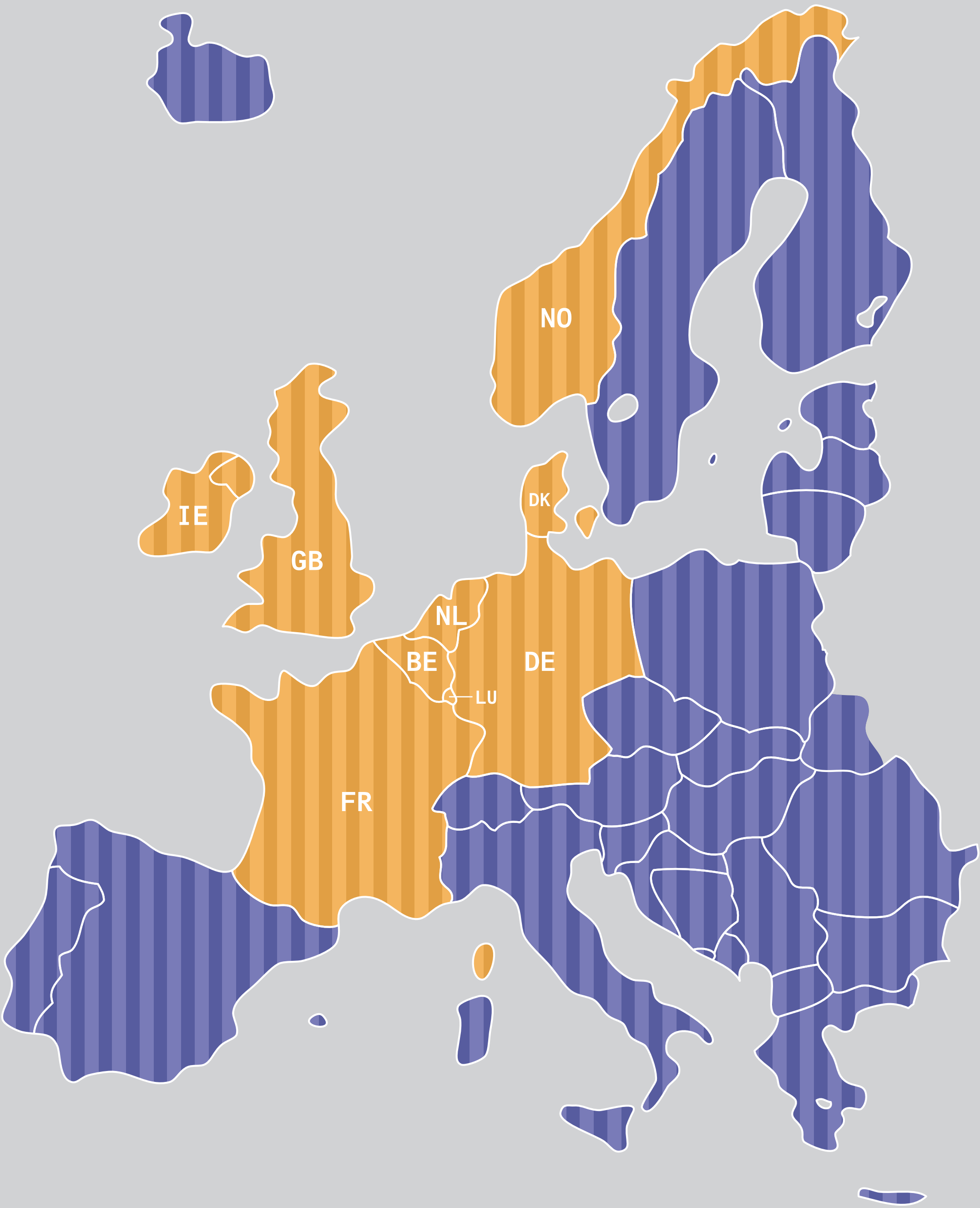


Figure 20:
Regional Map of Transmission Adequacy Indicator

Furthermore it is expected that the evolution of the scenarios beyond 2022 will include higher levels of offshore wind capacity. This is indicated by the dashed circle in Figure 20 and is addressed in Chapter 11 "North Seas Offshore Grid".

9 Environmental Assessment



The environmental assessment of new overhead lines, underground cables and substations at project-level has been common practice for many years. Through the environmental impact assessment (EIA) the direct and indirect effects of a grid project are assessed in detail, with a focus on the environmental factors (air, soil, fauna, flora,…) as defined in the Directive 85/337/EEC "on the assessment of the effects of certain public and private projects on the environment".

On the plan-level, with the European Directive 2001/42/EC "on the assessment of effects of certain plans and programmes on the environment", Strategic Environmental Assessments (SEA) have become a formal requirement for many plans and programmes, primarily in the public sector. Since the regulated nature of transmission SEA has become mandatory for the periodically National development plans in different member states. For the North Sea RG, the National development plans in Belgium and Ireland have been subjected to an SEA.

Individual investments or projects can be subjected to an additional environmental assessment on plan-level if they involve spatial planning. For example a proposed 380 kV link between the coast and the interior of Belgium to connect offshore wind production has been assessed three times: first in the SEA of the National development plan, secondly by the EIA of the associated spatial plan and finally by an EIA at project-level.

The sustainability of the proposed grid solutions has become a crucial parameter for transmission development planning. In order to minimize the impact of the HV grid on nature, landscape, humans… some common methodologies for grid development can be identified.

Firstly, possible options based on substations are preferred rather than connections.

Secondly, the priority is given to solutions that make use of existing infrastructure. The optimization of existing lines (upgrading, additional conductors, replacing conductors) and the restructuring of existing substations (by adding new transformers) have become a substantial part of the projects listed in the grid development plans.

Thirdly, if new connections are indispensable they are preferably combined with other linear infrastructure (bundling principle). Moreover in some countries (e.g. Belgium, the Netherlands) they ensure that the total length of the overhead grid does not increase (standstill principle) by dismantling existing lines, if possible, or undergrounding, if necessary.

This kind of approach has become typical for the strategic level of transmission plans, as different solutions of development are still open. At project-level when the preferred solution is already determined the options limited and the main focus is on mitigating measures like tower design, routing, screening, and so on.

9.1 Environmental Indicators

The impact of reinforcement of the existing lines and undergrounding on the total projects lengths

Applying the above-mentioned strategy tends to limit the impact of the necessary grid developments.

To achieve this, the upgrading of a line, 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 economical reasons.

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

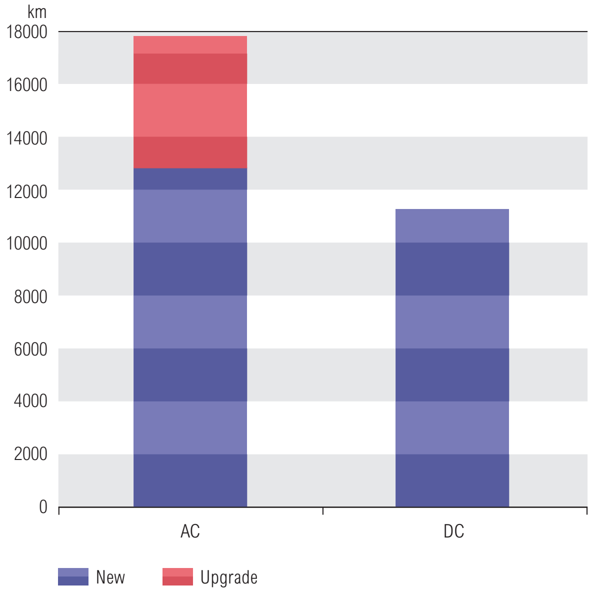


Figure 21:
Planned Lengths of Upgrade and New Build

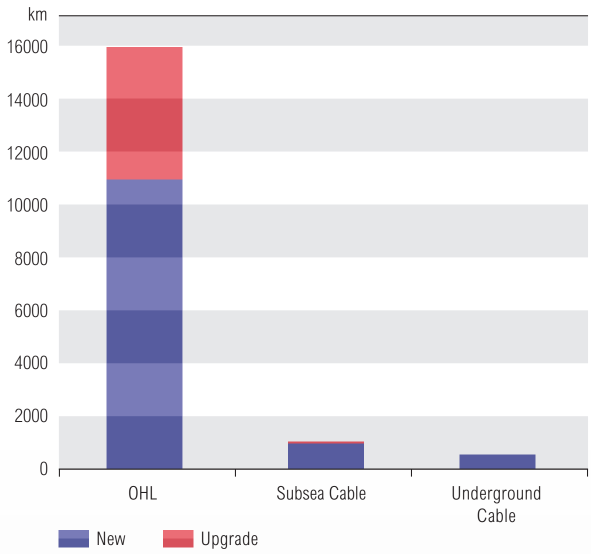


Figure 22:
AC Lengths by Technology

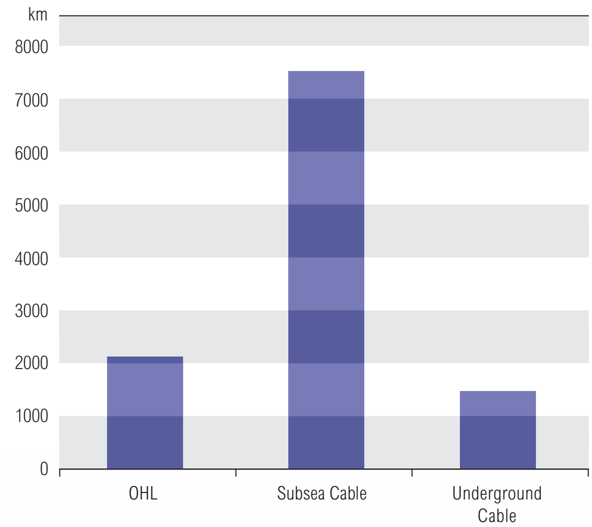


Figure 23:
DC Lengths by Technology

New grid infrastructure to enable renewable energy sources: RES connection and integration

An important role of the projects in the Regional Investment Plan is:

- to connect new RES to the main system or;
- to increase the grid capacity between areas so that renewable energy can be shared.

Those projects, combined with the projects in the distribution systems, will allow 139 GW of RES to connect in the North Sea Region, the largest amount of RES to be connected among the regional groups of ENTSOE.

New grid infrastructure to optimise the environmental performance of the energy mix: variation in CO_2 emissions

It is estimated that the projects in this Regional Investment Plan will enable savings of CO_2 emissions (209 Mt CO_2/yr for the North Sea region's projects of European significance). Those savings will be realized if the production from low-carbon power plants replaces production from high-carbon power plants and if the necessary grid reinforcements are achieved to give low-carbon power plants adequate grid access.

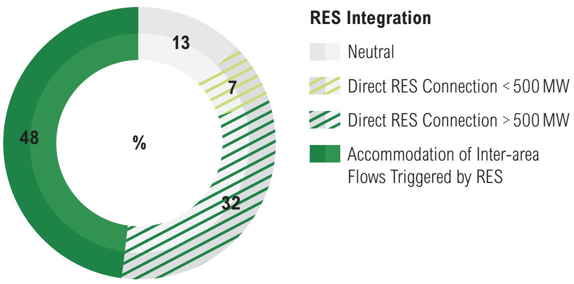


Figure 24:
Contribution of projects to RES Integration

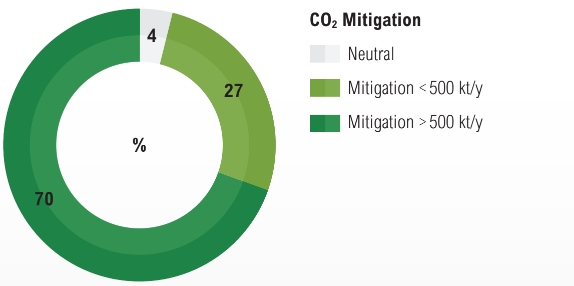


FIGURE 25:
Contribution of projects to CO_2 emission savings

New grid infrastructure to optimise the energy efficiency: variation in losses

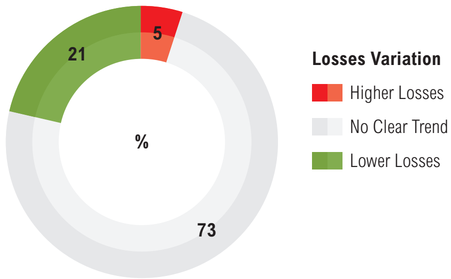
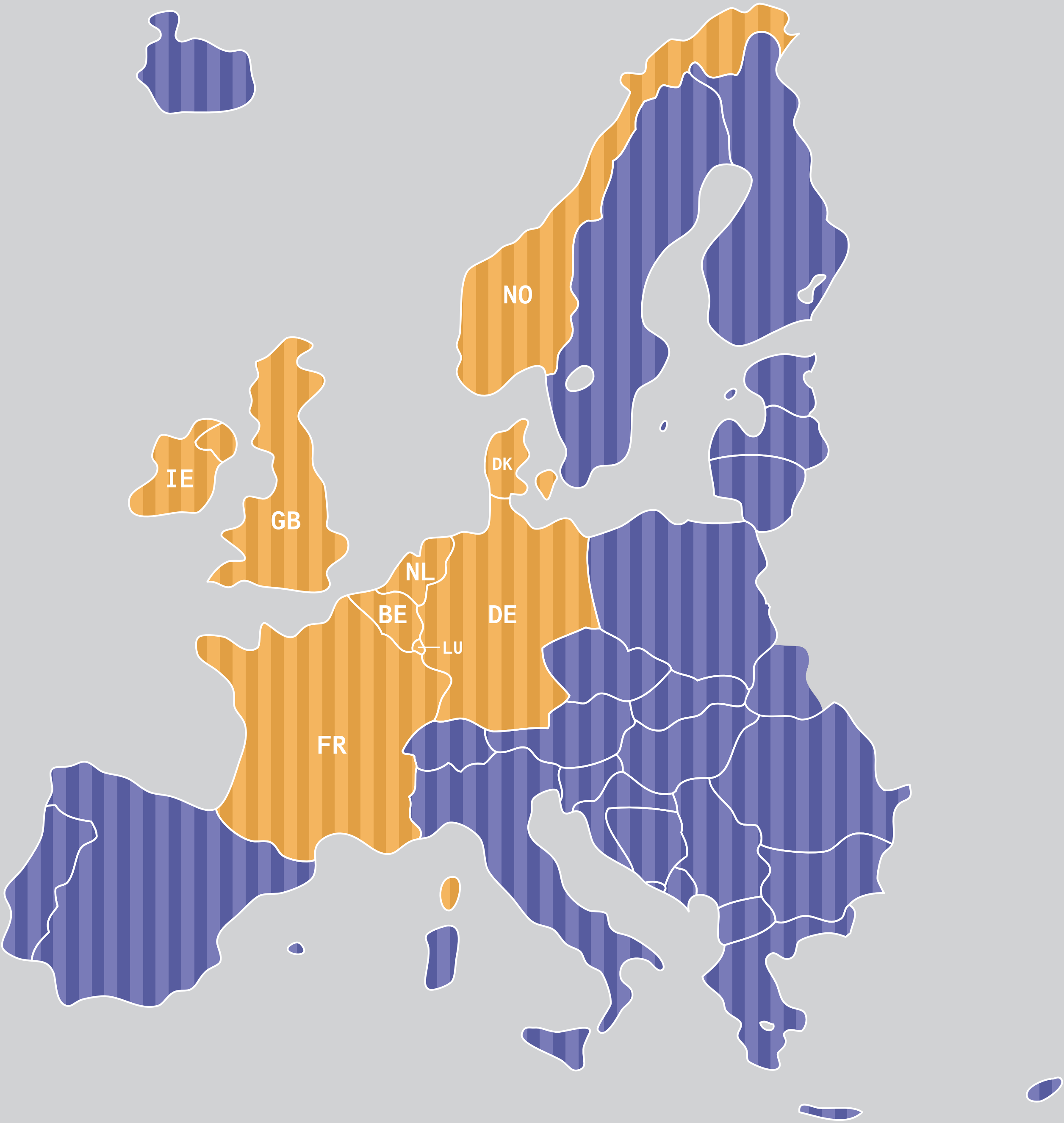


Figure 26:
Contribution of projects to efficiency

Furthermore, reinforcements may also reduce losses in the grid, and thus reduce the amount of generation needed to meet demand. This benefit can be achieved by a better load-flow pattern (production globally closer to the consumption), by increasing the voltage level and by the use of more efficient conductors, and so on. The projects are evaluated by their contributions to decrease the volume of losses.

10 Assessment of Resilience



High voltage grid projects are costly infrastructure investments, with a long lifetime (more than 40 years), setting precedence for coming projects and requiring years for completion. Both in order to avoid stranded costs and to meet grid users' expectations on time with appropriate solutions, TSOs assess the resilience of their investment projects. This assessment is performed in 4 major directions:

1. Sustainable, safe operation: investments should contribute to an improved quality of service and not put the reliability of the system at risk;
2. Economic performance: investments should prove useful and profitable in as many future situations as possible, bringing more benefits to the European population than they cost;
3. Technical sustainability: investments should take advantage of technological evolution so as to optimize their performance and ensure they do not become obsolete in the course of their expected lifetime;
4. Compatibility with longer run challenges looking ahead until 2050: investments should be appropriate as steps to meet 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 it may realistically have to face: high/low demand growth, different generation dispatch and exchange patterns, adverse climatic conditions, severe contingencies, and so on.

Several scenarios considered

The planning process begins with the definition of scenarios, depicting uncertainties on future developments on both the generation and demand sides, as well as a number of alternative grid operational conditions and development states that have to be considered to ensure the secure and efficient operation of the transmission grid in the future. In the present document, scenario B and scenario EU2020 have been considered (defined in Chapter 5). In addition, 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).

High variety of plausible situations

In order to assess the behavior of the planned grid against a large number of possible conditions, a number of cases are built taking into account forecast future demand, mix of generating units and cross-border power exchange patterns. As already presented in §4.2, 29 representative planning cases based on market studies results have been provided to TSOs in order for them to conduct the relevant grid studies. Examples of these cases are illustrated in Figure 27.

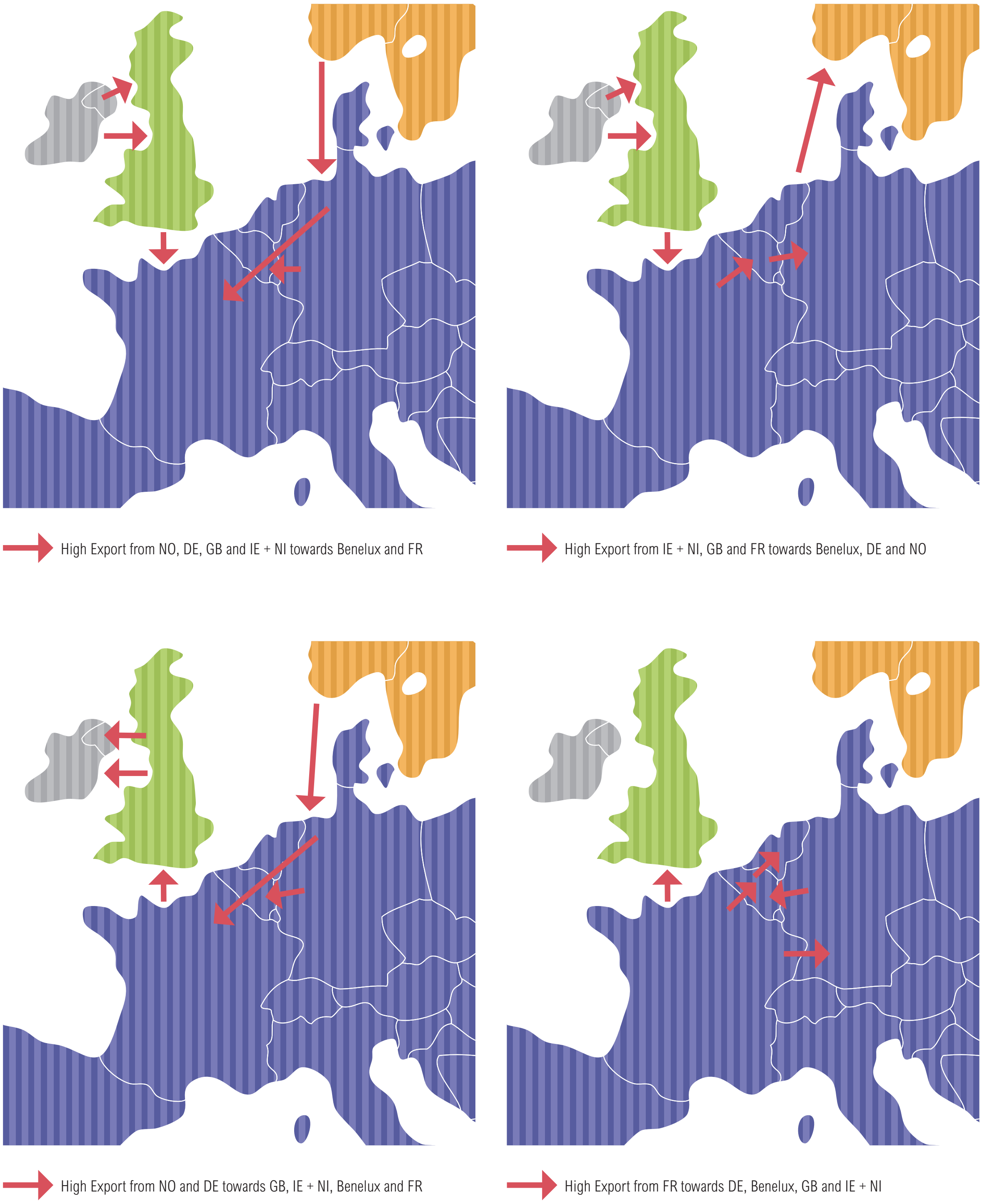


Figure 27:
Examples of 2030 Power Flows Analyzed

In addition, extreme conditions (e.g. ice, storms) are considered when designing the assets (towers, substations) and also when deciding the structure of the transmission grid (e.g. in France, in case of storm, at least one in-feed must remain available to each EHV transmission substation and in case of loss of load, the supply should be restored within a given time period).

Economic viability

Cost/benefit analyses are regularly updated through the entirety of the planning phase in order to assess the economic soundness of the planned grid investment. Thus the risk of stranded cost should be minimized.

Flexibility, smart grids

Transmission grids are equipped with special protection schemes (SPS) that allow for the safe operation of the grid in adverse conditions. Control systems allow the network topology to change and signals to be transmitted to grid users (generators, consumers), making congestion management possible in stressed situations. In addition, TSOs make greater use of systems for monitoring the temperature on the lines, allowing better use of the existing assets by having a more accurate assessment of grid thermal capacities. For instance, Elia uses the **ampacimon**[1)7] methodology.

Phase Shift Transformers (PSTs) have been used for many years in order to control the power flows and manage congestion. Such devices already exist in North Sea region, especially to control cross-border flows, for example at the Dutch borders with Belgium and Germany. While PSTs do not increase the capacity of lines, the overall grid capacity can be increased by optimizing flows using PSTs in cases where some lines are overloaded and free capacity exists on parallel lines. Elia plans a new one on the northern border of Belgium for 2020.

Several HVDC subsea projects are planned in the RG NS region linking the island systems together and to the main continental systems. Where appropriate, HVDC systems inserted within the synchronous AC grid will start to become more common. Flows on these facilities are fully controllable and the capacity not used by the market could be used in operational timeframes for congestion mitigation.

Lastly, grid development strategies are implemented in a modular (i.e. step by step) approach, which gives opportunities for adapting or even canceling projects according to external conditions or economic framework evolution.

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1) http://www.ampacimon.com/

New technologies

TSOs use new technologies where appropriate e.g. Voltage Source Convertor systems for some HVDC projects such as interconnections (both subsea and onland), connection of generation, and internal grid projects like those in Great Britain.

To advance the use of new technologies, TSOs are developing demonstration projects such as:

- the Kriegers Flak - connection of wind farms to several countries in the Baltic Sea,
- the COBRA project – a VSC-subsea interconnection between Denmark and the Netherlands, investigating the possibility of connecting new offshore wind farms to the cable built using new VSC technology; thus the project can be the first step towards an offshore grid, supporting offshore wind development and strengthening the European transmission grid,
- the Belgian 2 GW offshore hub, and
- the Scottish Hub project on the Scottish East Coast.

Kriegers Flak, the Scottish Hub and Cobra have each received an EEPR grant and thus are European demonstration projects, paving the way towards a North Sea offshore grid facilitating the gathering of experience concerning multi-terminal VSC solutions.

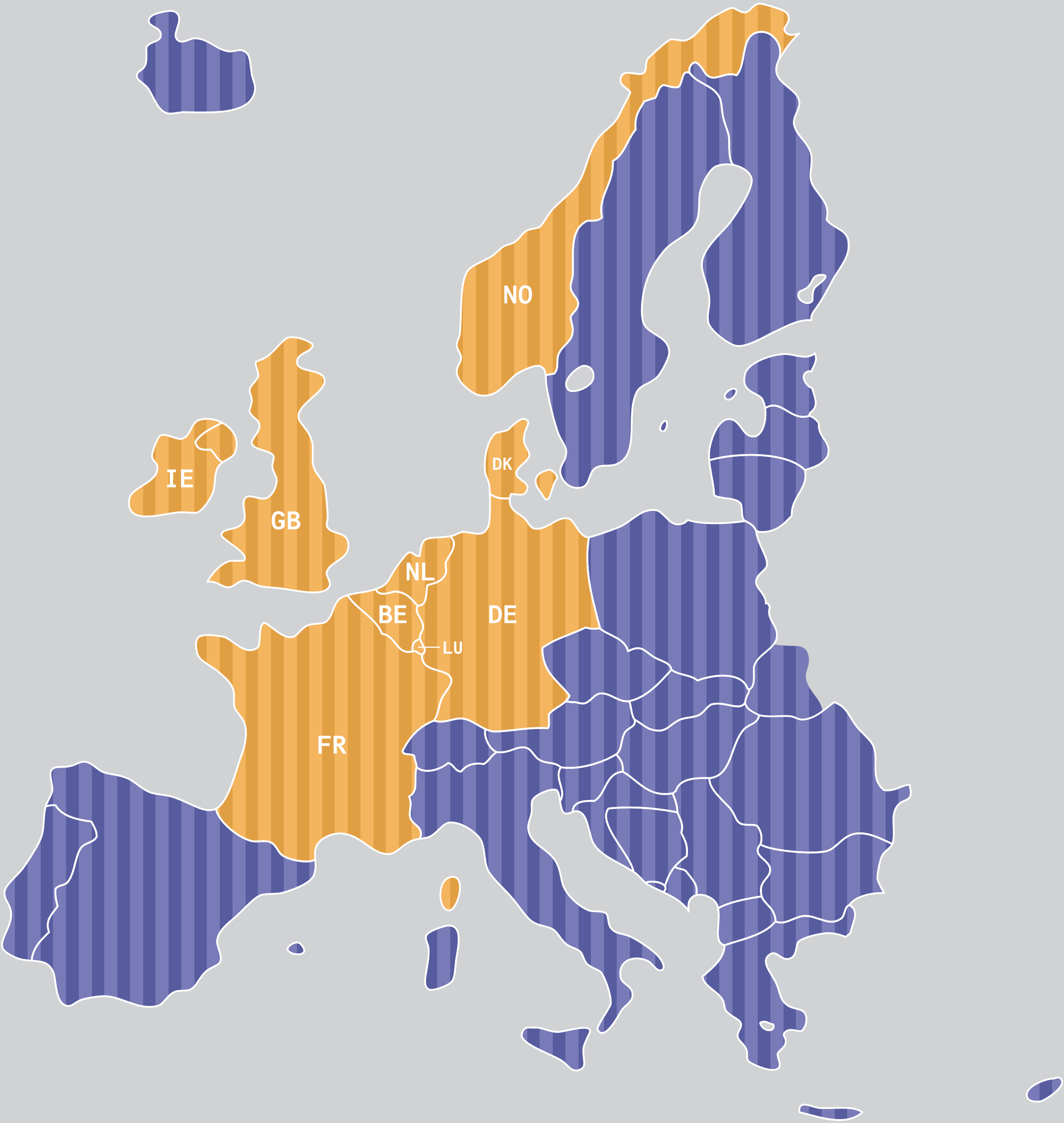
In the perspective of achieving wider use, it is recognized that standardization is needed, especially for offshore grids. New monitoring and control systems are to be specified, as well as new equipment (e.g. SPS, DC breakers).

Long-Term issues

As the economic lifetime of grid assets is around 40 years or more, TSOs develop long-term visions and plan grid development as the first steps towards the perceived long term future. Projects that are launched now should not jeopardise the expected grid development in the longer run. Reciprocally, long-term grid development is considered as additional to existing and planned assets.

In this regard the overall consistency of the process will be checked within the NSCOGI work on a 2030 offshore grid and ENTSO-E's 2050 e-Highways study.

11 North Seas Offshore Grid



In the North Sea Region, offshore wind generation is expected to play an important part in meeting renewable energy targets up to and beyond 2020.

Figure 28 shows four areas that are likely to benefit from early cooperation.

Connecting significant volumes of offshore generation, efficiently and economically is a key challenge, and as such the development of an offshore grid in the North Seas has been identified as one of the priorities in the Commission's October 2011 Energy Infrastructure Package communication.

ENTSO-E proposes a pragmatic, stepwise approach to the connection of this resource, while keeping in mind the ultimate goal of a possible future integrated offshore grid that extends beyond the North Sea[1]. This gives the opportunity to further extend the infrastructure and thereby also increasing interconnection capacities.

Although the backbone of such an offshore grid is likely to commence in the next ten years, it is only beyond 2020 – 2030 that the benefits of an integrated offshore grid are expected to be most significant.

Figure 28:
Map of Offshore Grid Resources

Due to the highly variable production from renewable generation it is important to maintain enough transmission capability to maintain supply when the output is low and provide commercial opportunity when the output is high enough.

[1] https://www.entsoe.eu/fileadmin/user_upload/_library/position_papers/110202_NSOG_ENTSO-E_Views.pdf

11.1 The North Seas Countries' Offshore Grid Initiative

In December 2010, the ten governments of the North Seas countries (Ireland, UK, France, Belgium, Luxembourg, Netherlands, Germany, Denmark, Sweden and Norway) signed a Memorandum of Understanding aimed at providing a coordinated, strategic development path for a possible offshore transmission network in the Northern Seas[1)]. The ENTSO-E work in this domain is now being taken forward within the North Seas Countries' Offshore Grid Initiative (NSCOGI), which ENTSO-E fully supports.

It should be recognized that other than the physical challenges of planning, constructing and operating such an interconnected European system there are many regulatory, legal, commercial and political hurdles that must be identified and addressed. ENTSO-E through NSCOGI will be looking at these wider issues as part of its deliverables.

Stepwise approach to a possible North Seas Grid

An integrated offshore grid is likely to develop in a stepwise manner with coordinated near shore wind connections, transmission, and point to point interconnectors forming the early steps.

Phase 1 – National co-ordination near shore

To date offshore generation developments have been relatively small and close to shore, therefore national regimes with single user, radial connections to each individual wind farm or clusters have been encouraged to provide timely access to markets. As wind volumes increase, and generation is sited further from shore, TSOs should be encouraged, in conjunction with developers, to promote a more optimized solution that anticipates and coordinates future need against the infrastructure investment. Delivering this essential first step will facilitate achievement of the 2020 targets, and will not present a barrier to subsequent decisions for future infrastructure development.

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1) http://ec.europa.ue/energy/renewables/grid/initiative_eu.htm

Phase 2 – an international meshed offshore grid

Continuation of national approaches is unlikely to meet increased longer-term targets. Studies have already been undertaken which demonstrate the possible benefits of a shift from national to multi-national regimes. Although these studies were initiated with many different drivers, they show the following possible benefits:

1. achieving EU/national targets by delivering RES at scale,
2. maximizing the use of finite resources (cable routes, landing points, cables etc),
3. optimizing the on and offshore grid investment,
4. minimizing asset costs and maximizing utilization by sharing infrastructure,
5. facilitating the internal market for electricity by increasing cross-border capacity,
6. increasing network reliability and resilience and maintaining security.

Technology development

Manufacturers believe that the appropriate offshore grid technology will be developed over the next few years. This is being explored as part of the North Seas Countries' Offshore Grid Initiative in consultation with manufacturers and is summarized in a recent ENTSO-E report on the status of available technology[1)]. There are also many additional challenges to be resolved before multi-user, multi-vendor, multi-use infrastructure can be planned, financed, delivered and operated, but ENTSO-E believes that initiating projects between countries in the region is a pragmatic enabler towards a wider grid in the North Sea Region.

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1) https://www.entsoe.eu/fileadmin/user_upload/_library/publications/entsoe/SDC/European_offshore_grid_-_Offshore_Technology_-_FINALversion.pdf

12 Appendices

12.1 Appendix A: Table of Projects of pan-European Significance

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

Project & investment items

A **project** in the TYNDP package 2012 can cluster several **investment items**.

Every row of the table in Appendix A to the TYNDP or Regional Investment Plan report corresponds to one investment item.

The basic rule for the clustering is that **an investment item belongs to a project if this item is required to develop the grid transfer capability increase associated with the project**.

A project can be limited to one investment item only.
An investment item can contribute to two projects;
in this case it is depicted only once in the table of projects,
in one of the projects (and only referred to in the other project: no technical description, status, etc. are repeated)

Labeling

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

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

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

Projects develop grid transfer capability across the boundaries as displayed on the following map (see Figure 29). The numbers attached to every boundary on the following map correspond to the projects' indices relieving the constraints across that boundary:

Figure 29:
Projects-Boundaries Correspondence

For each project, the following information is displayed:

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

[1] Direct access can be also achieved incidentally.

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

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

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

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
5	5.19	Vic (ES)	Pierola (ES)	Upgrading (uprating) the existing 75 km single circuit Vic – Pierola 400 kV line in order to increase its capacity from 1,360 MVA to 1,710 MVA.	1,200 – 1,400 MW in both directions			Perpignan, Gerona							under construction	2012	Delays due to authorization process.		Mid term interconnection project between France and Spain ("2.8 GW") . It includes cross border lines and internal lines required to assure NTC.
	5.20	Arkale (ES)	Hernani (ES)	Upgrading the existing single circuit Arkale – Hernani n° 2 220 kV OHL in order to increase its capacity up to 640 MVA.											design & permitting	2014	Delays due to authorization process.		
	5.36	Sta.Llogaia (ES)	Baixas (FR)	New HVDC (VSC) bipolar interconnection in the eastern part of the border, via 320 kV DC underground cable using existing infrastructures corridors and converters in both ending points.											partly under construction, design & permitting	2014	Progresses as planned.		
	5.37	Santa Llogaia (ES)	Bescanó (ES)	New double circuit Sta. Llogaia – Ramis – Bescano – Vic / Senmenat 400 kV OHL (single circuit in some sections) New 400 kV substations in Bescano, Ramis and Sta.Llogaia, with 400/220 kV transformers in Ramis and Bescano.											under construction	2011 – 2013	Bescano-Vic / Senmenat 400 kV commissioned. Difficulties in the authorization process of the section Bescano – Sta Llogaia 400 kV		
	5.46	Baixas (FR)	Gaudière (FR)	Reconductoring of existing 70 km double circuit 400 kV OHL to increase its capacity.											design & permitting	end 2013	Progresses as planned.		
16	16.38	Gatica (ES)	Aquitaine (FR)	New HVDC interconnection in the western part of the border via DC subsea cable in the Biscay Gulf.	FR – ES 1,200 MW ES – FR 2,000 MW			Biarritz, Basque country							under consideration	approx. 2020	New investment in TYNDP, defined since last release, aiming 4 GW capacity between France and Spain.		Long-term interconnection project between France and Spain ("4 GW") . It includes cross border lines and internal lines required to assure NTC.
	16.A14	Amorebieta (ES) Garraf (ES) Adrall (ES) Orcoyen (ES)	Gueñes (ES) Secuita (ES) La Pobla (ES) Elgea (ES)	Uprates required in Basque country and Catalonia in order to use fully the benefit of the long-term ES – FR interconnection.											under consideration	2016	New investment in TYNDP meant to solve congestion in this area.		
	16.A17	Arkale (ES)		New PST on Arkale – Argia 220 kV interconnection line.											design & permitting	2016	New investment enabling to take full advantage of the transfer capacity.		
17	17.42	Lonny (FR)	Vesle (FR)	Reconstruction of the existing 70 km single circuit 400 kV OHL as double circuit OHL.	9,000 MW			Reims, Paris area							design & permitting	2016	Progresses as planned.		Project needed to cope with larger and more volatile power flows from Normandy to Champagne, triggered especially by the development of new generation sources (along the Channel coasts, from Picardie to Champagne and further north abroad) that would naturally flow to large consumption areas: Paris area, but also more broadly from Britanny to Reims.
	17.44	Havre (FR)	Rougemontier (FR)	Reconductoring of existing 54 km double circuit 400 kV OHL to increase its capacity.											under construction	2016	As the pace of generation installation is lower than expected, the investment has been postponed.	This investment is needed for integrating new generation in Le Havre area. As the pace of generation installation is lower than assumed earlier, the investment has been postponed from 2015 to 2018	
	17.A18	tbd (FR)	tbd (FR)	New network reinforcement between Haute Normandie and the south of Paris area. Length about 160 km.											under consideration	long term	New investment in TYNDP, defined since last release.	Either existing assets uprate or new HVDC, actual needs still being evaluated, depending on uncertainties on generation location.	
	17.45	Taute (FR)	Oudon (FR)	"Cotentin – Maine" Project: New 163 km double circuit 400 kV OHL connected to existing network via two new substations in Cotentin and Maine regions.											under construction	2013	Delays due to authorization process.		
	17.A144	Cergy (FR)	Terrier (FR)	MORP project: New single circuit 400 kV line between existing 400 kV substations.											planned	2018	New investment in TYNDP, defined since last release, triggered by larger and more volatile power flows between generation developing north of Paris and Paris area.		
18	18.48	Gaudière (FR)	Rueyres (FR)	Reconductoring with ACCS limiting section (10 km) of existing single circuit 400 kV OHL.	>1,000 MW			Provence area							under construction	end 2012	Progresses as planned.		Larger and more volatile north – south power flows in southwestern France, triggered by the development of local RES generation but also influenced by transits flows with neighboring countries.
	18.A19	tbd (FR)	tbd (FR)	Restructuration of whole EHV grid in Massif Central area.											under consideration	long term	New investment in TYNDP, defined since last release, triggered by larger and more volatile power flows in Southwest France.		
	18.20.A20	(Provence) (FR)	(Midi) (FR)	New subsea HVDC link between Marseille area and Languedoc.											design & permitting	2018	New investment in TYNDP, defined since last release, triggered by larger and more volatile power flows in Southwest France.		

Table of projects – Regional Group North Sea

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environ-mental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
19	19.51	Boutre (FR)	La Bocca (FR)	PACA “Filet de sécurité” project: Construction of 3 new AC 220 kV underground cables – Boutre – Trans (65 km), – Bianςon – Fréjus (26 km) and – Bianςon – La Bocca (17 km). Installation of reactive power compensation devices in 220 kV Boutre and Trans substations.	500 MW			French riviera							design & permitting	2015	Progresses as planned.		Security of supply of the French Riviera.
20	20.53	Coulange (FR)	Le Chaffard (FR)	Reconductoring (with ACCS / ACCR) of two existing double circuit 400 kV OHL (Coulange – Pivoz-Cordier – Le Chaffard and Coulange – Beaumont-Monteux – Le Chaffard). Total length of both lines: 275 km	2,400 MW			Southeast France							under construction	2016	Progresses as planned.	Construction over 4 years because the works are only possible during limited periods every years on this strategic corridor.	The project aims at ensuring the reliable grid operation to cope with new generation development along the Rhone Valley and more volatile power flows between the Alps and southwestern France.
	20. 18, A20																	The investment contributes both to project 18 and project 20. For the technical description see project 18.	
21	21.54	Cornier (FR)	Piossasco (IT)	Replacement of conductors (by ACCS) on Albertville (FR) – Montagny (FR) – Cornier (FR) and Albertville (FR) – La Coche (FR) – La Praz (FR) – Villarodin (FR) – Venaus (IT) – Piossasco (IT) single circuit 400 kV OHLs. In addition, change of conductors and operation at 400 kV of an existing single circuit OHL between Grande Ile and Albertville currently operated at lower voltage, and associated works in Albertville 400 kV substation. Total length of lines: 257 km	FR – IT 1,800 MW (600 MW in the MT)										under construction	2012 – 2013	Mainly progresses as planned although the works on existing lines take slightly longer than initially thought.		Planned France – Italy interconnection development
	21.55	Grande Ile (FR)	Piossasco (IT)	“Savoie – Piémont” Project: New 190 km HVDC (VSC) interconnection FR – IT via underground cable and converter stations at both ends (two poles, each of them with 600 MW capacity). The cables will be laid in the security gallery of the Frejus motorway tunnel and possibly also along the existing motorways’ right-of-way.											design & permitting	2017 – 2018	Progresses as planned.		
	21.81	Trino (IT)	Lacchiarella (IT)	A new 380 kV double circuit OHL between the existing 380 kV substations of Trino and Lacchiarella in Northwest Italy area. Total line length: 95 km Voltage upgrade of the existing Magenta 220/132 kV substation up to 380 kV.											under construction	2013	Authorization process ended, construction phase on going.		
	21.84	Casanova (IT)	Vignole (IT)	Voltage upgrade of the existing 100 km Casanova – Vignole 220 kV OHL to 400 kV and new 400/220/150 kV substation in Asti area.											design & permitting	long term	Delays due to authorization process.		
	21.101	Turin (IT)		Restructuring of the 220 kV network in the urban area of Turin. Some new 220 kV cables, some new 220/132 kV substations and some reinforcements of existing assets are planned. Total length: 63 km											design & permitting	long term	Progresses as planned.		
22	22.57	under consideration (FR)	under consideration (CH)	Reinforcement of the interconnection in the area of Geneva’s lake.	FR – CH 1,000 MW CH – FR <1,500 MW										under consideration	long term	Progresses as planned. Several technical options (route, technologies) have been designed and are being investigated.	The very uncertain environment, regarding commissioning and decommissioning of generation in particular makes the assessment complex.	France – Switzerland interconnection development under consideration.
23	23.60	under consideration (FR)	under consideration (BE)	To be determined.	1,800 – 3,000 MW			Lille, Ruien area							under consideration	2018 – 2020	Project entered a feasibility study phase.		France-Belgium interconnection development: internal French grid reinforcements, that are prerequisite to maintain the present NTC and further interconnection development under consideration. This project enhances security of supply in Belgium and allows intra and inter countries RES integration.
	23.A21	Avelin (FR)	Mastaing (FR)	Operation at 400 kV of existing line currently operated at 220 kV.											design & permitting	2017	New investment in the TYNDP.	Upgrade of all grid assets in northern France at the same standard	
	23.A22	Avelin (FR)	Gavrelle (FR)	Substitution of a new double circuit 400 kV OHL to an existing 400 kV single circuit OHL											design & permitting	2017	New investment in the TYNDP.		

Table of projects – Regional Group North Sea

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
24	24.60a	Lillo (BE)	Mercator (BE)	Brabo Project: Doubling of the axis Zandvliet – Mercator via Lillo. First part: erecting a new 22 km double circuit 380 kV OHL with 1,500 MVA capacity Lillo and Mercator.	1,500 MW			Antwerp area							design & permitting	2017	New date of operation advanced to 2017 due to new generation projects.	Brabo Project	The project aims at ensuring the reliable grid operation to cope with new generation development in the northern part of Belgium and more volatile north – south flows. It also enhances the security of supply in Antwerp harbour.
	24.445	Zandvliet (BE)	Lillo (BE)	Brabo Project: Doubling of the axis Zandvliet – Mercator via Lillo. Second part: erecting a new 22 km double circuit 380 kV OHL with 1,500 MVA capacity Lillo and Zandvliet and a new 400 kV substation in Lillo.											design & permitting	2017	Permits cancelled by national authority. New permitting procedure has started.	Brabo Project	
	24.445a	Gramme (BE)	Van Eyck (BE)	Doubling of 108 km 380 kV axis Gramme – Van Eyck + high performance conductors + new 380 kV substation (Van Eyck).											design & permitting	2014	Permitting phase has started.		
	24.A26	Horta (BE)	Doel / Mercator (BE)	Upgrade with high performance conductors.											design & permitting	2016 – 2020	New investment in the TYNDP. The grid simulations performed by Regional Group North Sea showed higher north – south physical flows on northern Belgian boundary. This project avoid a NTC reduction due to higher loop flows.		
	24.A27	Zandvliet (BE)		New PST in Zandvliet substation.	1,500 MW			Antwerp area							planned	2016 – 2020	New investment in the TYNDP. The grid simulations performed by Regional Group North Sea showed higher north – south physical flows on northern Belgian boundary. This project avoid a NTC reduction due to higher loop flows.	4th PST on the Belgian north border.	
25	25.62	under consideration (FR)	under consideration (GB)	IFA2: New subsea HVDC link between the UK and France. Capacity is still to be determined. (Possibly 1000 MW)	1,000 MW										under consideration	2020	Further investigations during the feasibility phase have led to reassess the expected commissioning date for "IFA2".		France – UK interconnection development under consideration.

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

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

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Project identification					Project assessment														
Project number	**Investment number**	**Substation 1**	**Substation 2**	**Brief technical description**	**Grid transfer capacity increase**	**Socio-economic welfare**	**RES integration**	**Improved security of supply**	**Losses variation**	**CO_2 mitigation**	**Technical resilience**	**Flexibility**	**Social and environ-mental impact**	**Project costs**	**Present status**	**Expected date of commissioning**	**Evolution compared to the TYNDP 2010 situation**	**Investment comment**	**Project comment**
41	41.149	Dollern (DE)	Stade (DE)	New 400 kV double circuit OHL Dollern – Stade including new 400 kV switchgear in Stade. Length: 14 km	>3,000 MW										design & permitting	mid term	This investment depends on the commissioning of a conventional power plant in the area. The additional reason for delay is the long permitting procedure associated with this investment.		Evacuation of the new conventional generation in the 50Hertz and TenneT area.
	41.150	Conneforde (DE)	Maade (DE)	New 400 kV double circuit (underground cable + OHL) Conneforde – Maade including new 400 kV switchgear Maade. Length: 37 km											design & permitting	long term	Progresses as planned.		
	41.A74	north of Control Area 50Hertz Transmission (DE)		Construction of new substations / lines for integration of newly build power plants in northern part of 50Hertz Transmission control area.											planned	long term	New investment in TYNDP, because of additionnal need for generation evacuation. Some of the investments are to be commissioned by the mid term and the some by long term.	Support of conventional generation integration in northeastern Germany, maintaining of security of supply and support of market development.	
42	42.152	Dörpen / West (DE)		New substation for connection of offshore wind farms.	>8,000 MW										under construction	mid term	Progresses as planned.	Commercially sensitive information about this new wind farm connection cannot be displayed in the TYNDP report.	Integration of the offshore wind parks and the onshore grid reinforcements in the northern DE.
	42.159	Cluster BorWin1 (DE)	Diele (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205 km. Line capacity: 400 MW											under construction	mid term	The commission date of this wind farms connection should be in 2012. Energy transportation is however already enable.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.160	offshore wind park Nordergründe (DE)	Inhausen (DE)	New AC-cable connection with a total length of 35 km.											design & permitting	mid term	Progresses depend on development of the offshore wind farm.		
	42.161	offshore wind park GEOFreE (DE)	Göhl (DE)	New AC-cable connection with a total length of 32 km.											design & permitting	mid term	Progresses depend on development of the offshore wind farm.		
	42.163	Cluster HelWin1 (DE)	Büttel (DE)	New HVDC transmission systm consisting of offshore platform, cable and converters with a total length of 145 km. Line capacity: approx. 690 MW This Project includes also a new substation Büttel and connection of this new substation with the existing OHL Brünsbüttel – Wilster.											under construction	mid term	Progresses with delay.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.164	Cluster SylWin1 (DE)	Büttel (DE)	New line consisting of underground + subsea cable with a total length of 210 km. Line capacity: approx. 864 MW											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.165	Cluster DolWin1 (DE)	Dörpen / West (DE)	New line consisting of underground + subsea cable with a total length of 155 km. Line capacity: 800 MW											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.166	offshore wind park Riffgat (DE)	Emden / Borßum(DE)	New AC-cable connection with a total length of 80 km.											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.167	Cluster BorWin2 (DE)	Diele (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 205 km. Line capacity: 800 MW											under construction	mid term	Progresses as planned.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.A82	Cluster DolWin2 (DE)	Dörpen / West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 160 km. Line capacity: 900 MW											under construction	mid term	New investment in TYNDP, for connection of new offshore wind farms.	Due to nondisclosure agreements it is not possible to give further information about this wind farm connection in TYNDP.	
	42.A83	Cluster DolWin3 (DE)	Dörpen / West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 160 km. Line capacity: 900 MW											design & permitting	mid term	New investment in TYNDP, for connection of new offshore wind farms.		

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
	42.A84	Cluster BorWin3	Dörpen / West (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 180 km. Line capacity: 900 MW	>8,000 MW										design & permitting	mid term	New investment in TYNDP for connection of new offshore wind farms.		Integration of the offshore wind parks and the onshore grid reinforcements in the northern DE.
	42.A85	Cluster HelWin2	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 145 km. Line capacity: 690 MW											under construction	mid term	New investment in TYNDP for connection of new offshore wind farms.	Due to nondisclosure aggreements it is not possible to give further information about this wind farm connection in TYNDP	
	42.A86	Cluster BorWin4 (DE)	Emden / Ost (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 185 km. Line capacity: 900 MW											under consideration	long term	New investment in TYNDP for connection of new offshore wind farms.		
	42.A87	Cluster SylWin2 (DE)	Büttel (DE)	New HVDC transmission system consisting of offshore platform, cable and converters with a total length of 210 km. Line capacity: 800 MW											under consideration	long term	New investment in TYNDP for connection of new offshore wind farms.		
	42.211	further connections of more offshore wind farms (DE)		Further connections in the clusters BorWin, DolWin, SylWin and HelWin.											under consideration	long term	Progresses depend on development of the offshore wind farm.		
43	43.A81	Osterath (DE)	Philippsburg (DE)	New HVDC lines from Osterath to Philippsburg to integrate new wind generation especially from North / Baltic Sea towards Central-South Germany for consumption and storage.	10,000 MW			Bavaria and Baden-Württemberg area							under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		Combined DC and AC new infrastructure to accommodate the new RES generation, the associated flows from north to south and also to secure the security of supply in South Germany.
	43.A152	Emden (DE)	Osterath (DE)	New HVDC lines from Endem to Osterath to integrate new wind generation especially from North / Baltic Sea towards Central Germany for consumption and storage.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		
	43.A153	Wehrendorf (DE)	Urberach (DE)	New lines in HVDC technology from the region of Lower Saxony to North Baden-Württemberg to integrate new wind generation especially from North Sea towards Central-South Europe for consumption and storage. The investment is part of the transmission corridor Cloppenburg – North Baden-Württemberg.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		
	43.A154	Cloppenburg (DE)	Westerkappeln (DE)	New 400 kV double circuit OHL Cloppenburg – Westerkappel (75 km). The investment is part of the transmission corridor Cloppenburg – North Baden-Württemberg.											under consideration	long term	New investment in TYNDP due to increase of RES and changes in conventional power plants in Germany and increase transits.		
	43.A88	Brunsbüttel (DE), Wilster (DE), Kaltenkirchen (DE)	Großgartach (DE), Goldshöfe (DE), Grafenrheinfeld (DE)	New DC lines to integrate new wind generation from northern Germany towards southern Germany and southern Europe for consumption and storage.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.		
	43.A75	Lauchstadt (DE)	Meitingen (DE)	New DC lines to integrate new wind generation from Baltic Sea towards Central / Ssouth Europe for consumption and storage.											under consideration	long term	New investment in TYNDP due to long distance RES integration, voltage stability of the grid and security of supply in the south of Germany.	New Investment due to increase of RES and changes in conventionel power plants in Germany and increase transits.	
	43.A89	area of northern Lower Saxony (DE)		New lines for integration of on- and offshore wind generation incl. 380 kV lines Halbemond – Emden, Emden – Conneforde and Conneforde – Cloppenburg. Total length: 160 km											under consideration	long term	New investment in TYNDP due to new wind generation projects.		
	43.A90	area of Schleswig-Holstein (DE)		About 300 km new 380 kV lines and around 24 new transformers for integration of onshore wind in Schleswig-Holstein, incl. lines – Brunsbüttel – Barlt – Heide – Husum – Niebüll – border of Denmark, – Audorf – Kiel – Göhl – Siems – Lübeck – Kaltenkirchen and – Kaltenkirchen – Itzehoe – Brunsbüttel.											under consideration	long term	New investment in TYNDP due to new wind generation projects.	The German West-coast line (Brunsbuettel – Niebuel) is planned to be connected to the Danish grid in the 400 kV substation Endrup. The distance from the German/Danish border is approx. 80 km. Bilateral technical / economical investigations are ongoing. Reinforcements in the Danish 400 kV grid are foreseen in order to facilitate the increased power exchange capacity on the Danish-German border.	

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
44	44.147	Dollern (DE)	Hamburg / Nord (DE)	New 400 kV double circuit OHL Dollern – Hamburg / Nord including one new 400/230 kV transformer in substation Hamburg / Nord and new 400 kV switchgear Kummerfeld. Length: 43 km	5,000 MW			Bavaria and Baden-Württemberg area							design & permitting	mid term	Delays due to authorization process.		This project helps accomodating the increasing flows coming mainly form RES in NW DE to SW DE and CH.
	44.148	Audorf (DE)	Hamburg / Nord (DE)	New 400 kV double circuit OHL Audorf – Hamburg / Nord including two new 400/230 kV transformers in substation Audorf. Length: 65 km											design & permitting	mid term	This investment was scheduled for 2015. Presently it is foreseen a delay of around 1 year due to permitting process.		
	44.151	Wehrendorf (DE)	Ganderkesee (DE)	New line (length: approx. 95 km), extension of existing and erection of substations, erection of 380/110 kV transformers.											design & permitting	mid term	Delays due to authorization process.		
	44.156	Niederrhein (DE)	Dörpen / West (DE)	New 400 kV double circuit OHL Dörpen – Niederrhein including extension of existing substations. Length: 167 km											design & permitting	mid term	Delays due to authorization process.		
	44.157	Wahle (DE)	Mecklar (DE)	New 400 kV double circuit OHL Wahle – Mecklar including two new substations. Length: 210 km											design & permitting	mid term	Delays due to authorization process.		
	44.90.170	Großgartach (DE)	Hüffenhardt (DE)	New 380 kV OHL. Length: 23 km Included with the project: – 1 new 380 kV substation – 2 transformers											under construction	2012	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.171	Hüffenhardt (DE)	Neurott (DE)	Upgrade of the line from 220 kV to 380 kV. Length: 11 km Included with the project: 1 new 380 kV substation.											planned	2020	Progresses as planned.		
	44.90.172	Mühlhausen (DE)	Großgartach (DE)	Upgrading line from 220 kV to 380 kV. Length: 45 km											design & permitting	2014	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.90.173	Hoheneck (DE)	Endersbach (DE)	Upgrading line from 220 kV to 380 kV. Length: 20 km											design & permitting	2014	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.174	Bruchsal Kändelweg (DE)	Ubstadt (DE)	A new 380 kV OHL. Length: 6 km											design & permitting	2014	Postponed from one year due to permitting procedures.		
	44.90.176	Daxlanden (DE)	Eichstetten (DE)	Upgrade of transmission capacity of existing 380 kV line. Length: 120 km											under consideration	2020	Progresses as planned.	This investment contributes to both project 90 and 44.	
	44.178	Baden-Württemberg, Süden & Nordosten (DE)"		Installation of 2 × 250 MVAr 380 kV capacitance banks.											under construction	2014	One more bank in addition. Two have already been installed. Projects realized earlier because the need for reactive power compensation became urgent.		
	44.179	Rommerskirchen (DE)	Weißenthurm (DE)	New line, extension of existing and erection of substations, erection of 380/110 kV transformers. Total line length: 100 km.											under construction, design & permitting	mid term	Some parts are commissioned but the main elements of the investment are still in design and permitting due to delays in permitting process.		
	44.181	Dauersberg (DE)	Limburg (DE)	New 380 kV double circuit OHL, extension of existing of substations. Total line length: 20 km											under construction, design & permitting	mid term	Some parts are commissioned but the main elements of the investment are still in design and permitting due to delays in permitting process.		
	44.182	Kriftel (DE)	Obererlenbach (DE)	New 400 kV double circuit OHL Kriftel – Obererlebenbach in existing OHL corridor. Length: 11 km											planned	mid term	Some parts are commissioned but the main elements of the investment are still in design and permitting due to delays in permitting process.		
	44.A80	Area of West Germany (DE)		Installation of several 300 MVAr 380 kV capacitance banks, extension of existing substations.											under consideration	long term	New investment in TYNDP, because of additional needs for RES integration (combined with SoS).		
	44.183	Wehrendorf (DE)		Installation of 300 MVAr 380 kV capacitance banks, extension of existing substations.											design & permitting	mid term	Delays due to authorization process.		
	44.184	Bürstadt (DE)		Installation of 2 × 300 MVAr 380 kV capacitance banks, extension of existing substations.											design & permitting	mid term	Delays due to authorization process.		
	44.185	area of Muensterland and Westfalia (DE)		New lines and installation of additional circuits, extension of existing and erection of several 380/110 kV substations. Total length: approx. 110 km											design & permitting	long term	Delays due to authorization process.		
	44.186	Gütersloh (DE)	Bechterdissen (DE)	New lines and installation of additional circuits, extension of existing and erection of 380/110 kV substation. Total line length: 27 km											under construction	mid term	Delays due to authorization process.		
	44.187	area of West-Rhineland (DE)		New lines and installation of additional circuits, extension of existing and erection of several 380/110 kV substations.											under construction	2013	Progresses as planned.		

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

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

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

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47	47.A76	Vöhringen / Leupolz (DE)	Westtirol (AT)	Upgrade of an existing OHL to 380 kV, extension of existing and erection of new 380 kV substations including 380 / 110 kV transformers. Transmissions routs Vöhringen – Westtirol and Pkt. Woringen – Memmingen. Length: 114 km. This project will increase the current power exchange capacity between the DE, AT and CH.	>2,000 MW										planned	long term	New investment in TYNDP.		The reinforcement of the interconnection between Austria and Germany. Also the support the interaction between the RES in northern Europe(mainly DE) with the pump storage in the Austrian Alps. The project scheduling is not related only to the network needs, but even to the feasibility and to the authorization process (the possibility to anticipate specific projects could be evaluated in the future considering the three above mentioned elements).
	47.158	Irsching (DE)	Ottenhofen (DE)	Upgrade of 230 kV connection Irsching – Ottenhofen to 400 kV, including new 400 kV switchgear Zolling. Length: 76 km											planned	mid term	Progresses as planned.	The investment contributes also to project 45.	
	47.212	Isar / Ottenhofen (DE)	St. Peter (AT)	New 400 kV double circuit OHL Isar – St. Peter including new 400 kV switchgears Altheim, Simbach and St. Peter, and one new 400/230 kV transformer in substation Altheim and fourth circuit on line Isar – Ottenhofen. Line length: 90 km											design & permitting	2017	Progresses as planned.		
	47.216	St. Peter (AT)	Tauern (AT)	Completion of the 380 kV line St. Peter – Tauern. This contains an upgrade of the existing 380 kV line St. Peter – Salzburg from 220 kV operation to 380 kV operation and the erection of a new internal double circuit 380 kV line connecting the substations Salzburg and Tauern (replacement of existing 220 kV lines on optimized routes). Moreover the erection of the new substations Wagenham and Pongau and the integration of the substations Salzburg and Kaprun is planned. Line length: 130 km											design & permitting	2017 / 2019	Preparation for the permitting procedure is ongoing. APG is making efforts to set the 380 kV Salzburg-line 2017 into service. Depending on possible delays during the permitting procedure the commissioning is expected between 2017 and 2019	The investment contributes also to project 26.	
	47.26.218																	The investment contributes both to project 26 and project 47. For the technical description see project 47.	
	47.219	Westtirol (AT)	Zell-Ziller (AT)	Upgrade of the existing 220 kV line Westtirol – Zell-Ziller and erection of additional 220/380 kV transformers. Line length: 105 km											partly under construction	2013 – 2020	Project consists of several measures and is on schedule.		
	47.26.220																	The investment contributes both to project 26 and project 47. For the technical description see project 47.	
	47.221	St. Peter (AT)	Ernsthofen (AT)	Upgrade from 220 kV operation to 380 kV and erection of a 380 kV substation in Ernsthofen and St. Peter.											under construction	2013	The project is on schedule. Permissions are obtained. Commissioning is expected for 2013		
58	58.353	Krajnik (PL)	Baczyna (PL)	Construction of a new double circuit 400 kV OHL Krajnik – Baczyna (2 × 1,870 MVA, 91 km), single circuit temporarily working at 220 kV on Krajnik – Gorzów part. New substation 400 kV Baczyna will be connected by splitting and extending existing line Krajnik – Plewiska. Upgrading of limitations line Krajnik – Plewiska.	>1,000 MW										planned	2020	Progresses as planned.		Bridge Third interconnection between Poland and Germany.
	58.355	Mikułowa (PL)	Świebodzice (PL)	Double circuit line 220 kV Mikułowa – Świebodzice will be upgraded to 400 kV – single circuit temporarily working at 220 kV.											planned	2020	Progresses as planned.		
	58.A67	Gubin (PL)		New 400 kV substation planned near the PL – DE border. The substation will be connected to planned line Eisenhüttenstadt (DE) – Plewiska (PL) creating new lines Eisenhüttenstadt (DE) – Gubin (PL) and Gubin (PL) – Plewiska (PL).											planned	2020	New investment in TYNDP.	This new substation on the third DE – PL connection is necessary for future generation connection while ensuring interconnection capability.	
	58.140	Eisenhüttenstadt (DE)	Plewiska (PL)	New 400 kV double circuit OHL Eisenhüttenstadt (DE) – Plewiska (PL) including the construction of new substation Plewiska Bis (PL).											planned	2020	Progresses as planned.		

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67	67.402	Barkeryd (SE) Hallsberg (SE)	Tveiten (NO) Hurva (SE)	"South West link" consisting of three main parts: 1) New 400 kV line between Hallsberg and Barkeryd (SE), 2) new double HVDC VSC underground cable and OHL between Barkeryd and Hurva (SE) and 3) new double HVDC VSC line between Barkeryd (SE) and Tveiten (NO). The project also include new substations and converter stations in the connection points line.	East – West 1,400 MW North – South 1,200 MW										design & permitting	2014-2019	Commissioning date updated after bilateral negotiations between the two countries. Hallsberg – Barkeryd – Hurva expected in 2014, Barkeryd – Tveiten in 2019.		5 investments of HVDC and AC lines in Sweden and Norway as well as between the countries, resulting in increased GTC and market integration
	67.411	Rød (NO)	Sylling (NO)	Voltage upgrading of existing single circuit 300 kV OHL Rød – Tveiten – Flesaker – Sylling in connection with the new HVDC line to Sweden, the Syd Vest link.											design & permitting	2018 / 2020	Investment postponed, especially because of long permitting processes.		
	67.412	Rød (NO) – Sylling (NO) – Flesaker (NO)	Hasle (NO) Tegneby (NO) Tegneby (NO)	Reinvestment and capacity increase Oslofjord 400 kV subsea cables. Three cables: – Filtvedt – Brenntangen, – Solberg – Brenntangen and – Teigen – Evje.											design & permitting	2015	Investment delayed, especially because of long permitting processes. One cable is under construction.		
68	68.421	Ofoten (NO)	Balsfjord (NO)	New 160 km single circuit 400 kV OHL.	350 – 1,500 MW			Northern Norway							design & permitting	2016	Investment delayed, especially because of long permitting processes.		The main purpose of this project is to secure the norther part of Norway.
	68.422	Balsfjord (NO)	Hammerfest (NO)	New 360 km single circuit 400 kV OHL.											design & permitting	2018	Investment delayed, especially because of long permitting processes.		
	68.423	Skaidi (NO)	Varangerbotn (NO)	New 230 km single circuit 400 kV OHL.											planned	2022	Investment postponed, especially because of long permitting processes.		
69	69.424j	Bramford (GB)	Twinstead (GB)	New 400 kV double circuit.	2,600 MW										design & permitting	2018 / 2019	Delayed by one year to 2018 / 19 due to an anticipated slower growth in the uptake of wind.		This project supports the evacuation of energy from a new nuclear power plant and from the offshore wind parks of the eastern coast of GB.
	69.A39	Sizewell C (GB)	Bramford (GB)	Reconductor Sizewell C – Bramford – Sizewell.	1,800 MW										planned	2015 / 16	New investment in TYNDP, answering an expected growth in offshore wind and nuclear generation in and around Norfolk and East Anglia, above what was anticipated for the TYNDP 2010.		
	69.A40	Norwich Main (GB)	Bramford (GB)	Norfolk Offshore Wind: NORW – BRFO Tee-in to Lowestoft.	1,800 MW										planned	2015 / 16	New investment in TYNDP, answering an expected growth in offshore wind and nuclear generation in and around Norfolk and East Anglia, above what was anticipated for the TYNDP 2010.		
	69.A41	Walpole (GB)	Bramford (GB)	Reconductoring Norwich Main – Walpole and Bramford – Norwich Main.											under Construction	2015 / 2016	New investment in TYNDP, answering an expected growth in offshore wind and nuclear generation in and around Norfolk and East Anglia, above what was anticipated for the TYNDP 2010.		
70	70.405	Kristiansand (NO)	Rød (NO)	Voltage upgrading of an existing single circuit 300 kV OHL and a new section of OHL between Rød and Bamle. Total length: 175 km	700 MW										design & permitting	2014	Progresses as planned.		Market integration and RES integration.
	70.426	Kristiansand (NO)	Tjele (DK)	Skagerak 4: 4th HVDC connection between southern Norway and western Denmark, built in parallel with the existing 3 HVDC cables, new 700 MW including 230 km 500 kV DC subsea cable.											under construction	2014	Progresses as planned.		
71	71.427	Endrup (DK)	Eemshaven (NL)	COBRA: New single circuit HVDC connection between Jutland and the Netherlands via 350 km subsea cable. The DC voltage will be up to 320 kV and the capacity 600 – 700 MW.	700 MW										design & permitting	2016	Progresses as planned.		Cobra

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72	72.430	Revsing (DK)	Landerupgård (DK)	New 18 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.	950 MW			DK West and North DE							planned	2017	Progresses as planned.		The main purpose of the project is to integrate and transmit large scale wind power in DK West.
	72.435	Endrup (DK)	Revsing(DK)	Upgrade of 50 km double circuit 400 kV OHL to reach a capacity of approx. 2,000 MW.											design & permitting	2015	Earlier date of commissioning than initially expected caused by reprioritization of project. Also one of the substations has been changed: Endrup was replaced by Tjele.		
	72.436	Idomlund (DK)	Endrup (DK)	New 74 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.											under consideration	2018/2020	Envisaged route changed from Idomlund – Tjele to Idomlund – Endrup.		
73	73.432	Asvæsværket (DK)	Kyndbyværket (DK)	New 60 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.	>1,000 MW										design & permitting	2014	Progresses as planned.		The project will increase the stability of the DK eastern power system and allow for larger transmission and transit.
	73.433	Glentegård (DK)	Amagerværket & H.C. Ørstedværket (DK)	New 22 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.											planned	2016	Progresses as planned.		
74	74.443	Richborough (GB)	Zeebrugge (BE)	NEMO project: New DC sea link including 135 km of 250 kV DC subsea cable with 1,000 MW capacity.	>1,000 MW			Thames estuar							planned	2018	Investment delayed to 2018 due to authorization delays related to needed internal grid reinforcements.		Interconnection between UK and the mainland Europe (BE).
	74.449	Richborough (GB)	Canterbury (GB)	New 400 kV double circuit OHL and new 400 kV substation in Richborough.											planned	2019/2020	Progresses as planned.	The reinforcements shown here reflect initial options but are subject to consultation and review of other feasible options.	
	74.450	Sellindge (GB)	Dungeness (GB)	Reconductor Sellindge – Dungeness.											planned	2014/2015	The reconductoring of the Sellindge to Dungeness circuits (Project 450) remain as originally planned in the TYNDP 2010.		
75	75.444	Zomergem (BE)	Zeebrugge (BE)	New approx 50 km double circuit 380 kV (3,000 MVA for each circuit) between Zomergem and Zeebrugge to evacuate the locally (offshore) produced power line and allow connection of NEMO project to 380 kV grid.	1,500 MW										design & permitting	2014	Progresses as planned.	Stevin project	The project allows the connection of 2.3 GW of offshore wind production. It also allows onshore RES connection. This project enhances security of supply of Belgian coastal area and allows the NEMO connection.
	75.A28	Zeebrugge (BE)	offshore platform (BE)	2 offshore platforms connected to AC grid with underground cables including compensation.											planned	2016	New investment in TYNDP, resulting from recent studies demonstrating such a platform would be optimal for Belgian offshore wind offtake. Planning and implementation of the project depends on the evolution of Belgian legislation.	Belgian offshore platform	
76	76.A42	Pelham (GB)	Waltham Cross (GB)	Reconductor Pelham – Rye House – Waltham Cross.	7,600 MW			London area							design & permitting	2015/2016	New investment in TYNDP.	New projects in the London area, not previously reported in the TYNDP 2010. 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).	
	76.A43	Hackney (GB)	Waltham Cross (GB)	Uprate to 400 kV Hackney – Tottenham – Waltham Cross.											design & permitting	2015/2016	New investment in TYNDP.		
	76.A44	Hackney (GB)	St. John's Wood (GB)	New 400 kV St. John's Wood – Hackney double circuit.											design & permitting	2017/2018	New investment in TYNDP.		
	76.A45	Tilbury (GB)	Elstree (GB)	Uprate to 400 kV Tilbury – Warley – Elstree.											planned	2021/22	New investment in TYNDP.		
	76.A46	St. John's Wood (GB)	Wimbledon (GB)	New 400 kV St. John's Wood – Wimbledon cables.											design & permitting	2017/2018	New investment in TYNDP.		
	76.A47	West Weybridge (GB)	Beddington (GB)	Uprate to 400 kV West Weybridge – Chessington – Beddington.											planned	2017/2018	New investment in TYNDP.		

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77	77.452	Deeside (GB)	Hunterston (GB)	New 2,000 MW HVDC Link via 360 km 500 kV DC subsea cable on the west coast of the UK and new 400 kV substation in Deeside.	4,000 MW										design & permitting	2015/2016	Progresses as planned (still targeting the financial year 2015/2016).		This project facilitates the connection of RES and the connection of the remote Scottish Islands.
	77.453	Peterhead (GB)	Hawthorn Pit (GB)	New 2,000 MW HVDC Link via 365 km 500 kV DC subsea cable on the east coast of the UK and new 400 kV substation in Hawthorn Pit.											planned	2018/2019	Progresses as planned (still targeting the financial year 2018/2019).		
	77.454	Hawthorn Pit (GB)	Norton (GB)	Uprate to 400 kV Hawthorn Pit – Norton.											planned	2018/2019	Progresses as planned (still targeting the financial year 2018/2019).		
	77.456	Harker (GB)	Quernmore (GB)	Reconductor Harker – Hutton – Quernmore.											design & permitting	2014/2015	Progresses as planned (still targeting the financial year 2014/2015).		
	77.449a	Gravir (GB)	Beauly (GB)	Western Isles link. New 450 MW HVDC link, +/- 150 kV. Route length: 156 km (80 km subsea, 76 km onshore underground cable)											design & permitting	2015	The 2010 TYNDP showed commissioning scheduled for 2013. However the developers of the large western Isles wind farm projects which drive the need for the link, have experienced commercial delays. Commissioning of the link is therefore now projected for 2015.		
	77.450a	Kergord and Caithness (GB)	Blackhillock (GB)	The Moray Firth HVDC development – Shetland and Caithness links with offshore HVDC hub. Three ended HVDC link, 2 × 600 MW legs and common 1,200 MW leg. Total route length: 395 km											design & permitting	2016	Projected commissioning is now 2016. The 2010 TYNDP showed commissioning scheduled for 2014. At that time the concept was to include an offshore node in a subsea HVDC link that was planned from Shetland to the Scottish mainland. That link was being designed to connect the Viking Energy wind farm project on Shetland. The Shetland link was termed the Base Project and the node was referred to as Incremental Works. The node would receive a connection from Caithness in 2016 for the export of renewables from that region and would also offer the potential for connection of adjacent offshore wind farms. However, the Viking project suffered consenting delays, and so late in 2010 the Caithness to Moray HVDC link was re-designated as the Base Project into which the node would be incorporated. The achievable timetable for the Caithness leg with commissioning in 2016 then became the timetable for the investment.		
	77.451a	Dounreay (GB)	Beauly (GB)	String a second 275 kV OHL circuit on existing towers.											under construction	2012	Progresses as planned.		
	77.452a	Beauly (GB)	Kintore (GB)	Reconductor existing 275 kV overhead line route.											design & permitting	2014	Progresses as planned (still targeting the financial year 2014/2015).		
	77.453a	Blackhillock (GB)	Kincardine (GB)	Reinsulate existing 275 kV route for 400 kV operation and establish three new 400 kV substations en route.											design & permitting	2016	Scheduled completion in 2016 is one year later than foreseen in the 2010 TYNDP. The north of Scotland transmission system is significantly depleted by construction outages to accommodate the main Beauly – Denny rebuild by 2014. The system access that is available for this investment (453a) to accommodate a build-up of renewable generation leads to the revised completion date in 2016.		
	77.455	Beauly (GB)	Denny (GB)	New double circuit 400 kV OHL (220 km) with new terminal substations and substation extensions en route.											under construction	2014	Progresses as planned.		
	77.457	Harker (GB)	Stella West (GB)	New 400 kV series and shunt compensation at a number of locations across the Anglo-Scottish border.											design & permitting	2014/2015	Progresses as planned.		

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78	78.458	Hinkley (GB)	Seabank (GB)	New 60 km double circuit 400 kV OHL	3,200 MW										design & permitting	2019/20	Seabank has been delayed by three years due to corresponding delays to the associated new nuclear project.		Project needed for renewables off of the South-west peninsula, the replanting of Hinkley Point nuclear power station and further CCGT at Seabank.
79	79.A48	Trawsfynydd (GB)	Treudyyn (GB)	Reconductor Trawsfynydd – Treuddyn.	1,700 MW										planned	2017/2018	New investment in the TYNDP, as it was mistakenly omitted from the TYNDP 2010 submission. It is necessary due to RES Integration in North Wales.		Reinforcement of the internal grid to integrate the additional flows from the RES generation.
	79.459	New Substation (GB)	Legacy – Shrewsbury Tee (GB)	New 400 kV double circuit OHL and new 400 kV substation in Mid-Wales.	880 MW										design & permitting	2016/2017	Progresses as planned (still targeting the financial year 2016/2017).	Investment needed to connect Mid-Wales wind farms	
	79.459b	Wylfa (GB)	Pembroke (GB)	New HVDC bipolar interconnection with possible offshore connection points at the Irish Sea offshore wind farm.	2,000 MW										planned	2020/21	Design Change – The design of the HVDC reinforcement circuit from Wylfa has changed from that in the TYNDP 2010 to now terminate at Pembroke instead of Mid-Wales. This has the potential to save some onshore consenting challenges. Additional benefits may be realized by coordinating the development of the offshore transmission assets with that of the onshore system. The location of the Wylfa HVDC termination may yet move offshore to be located closer to the wind turbines. The expected commissioning date has remained at 2020.		
	79.460	Pentir (GB)	Trawsfynydd (GB)	Upgrade Pentir – Trawsfynydd to double circuit.	3,800 MW										planned	2016/2017	Slight delay in expected commissioning date.	Investment needed to accommodate new wind generation off Anglesey and nuclear replanting at Wylfa.	
	79.460b	Wylfa (GB)	Pentir (GB)	New 400 kV Wylfa – Pentir double circuit.	3,600 MW										planned	2017/2018	Progresses as planned (still targeting the financial year 2017/2018).	Investment needed to connect offshore wind and nuclear.	
80	80.461	Woodland (IE)	Deeside (GB)	A new 260 km HVDC (200 kV DC) underground and subsea connection between Ireland and Britain with 500 MW capacity. On the Irish side, a 45 km direct current underground cable will be built to the Woodland substation where the VSC converter station will be placed.	500 MW			Island of Ireland							under construction	2012	Investment still on schedule for 2012, with less than 1 year delay.		This medium term project will establish 500 MW interconnection capacity between Ireland and GB.
81	81.462	Woodland (IE)	Turleenan (NI)	A new 140 km single circuit 400 kV 1,500 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.	600 MW			NE Ireland							design & permitting	2016	Project delayed due to permitting process in both jurisdictions. The intermediate station Moyhill is deferred pending outcome of future load growth.		This medium term project will increase transfer capacity between Ireland and Northern Ireland to improve security of supply and facilitate Single Market development.
82	82.470	Bellacorick (IE)	Cashla or Flagford (IE)	New 130 km single circuit 400 kV OHL from Northwest Mayo to the EHV system.	650 MW										design & permitting	2019	Investment technical description and commissioning date are now defined, and status changed to "design and permitting".		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.
	82.A37	tbd (NI)	Tunes Wind (NI)	North coast offshore wind farm. Multiple connection options are under consideration.	300 MW										under consideration	2020	New investment in TYNDP.		
	82.463	tbd (IE)	tbd (NI)	Strengthening of EHV networks (partial uprate and new) into Donegal and north and west of Northern Ireland and enhanced links between the two countries. Various technologies are being considered.	1,500–2,000 MW										under consideration	2020	New investment in TYNDP.		

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Project identification					Project assessment														
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83	83.467	Moneypoint (IE)	Kilpaddoge (IE)	A new 10 km single circuit 220 kV 500 MVA (underground + subsea) cable constructed across the River Shannon Estuary from Moneypoint in Co. Clare to Tarbert or a new Kilpaddoge station in Co. Kerry. A new 400/220 kV transformer at Moneypoint station is included in this project.	1,500 – 2,000 MW										design & permitting	2014	Project delayed by 2 years because awaiting the completion of the Moneypoint 400 kV station redevelopment works to facilitate the new connection, and a delay due to foreshore permitting arising from a change in one of the connection points (from Tarbert to Kilpaddoge).		The infrastructure development is required to facilitate connection of renewables in the south of the Island. The project will also facilitate new interconnection connecting to the grid in the south.
	83.468	Moneypoint (IE)	North Kerry (IE)	A new 27 km 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.											design & permitting	2019	Investment technical description and commissioning date are now defined and status changed to "design and permitting".	Increased capacity between the southwest and the midwest regions.	
	83.469	Knockraha (IE)	Dunstown (IE)	A new 250 km single circuit 400 kV OHL from Cork to the east, with one intermediary station in the southeast.											design & permitting	2020	Investment technical description and commissioning date are now defined and status changed to "design and permitting".	Increased capacity between Knockraha in the southwest and Dunstown in the mideast regions. The project will also facilitate future interconnection.	
84	84.471	Maynooth (IE)	Woodland (IE)	A new 25 km single circuit 400 kV OHL from Woodland 400 kV station to a new 400 kV station near or at Maynooth 220 kV station. The project may involve upgrading existing 220 kV circuits to 400 kV or utilizing the route.	1,500 – 2,000 MW			Dublin area							under consideration	>2020	TYNDP 2010 investment 471 now presented in two parts (471 and IE2).		This project will provide a high capacity path around Dublin improving security of supply to the city and operability of the Dublin network.
	84.A31	Finglas / Huntstown (IE)	Woodland (IE)	A new 25 km 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.											under consideration	>2020	New investment in TYNDP to avoid overloads in Dublin City network and to ensure supply to north Dublin City load.		
	84.A32	Dunstown (IE)	Maynooth (IE)	A new 40 km single circuit 400 kV OHL circuit from Dunstown 400 kV station to a new 400 kV station in the vicinity of Maynooth 220 kV station.											under consideration	>2020	New investment in TYNDP to avoid overloads in Dublin City network, split out from TYNDP 2010 investment 471.		
	84.A33	Carrickmines (IE)	Dunstown (IE)	A new 45 km single circuit 400 kV OHL from Dunstown 400 kV station to a new 400 kV station in the vicinity of Carrickmines 220 kV station.											under consideration	>2020	New investment in TYNDP to avoid overloads in Dublin City network.		
86	86.A49	Keadby (GB)	Grimsby West (GB)	KEAD – KILL KILL – SHBA KEAD – GRIW circuit uprate.	5,200 MW										under consideration	long term	New investment in TYNDP.	These investments are required due to unprecedented volumes of offshore wind generation connection requests.	This projects helps accommodate new offshore RES generation in the North Sea .
	86.A50	under consideration (GB East Coast)	under consideration (GB East Coast)	Connection of Triton Knoll, Doggerbank & Hornsea GB Wind Farms and all associated works.											under consideration	long term	This investment groups former 424b, 424c, 424d, 424e, 424f, 424g, 424h and 424i investments of TYNDP 2010. The group of projects on the east coast of Great Britain has been removed as work is in progress to optimize the onshore / offshore coordination and reduce potential consenting issues. Given the potential for more than 20 GW of renewable offshore generation capacity in UK waters on the East Coast it is expected that multiple connection sites will be required together with suitable circuit capacity, both onshore and offshore.		
88	88.A23	offshore wind farms (FR)	several French substations (FR)	Subsea cables and substations works.	3,000 MW (MT) 6,000 MW (LT)										planned	2015 – 2020	New investment in TYNDP, required to connect offshore wind farms as decided by the French government in 2010.	Project development will adapt to the pace of generation installation.	Connection of 6 GW offshore wind farms in 2 phases. First 3 GW phase in progress (tender).
89	89.A24	Calan (FR)	Plaine-Haute (FR)	New 80 km double circuit 220 kV underground cable with 2 phase shifters and T-connection of an existing HV substation. 1,150 MVAR of capacitors and SVC. New transformer 400/220 kV	500 MW			Brittany area							design & permitting	2017	New investment in TYNDP, required to secure Brittany's supply, along with DSM management plan and a new CCGT in Finistère area.		The project is needed to secure Brittany's supply.

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90	90.131	Bickigen (CH)		Addition of a second 400/220 kV transformer in an existing substation.	4,000 MW										design & permitting	2012	Progresses as planned.		This project increase the transfer capability between FR, DE, AT towards pump storage in CH.
	90.132	Mühleberg (CH)		Construction of a new 400/220 kV substation.											design & permitting	2015	Delays due to authorization process.		
	90.134	Bassecourt (CH)	Romanel (CH)	Construction of different new 400 kV line sections and voltage upgrade of existing 225 kV lines into 400 kV lines. Total length: 140 km											design & permitting	2015	Delays due to authorization process.		
	90.136	area of Bodensee (DE, AT, CH)		Construction of new lines, extension of existing ones and erection of 400/220/110 kV substation. This project will increase the current power exchange capacity between the DE, AT and CH. The project is expected to increase NTC and improve the security of supply.											planned	long term	Progress as planned.		
	90.129	Beznau (CH)	Mettlen (CH)	Upgrade of the existing 65 km double circuit 220 kV OHL to 400 kV.											design & permitting	2015	Progresses as planned.		
	90.130	La Punt (CH)	Pradella / Ova Spin (CH)	Installation of the second circuit on existing towers of a double circuit 400 kV OHL (50 km).											planned	2017	Delays due to authorization process.		
	90.133	Bonaduz (CH)	Mettlen (CH)	Upgrade of the existing 180 km double circuit 220 kV OHL into 400 kV.											under consideration	2020	Progresses as planned.		
	90.44.170																	The investment contributes both to project 44 and project 90. For the technical description see project 44.	This project increase the transfer capability between FR, DE, AT towards pump storage in CH.
	90.44.172																	The investment contributes both to project 44 and project 90. For the technical description see project 44.	
	90.44.173																	The investment contributes both to project 44 and project 90. For the technical description see project 44.	
	90.44.176																	The investment contributes both to project 44 and project 90. For the technical description see project 44.	
	90.177	Goldshöfe (DE)	Bünzwangen (DE)	A new 380 kV OHL. Length: 45 km											under consideration	2020	Progresses as planned.	The investment contributes also to project 45.	
92	92.146	Aachen / Düren region (DE)	Lixhe (BE)	Connection between Germany and Belgium including new 100 km HVDC underground cable and extension of existing 380 kV substations. On Belgian side, new 380 kV circuit between Lixhe and Herderen and second 380 kV OHL in / out from Herderen to Lixhe. In Belgium, addition of 2 transformers 380/150 kV in Lixhe and in Limburg part.	1,000 MW			Northern Belgium							design & permitting	2017	Project entered design and permitting phase in 2011, technical description has been completed and expected date of commissioning is 2017.	Alegro Project	First Belgium – Germany interconnection. This project enhances security of supply of both BE and DE. This HVDC link in an AC grid brings flexibility and bidirectional power control allowing integration of RES in both countries. This project aims to be a demonstration for HVDC link integration in the AC meshed grid.

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93	93.413	Ørskog (NO)	Fardal (NO)	New 285 km single circuit 400 kV OHL.	2,250 MW			Southwest of Trondheim (county Møre and Romsdal)							under construction	2015	Investment delayed due to due to long permitting procedure.	The project is key to improve security of supply in Mid-Norway: Presently, for several N-1 contingencies, load might be disconnected. The project is also the pre-requisite to lift the ban on RES development in the whole area covered by the new line Ørskog – Fardal.	Security of supply for Mid-Norway (Møre and Romsdal mainly) and RES integration in western Norway.
	93.398A	under consideration (SE)		New shunt compensation of OHL.											under consideration	2015	New part of investment 398 in TYNDP 2010.	Investment 398 in TYNDP 2010 has been divided into 398A and 398B. 398B is described in project 104.	
	93.403	Scandinavia North (SE)	Scandinavia South (SE)	A joint Stattnett & Svenska Kraftnat study north-south reinforcement (AC or VSC), expected length: 400 – 500 km, under study.											under consideration	2025	Postponed after reprioritization of the project portfolio.		
	93.414	Fardal (NO)	Aurland (NO)	Voltage upgrading of existing single circuit 300 kV OHL Fardal – Aurland Extension of 413 – Ørskog – Fardal.											planned	2020	Investment postponed, especially because of long permitting processes.		
	93.417	Aura / Viklandet (NO)	Fåberg (NO)	Voltage upgrading of existing single circuit 300 kV OHL Aura / Viklandet – Fåberg.											under consideration	long term	Investment postponed, especially because of long permitting processes.		
	93.416	Klæbu (NO)	Aura / Viklandet (NO)	Voltage upgrading of existing single circuit 300 kV OHL Klæbu – Aura.											design & permitting	2018 (2016-2020)	Investment postponed, especially because of long permitting processes.		
94	94.139	Vierraden (DE)	Krajnik (PL)	Upgrade of existing 220 kV line Vierraden – Krajnik to double circuit 400 kV OHL.	>1,000 MW										design & permitting	long term	Expected date of commissioning was adjusted due to long permitting process and strong local public resistance.		PSTs: Control of the transits of power on the polish synchronous profile (increase of import capacity, increase of grid operation safety).
	94.A68	Krajnik (PL)		Upgrade 400 kV.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		
	94.A69	Mikułowa (PL)		Upgrade 400 kV.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		
	94.A70	Krajnik (PL)		New PST.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		
	94.A71	Mikułowa (PL)		New PST.											design & permitting	2014	New investment in the TYNDP, split out from investment 139.		
103	103.145	Niederrhein (DE)	Doetinchem (NL)	New 400 kV line double circuit DE-NL interconnection line. Length: 60 km	13,900 MW			NW part of Netherlands							design & permitting	>2013	Delays due to authorization process.		The project reinforces the Dutch grid to accommodate new conventional and renewable generation, to handle new flow patterns and to increase the interconnection capacity between DE and NL.
	103.438	Eemshaven (NL)	Diemen (NL)	New 175 – 200 km AC overhead line with capacity of 2 × 2,650 MVA of 380 kV.											design & permitting	2018	Delays due to authorization process.		
	103.439	Borssele (NL)	Geertruidenberg (NL)	New 100 – 130 km double circuit 380 kV OHL with 2 × 2,650 MVA capacity.											design & permitting	2016	Delays due to authorization process.		
	103.440	Maasvlakte (NL)	Beverwijk (NL)	New 380 kV double circuit mixed project (OHL + underground cable) including approximately 20 km of underground cable for 2,650 MVA. The cable sections are a pilot project. The total length of cable at 380 kV is frozen until more experience is gained.											under construction	2016	Delays due to authorization process.		
	103.441	Zwolle (NL)	Hengelo (NL)	Upgrade of the capacity of the existing 60 km double circuit 380 kV OHL to reach a capacity of 2 × 2,650 MVA.											under consideration	long term	Progresses as planned.		
	103.442	Krimpen aan de Ijssel (NL)	Maasbracht (NL)	Upgrade of the capacity of the existing 150 km double circuit 380 kV OHL to reach a capacity of 2 × 2,650 MVA.											under consideration	long term	Progresses as planned.		

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					Project identification / **Project assessment**														
104	104.398B	under consideration (SE)		New series compensation of OHL.	1,200 MW										under consideration	2015	Reprioritization of projects.	Investment 398 in TYNDP 2010 have been divided into 398A and 398B. 398A is described in project 93.	RES integration in Mid-Norway (Trøndelag and Nordland) and reinforcement of Swedish internal interconnections in order to facilitate wind power integration in northern Sweden.
	104.415	Namsos (NO)	Klæbu and Storeheia (NO)	New line and voltage upgrade of 286 km single circuit 400 kV OHL											design & permitting	2015	Delays due to authorization process.	New line and voltage upgrade to facilitate new wind power generation.	
	104.418	Nedre Røssåga (NO)	Namsos (NO)	Upgrade of 70 km single circuit 400 kV OHL.											design & permitting	2019	Investment postponed, especially because of long permitting processes.	Increased capacity between North and Mid-Norway. Facilitates RES integration.	
	104.420	Storheia (NO)	Orkdal / Trollheim (NO)	New 130 km single circuit 400 kV OHL.											design & permitting	2017 – 2020	Investment postponed due to long permitting procedure.	New line to facilitate wind power generation.	
	104.A59	Råbäcken (SE)	Letsi – Betåsen (SE)	New 55 km single circuit 400 kV OHL.											under consideration	2017	New investment in TYNDP. Will probably be postponed after 2020 due to later development of wind power in the area.		
	104.A51	Svartisen (NO)	Nedre Røssåga (NO)	New 116 km 400 kV OHL.											planned	2020	New investment in TYNDP.	New line to facilitate wind power generation.	
106	106.A34	tbd (IE)	tbd (GB)	A new HVDC subsea connection between Ireland and Great Britain.	700 – 1000 MW										under consideration	long term	New investment in TYNDP, conceptual, cost benefit analysis to be confirmed.		This project will increase interconnection capacity between Ireland and Great Britain.
107	107.A25	tbd (IE)	tbd (FR)	A new HVDC subsea connection between Ireland and France.	700 – 1000 MW										under consideration	long term	New investment in TYNDP, conceptual, cost benefit analysis to be confirmed.		This project will establish interconnection capacity between Ireland and France.
109	109.A35	Oriel (IE)	Oriel wind farm (IE)	Oriel offshore wind farm connecting to a new Oriel 220 kV station located on the Louth – Woodland 220 kV circuit.	330 MW										under consideration	2016	New investment in TYNDP, required to connect offshore wind.		This project will facilitate the connection of offshore wind.
	109.A36	Carrickmines (IE)	Kish Bank wind farm (IE)	Kish Bank offshore wind farm connecting to the existing Carrickmines 220 kV station.	364 MW										under consideration	2015	New investment in TYNDP, required to connect offshore wind.		
	109.A38	Northern Ireland (NI)	East Coast Offshore (IE)	“East Coast Offshore” wind farm connecting to a 275 kV station to be determined. Multiple connection options are under consideration.	300 – 600 MW										under consideration	2018	New investment in TYNDP, required to connect offshore wind.		
110	110.424	Kvilldal (NO)	tbd (GB)	A new 1,000 MW HVDC bipolar installation connecting western Norway and Great Britain via 800 km subsea cable. DC voltage is to be determined.	1,000 – 1,400 MW										design & permitting	2018 / 2021	Capacity revised. Investment postponed, especially because of long permitting processes.		Market integration. Facilitate RES integration in southern and western Norway and improve security of supply.

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	40	Avelin (FR) Mastaing (FR)		Installation of a 3rd busbar in Avelin (existing 400 kV substation) andreplacement of components to increase the ability to withstand short-circuit power. Connection of Mastaing (existing 400 kV substation) to existing 400 kV circuit between Avelin (FR) and Lonny (FR).											commissioned	commissioned	Commissioned.		
	41	Fruges, Sud-Aveyron, Marne-Sud, Somme (FR)	0	New 400 kV substations connected to existing 400 kV network and equipped with transformers to 220 kV or high voltage networks.											design & permitting	mid term	Project progress according to the plan.		
	58	Ensdorf (DE)	St. Avold (FR)	Change of conductors on the German part of this single circuit 220 kV line (9 km) and installation of a phase-shifter in Ensdorf (DE) 220 kV substation.											commissioned	commissioned	Commissioned.		
	168	Goldshöfe (DE)	Dellmensigen (DE)	Upgrade the line Goldshöfe – Dellmensigen from 220 kV to 380 kV. Line length: 114 km Included with the project : 3 × 380 kV substations, 2 transformers											under construction	2014	Investment 168 has been postponed to 2014 due to local resistance against the project in a specific area. The rest of the investment is ready.		
	168a	region South-West Bavaria (DE)		Upgrading the existing 220 kV OHL to 380 kV, length 100 km, and the extension of existing substations, erection of 380/110 kV-transformers.											cancelled	cancelled	The project was abandoned / was not seen necessary with the new set of projects in place. Note: in the previous TYNDP the status of the project was under consideration and not planned (printing mistake).		
	192	Hamburg / Krümmel (DE)	Schwerin (DE)	This 380 kV double circuit OHL project will close the missing gap in the northeastern German grid infrastructure. Only 65 km of new line must be constructed, 22 km already exist.											under construction	2012 / 2013	Commissioning delayed by complex permitting procedure. Line is partly constructed. Is expected to be commissioned in 2012 / 2013 short term.		
	198	Wuhlheide (DE)	Thyrow (DE)	Berlin South Ring: replacement of an existing old 220 kV double circuit OHL by a 380 kV double circuit OHL. Length: 50 km											cancelled	cancelled	Project was depending on the replacement of a CHP power plant based in Berlin. Due to a new general CHP concept the plant size could be adopted and the upgrade of the existing 220 kV connection to 380 kV was not necessary any longer. Project was given up with regard to the CHP plant investor.		
	397	Varangerbotn (NO)	Pirttikoski or Petäjäskoski (FI)	New single circuit 380 – 400 kV OHL (500 km).											under consideration	2020 / 2025	Based on a common Statnett / Fingrid study conclusion from the more detailed study on the project that is can be postponed beyond 2021. The need is related to the oil / refinery and wind development on the northern Norway		
	407	Tonstad (NO)	Arendal (NO)	Voltage upgrading of existing single circuit 400 kV OHL Tonstad – Solhom – Arendal.													This investment proposed as stand-alone in the TYNDP 2010 is now merged into investment 37.406. Its evolution is monitored there.		
	409	Feda, Tonstad (NO)		Reactive power devices in 400 kV substations.													This investment proposed as stand-alone in the TYNDP 2010 is now merged into investment 37.406. Its evolution is monitored there.		
	413a	Sima (NO)	Samnanger (NO)	New 420 kV line Sima – Samnanger to ensure security of supply in the region of Hordaland/ Bergen, and to integrate new hydro power.											under construction	2013 / 2014	Project going according to the plan.		
	419	Namsos (NO)	Storheia (NO)	New 119 km 800 MVA single circuit Namsos – Roan – Storheia OHL to connect new wind power generation at Fosen.											under construction	2015	This projects is now embedded in the investment 104.415.		

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	456c	Quernmore (GB)	Padiham (GB)	New 400 kV double circuit.											canceled	cancelled	Both projects were originally proposed in TYNDP 2010 to accommodate expected new nuclear build in the area and to reinforce the local system. Since that time there has been changes to the generation background and changes anticipated system flows, therefore these new circuits are no long thought to be required.		
	465	Laois – Kilkenny (IE)		A new 500 MVA 400/110 kV substation connected into the Moneypoint – Dunstown 400 kV line and the Athy – Portlaoise 110 kV line and with two 400/110 kV 250 MVA transformers. This project also comprises a new 110 kV line from Loughteeog to Ballyragget 38 kV station and upgrading of Ballyragget station and the Ballyragget – Kilkenny 38 kV line from 38 kV to 110 kV substation.											design & permitting	2014	Progress according to the plan.		
	431	Tjele (DK)	Trige (DK)	New 46 km single circuit 400 kV line via cable with capacity of approx. 1,200 MW.											Planned	long term	Investment moved to longer time horizon.		
	203	area Wolmirstedt (DE)	under consideration	Support of RES and conventional generation integration, maintaining of security of supply and support of market development.											under consideration	2020	Included in new investment H3 due to new wind BS generation.		
	456b	Harker(GB)	Quernmore(GB)	New 400 kV double circuit.											cancelled	cancelled	Both projects were originally proposed in TYNDP 2010 to accommodate expected new nuclear build in the area and to reinforce the local system. Since that time there has been changes to the generation background and changes anticipated system flows, therefore these new circuits are no long thought to be required.		
	451	Rowdown (GB)		New 400 kV quadboosters.											cancelled	cancelled	The installation of new quad-boosters at Rowdown is no longer deemed necessary due to a change in strategy, with the other developments in and around London meeting the system requirements, as described in Cluster 105.		
	429	Ferslev (DK)	Vester Hassing (DK)	New 20 km single circuit 400 kV line via a cable with a capacity of approx. 800 MW.											planned	2018	No change.		
	180	Mengede (DE)	Kruckel (DE)	Installation of a second circuit 380 kV OHL and extension of existing substations. Line length: 16 km.											design & permitting	mid term	Project develops according ot the plan.		
	52	Feuillane (FR)	Realtor (FR)	Operation at 400 kV of existing 63 km double circuit OHL previously operated at 220 kV, creation of a new 400 kV substation and restructuring of the existing 220 kV local network.											under construction	2012	To be commissioned by end of 2012. Delays due to longer than expected authorization process.		
	61	Moulaine (FR)	Belval (LU)	Connection of SOTEL (industrial grid in LU) to RTE network by mixed (underground cable & OHL) single circuit 220 kV line. Parts of the new line use existing ones.											under construction	short term	Commissioned in 2010 for the FR part, the LU part is still pending.		
	143	Kassö (DK) Ensted (DK)		Installation of two PSTs. This step includes also planed strengthening of existing 380 kV lines in the grid of TenneT.eu and Energinet.dk.											commissioned	commissioned	Commissioned.		
	39	Avelin (FR)	Warande (FR)	Reconductoring (with ACSS) of both circuits of existing 400 kV OHL between Avelin, Weppes and Warande. Total length: 85 km											commissioned	commissioned	Commissioned in 2010.		
	43	Mandarins (FR)		Replacement of thyristors in the AC/DC substation (IFA 2000 interconnector, DC voltage 270 kV).											commissioned	commissioned	Currently under final tests. Will be commissioned in Summer 2012.		
	47	Tamareau (FR)	Tavel (FR)	Reconductoring with ACCS of both circuits of existing 92 km double circuit 400 kV OHL to increase its capacity.											commissioned	commissioned	Currently under final tests; will be commissioned in Summer 2012.		

Table of projects – Regional Group North Sea

Project identification					Project assessment														
Project number	**Investment number**	**Substation 1**	**Substation 2**	**Brief technical description**	**Grid transfer capacity increase**	**Socio-economic welfare**	**RES integration**	**Improved security of supply**	**Losses variation**	**CO_2 mitigation**	**Technical resilience**	**Flexibility**	**Social and environ-mental impact**	**Project costs**	**Present status**	**Expected date of commissioning**	**Evolution compared to the TYNDP 2010 situation**	**Investment comment**	**Project comment**
	49	Cantegrit (FR)	Mouguerre (FR)	Reconductoring (with ACSS) of existing 83 km single circuit 220 kV OHL to increase its capacity.											commissioned	commissioned	Commissioned in 2011.		
	50	Néoules (FR)	Broc-Carros (FR)	The second circuit (formerly operated at 220 kV) of a 197 km double circuit 400 kV OHL will be operated at 400 kV and 400/225 autotransformers installed in relevant substations.											commissioned	commissioned	Commissioned in 2010.		
	56	Camporosso (IT)		New 450 MVA PST in Camporosso (IT) 220 kV substation on Camporosso (IT) – Menton (FR) – Trinité-Victor (FR) OHL.											under construction	2012	Will be commissioned in 2012.		
	59	Moulaine (FR)	Aubange (BE)	Installation of a second circuit on the existing 220 kV cross-border OHL											commissioned	commissioned	Commissioned in 2010.		
	169	Großgartach (DE)		Upgrade the substation for a higher short circuit capacity. New installation includes 10 gas insulated bays, 63 kA, 3 busbars and 2 transformers.											commissioned	commissioned	Commissioned.		
	201	Bärwalde (DE)	Schmölln (DE)	New internal double circuit 380 kV line connecting the substations St. Peter and Salzach neu (replacement of the existing 220 kV line). Length: 46 km											design & permitting	2014	Delays due to authorization process.		
	196	wind farm Baltic 1 (DE)	Bentwisch (DE)	Connection of the offshore wind farm Baltic 1 (AC-cables on transmission voltage level).											commissioned	commissioned	Commissioned.		
	210	substations in 50Hertz Transmission control area		Construction of new 380/110 kV substations.											commissioned	commissioned	Freiberg and Stendal / West are commissioned. The remaining substations were transferred to the 44.209 investment.		
	410	Kristiansand (NO)		Spare transformer for the HVDC Skagerak interconnection transformer.											under construction	2012	Will be commissioned 2012.		
	434	Fraugde (DK)	Herslev(DK)	New single circuit HVDC-LCC installation including a 56 km 450 kV DC subsea cable with 600 MW capacity.											commissioned	commissioned	Commissioned September 2010.		
	437	Grain (GB)	Maasvlakte (NL)	New 1,000 MW HVDC bipolar installation including 260 km of 450 kV DC subsea cable											commissioned	commissioned	The BritNed HVDC interconnection between Grain (UK) and Maasvlakte (NL) was commis-sioned in 2011 and is now operational providing 1,000 MW capability between the two countries.		
	464	Moyhill (IE)	Woodland (IE)	This element of the interconnection project between Ireland and Northern Ireland is cancelled. Previously, the Turleenan – Woodland circuit consisted of a Moyhill – Turleenan and a Moyhill – Woodland circuit. However the planning application for the Moyhill station has been deferred.											cancelled	cancelled	In TYNDP 2010 the Turleenan – Moyhill – Woodland 400 kV circuit was described by two separate investments: – 462 (Turleenan to Moyhill) and – 464 (Moyhill to Woodland). Since then plans for Moyhill have been deferred. The project is now Turleenan – Woodland 400 kV, described in the table by investment 462 and 464 (Project #110 / Boundary #49).		
	466	Flagford (IE)	Srananagh (IE)	The construction of a new 55 km single circuit 220 kV line connecting the existing Flagford 220/100 kV station to a new Srananagh 220/110 kV station.											commissioned	commissioned	This investment is expected to be completed by the time TYNDP 2012 – 2022 is published		
	448	Thames estuary (GB)		Double circuit 400 kV line upgrade around the Thames estuary.											cancelled	cancelled	With changes in the scenario backgrounds, the initially proposed new 400 kV circuit around the Thames Estuary is no longer deemed necessary compared with the TYNDP 2010 assessment.		
	A61	Samnanger (NO)	Sauda (NO)	Voltage upgrade of existing 300 kV line.											under consideration	2021	New project.		

12.2 Appendix B: Example of Market Study Results

This appendix presents some examples of the projected exchanges across the HVDC subsea interconnectors that form part of the main power corridors in the North Sea Region. These results were calculated as part of the market studies and based on the EU2020 Scenario and 2020 transfer capacities between countries (which, for clarity, does not include Kriegers Flak, IE-GB2 and IE-FR but does include NorNed 2 even though it is now no longer expected to be constructed in this period).

In each graph, the X-axis represents the number of hours in the year, while the Y-axis represents the expected utilization of the available interconnectors across each boundary. In this way a curve that flattens out at maximum capacity (i.e. +100% or -100%) indicates that for a number of hours, the interconnectors across that boundary are running at full import or export.

It does not necessarily follow that additional interconnector capacity is justified in these cases as this is just one element of the investment decision and further detailed investigations would need to be carried out by the TSOs at each end to assess the need for additional cross-border capacity.

Between the island of Ireland and Great Britain

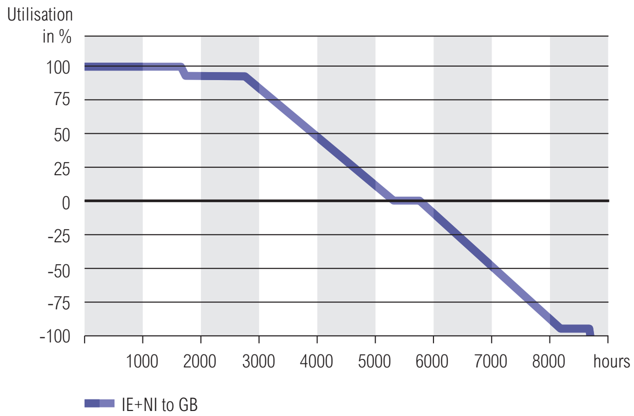

Figure 30:
Duration curves of market flows
Scenario EU 2020 / Grid 2020

Between Norway and Continental Europe plus Great Britain

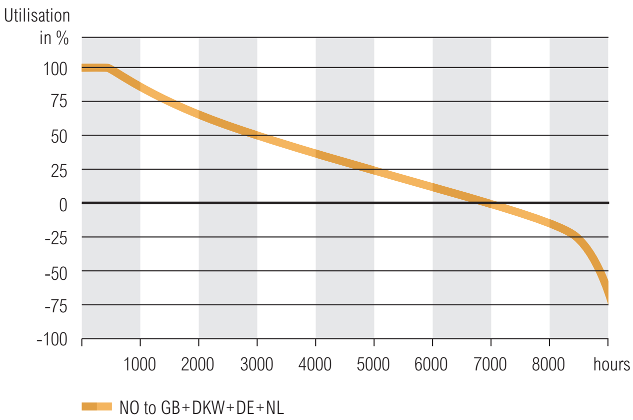

Figure 31:
Duration curves of market flows
Scenario EU 2020 / Grid 2020

Between Continental Europe and Great Britain

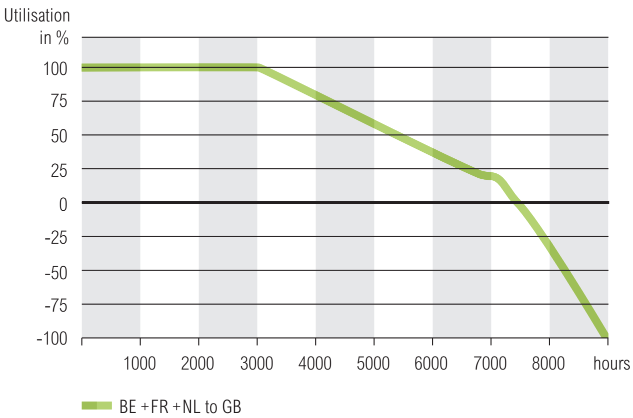

Figure 32:
Duration curves of market flows
Scenario EU 2020 / Grid 2020

12.3 Appendix C: Results of Grid Studies

Chapter 4 of this Regional Investment Plan describes the methodology used to detect the bottlenecks in the grid. Common grid studies were performed to assess 29 planning cases, namely critical and/or frequent situations. The selected 29 common planning cases allowed for the consideration of High loading of the AC interconnectors, High transit flows, High and low load, Multiple generation patterns, and Maximum flows in both directions on the DC interconnectors.

In these studies, the physical power flows are calculated for all the individual transmission assets (lines, transformers, etc), both within countries as well as cross-border connections. The analysis performed by the TSOs shows where the reliability criteria are not met. Grid extensions can then be studied and proposed. Detailed information on the methodology can also be found in ENTSO-E's planning standards.

The following paragraph gives a short overview of their main results.

For **The Netherlands**, the security analysis showed that the Dutch grid is limited on three internal lines and one interconnector line (Krimpen ad IJssel – Geertruidenberg, Eindhoven – Maasbracht, lines towards Diemen and the interconnection Zandvliet – Kreekrak). The solutions for the bottlenecks, Krimpen ad IJssel – Geertruidenberg and Eindhoven – Maasbracht, will be solved by the upgrade of the Krimpen ad IJssel – Maasbracht line in Project 103. The congestion on the lines towards Diemen can be solved with a modification of the substation of Diemen which is already planned. The solution for the Zandvliet – Kreekrak congestion is found in the reinforcements in Belgium by installing an additional phase shifter in Zandvliet.

The technical analysis for **Belgium** shows that the Dutch-Belgian border is congested. Some further congestion occurs on the eastern axis for flows NL to BE, and both eastern and western axes for flows BE to NL. A short-term counter-measure is to limit the cross-border flow by using the PSTs, but this will lead to a higher flow across Germany and France, and requires good coordination with neighboring TSOs. Regardless, a number of investments (reinforcement of the 380 kV grid between Gramme and Van Eyck (BE), the Brabo project to strengthen the Antwerp 380 kV grid), the reinforcement of the 380 kV Mercator – Doel - Horta axis and the installation of an additional phase shifter in Zandvliet) will make it possible to bear these high power flows.

The France-Belgium border is often highly overloaded. The main overload is on the Avelin-Avelgem line, with some overloads further into the Belgian grid. In the direction Belgium to France, overloads occur when a combination of factors is present. The best solution to solve this bottleneck is currently under technical study and cost-benefits analysis.

The study demonstrated that the new interconnector operated between **Luxembourg** and Belgium could experience high power flows of the same magnitude in both directions – up to 180% loading in some cases due to loop flows. New high level evaluations concerted at a regional perimeter with all adjacent TSOs pointed out possible reduction of overloading by a reinforced solution with more 220 kV interconnection lines controlled by phase shift transformers or an upgrade of the interconnection through Luxembourg to a 400 kV level

The **German** TSOs have performed common grid calculations for the horizon year 2020 to develop the necessary (internal) grid reinforcements. For the interconnector projects the grid calculations were carried out together with partner TSOs within feasibility studies. The German projects/ investments of European significance are included in the TYNDP/RgIP 2012.

Studies for **France** included six of the common planning cases. N-1 contingency analysis was performed on the 400 kV network. Simulations results confirm the congestion on the Belgium-France border in N-1 operation. In addition, stresses on the French grid and the French-German border appear from 4.5 GW flow from France to Germany. The French and German TSOs are currently conducting a joint investigation for a more detailed assessment of congestion and the potential need for additional investment.

Ireland and **Northern Ireland** examined a number of the 29 common planning cases where import and export flows on the interconnectors between the island and Great Britain were maximized. Many of the planning cases exhibited wind generation curtailment in Ireland and Northern Ireland due to a lack of interconnection capacity. N-1 security analysis in AC load flow indicated no thermal violations.

Because of the wind curtailment, a second market study was undertaken to include two additional 700 MW interconnectors; one to France and one to Great Britain. Wind curtailment was reduced resulting in more significant levels of imports and exports. A study examined all 8760 hourly dispatch scenarios in AC loadflow. N-1 security analysis indicated no thermal violations of the onshore grid with these additional interconnectors in place.

The studies demonstrated that the network as planned and outlined in the TYNDP 2012 will have adequate capacity based on the assumed generation portfolio, network developments and the additional interconnection. The studies also indicated that there may be a need for new reactive compensation on the system by 2020. Future studies are planned to identify such reactive power requirements.

Technical studies for **Great Britain** considered the common planning cases and additional regional sensitivities, representing typical summer through to winter peak scenarios. The planning cases selected represent a wide range of operating conditions and test the transmission system against the full operating range of the interconnectors chosen to be in service for 2020. In addition to the interconnector sensitivities the cases assume a range of generation operation including high wind farm output, high wind and nuclear output, and Low wind and high nuclear and CCGT output.

The analysis highlighted high North to South power flows in the central Great Britain system from high wind output cases. Some overloading was present for N-1 and N-D conditions, particularly on the Anglo - Scottish circuits. Circuits were stressed around North and East London under high demand and interconnector export. Generation growth around North Wales and the South West peninsula requires additional circuit capacity as indentified in the TYNDP table of projects.

Due to all the planned HVDC links to Europe in 2020 (the market studies frequently indicated either full export or full import), the **Norwegian** grid will experience high bulk power flows in the AC network, especially in the South of Norway close to the interconnectors' landing points. This is due to the fact that most reservoir plants will react to the same price signal. Southern Norway will also be a possible transit area for exchange between the Nordic region and the continental Europe. Assessments of system operations must therefore be made beyond southern Norway, although the impact on the grid will be greatest near the landing points.

The transmission system in **Denmark** is located between the thermal- and wind-power based continental European transmission system to the South and the hydro-power based Scandinavian system in the North. These two regions experience different market prices, thus, the Danish transmission system can be subject to significant power flow between these two areas.

Additionally, the system is comprised of two synchronous systems that operate with differing market prices, which introduces complexity to internal power transfer through the Danish system. Nevertheless, the total power transfers through this system are strictly northwards or southwards, that is, following price differences between North Europe and Scandinavia, with no loop-flows at the Danish AC system borders, like they can be observed at other borders in the region.

Studies of the **Danish** TSO executed have shown that keeping the net transfer capacity (NTC) might be challenged at the AC system borders during periods of significant power transports and either a simultaneous outage of a domestic production unit or a HVDC link connection. The studies comprised the 27 common RG NS planning cases as well as 9 specific Danish planning cases. These 9 specific planning cases were selected among the dispatches of the market.

The results did not show any problems at the Danish AC borders under normal operation conditions and no constraints on the internal Danish AC lines or transformers were found during N-1 contingency analysis applying the planning cases described above. Anyhow, during some of the N-1 contingencies, it emerged that securing the agreed NTC at the AC borders to Germany and to Sweden might require attention, because they might be exceeded – by 41 % at the border to Sweden and by 24 % at the border to Germany. This is not in any case also a physical overload, assuming the contingency is mitigated fast enough. Further investigations together with the neighbors will be executed in bilateral cooperation. The focus of these investigations will be (n-1)-security and system stability.

12.4 Appendix E: Project Details

The following table provides some details of the projects relating to the North Sea Region that are described in Chapter 7 and listed in Appendix 1.

Project.	Description
17	Major reinforcements are required in order to accommodate larger and more volatile North South power flows from Normandy to Champagne, triggered especially by the development of both conventional and RES generation (along the Channel costs, from Picardie to Champagne and further north abroad) that would natraly flow to large consumption areas from Brittany, Paris area to Reims. It includes the mid-term Cotentin Maine investment 2012/13), and, in the long term (2018/20), the recon-ductoring of the 54-km 400kV OHL Le Havre-Rougemontier , erection of a 400-kV underground line between Cergy an Terrier (in Paris area) and the reconstruction of the existing 70 km 400-kV single circuit OHL Lonny-Vesle as double circuit OHL. In addtition, a new reinforcement between Haute normandie and South of Paris is un-der consideration.
23	France-Belgium interconnection development under consideration. A prerequisite to maintain the current NTC is, the internal reinforcement of the French grid .The exist-ing 400 kV **Gavrelle-Avelin** single circuit OHL will be substituted by a double-circuit 400-kV OHL,, associated with the operation upgrade of **Avelin-Mastaing** from 225 kV to 400 kVThis project also improves the security of supply and RES in-tegration.
24	The reinforcement of the 380 kV grid between **Gramme** and **Van Eyck** (BE) con-sists of a second 380 kV circuit and a fully-equipped 380 kV substation in Van Eyck. The project is scheduled for completion in 2014 and is required to cope with the evolution of international transit flows. It will increase the potential connection of central units in the provinces of Limburg and Liège. **BRABO** (2017) – consideration is also being given for a new double-circuit 380 kV line between Zandvliet and Lillo and later from Lillo to Kallo and Mercator - will im-prove security of supply to the Antwerp harbour area, enable connection of new generating units and will increase Belgian import capacity. A number of longer-term investments will complement these including the rein-forcement of the 380 kV **Mercator – Doel - Horta** axis (using high performance conductors, planned between 2016 and 2020) and the installation of an additional phase shifter in **Zandvliet** (planned between 2016 and 2020). They enable to se-cure and increase the exchange capacity at the Northern border. Additionally, a sec-ond 380 kV circuit between **Meerhout** and **Massenhoven** will be necessary if a power plant (1000 MW) is connected in Meerhout.
25	**IFA2** – A new 1000 MW DC France–GB interconnector between France and Great Britain is progressing further. A seabed survey is being investigated. Commission-ing is planned for around 2020.
36	**Kriegers Flak CGS** is considered to be a pilot project to build, utilise and demon-strate a multi-vendor, multi-terminal HVDC VSC offshore system interconnecting different countries and integrating offshore wind power. This will be a full-scale prototype of future European HVDC super grids, e.g. offshore transmission systems in North Sea and Baltic Sea, placing the Kriegers Flak CGS among the projects of Pan-European significance and has been awarded a grant from the EEPR. In future, Sweden may join the Kriegers Flak CGS project.

37	**Nord.Link/NorGer** - A HVDC link approximately 1000-1400 MW is planned from Norway to Germany. It will bring the Nordic and the German power markets closer together. The interconnector will make German wind power more accessible for Norway and in return, the Norwegian hydropower with regulative ability will be available for the German market. The commissioning date is planned to be in the period 2018-2021. All planned HVDC interconnectors to Norway require substantial internal AC grid reinforcements. These are primarily related to voltage upgrades from 300 kV to 420 kV in the south of Norway.
38	**NorNed2** is now unlikely to be realised during this planning period but is included in the TYNDP calculations and therefore on the project list. NorNed 2 is not included in the current Norwegian national grid development plan..
39	The upgrading of the 400 kV back-bone transmission system in Denmark West and the 400 kV connections to Germany, when commissioned in 2017, will increase the grid transfer capacity from **Denmark West** to **Germany** by 1000 MW and from DE to DK-W by 1550 MW. The projects involve transmission system upgrades in the two countries and have regional importance for integration of wind power in DK and northern DE, improving security of supply and improving integration of the market for electricity.
40	This project will reinforce the internal network of **Luxembourg** to improve security of supply but also to cater for expected loop-flows through its system. In the medium-term this will involve reinforcement of the internal grid by closing a 220 kV mesh around the capital of Luxembourg town and maximizing usage of existing 220 kV infrastructure by the installation of a phase shift transformer. In the longer-term, an additional double circuit line will be built between Bascharage (LU) and Aubange (BE) at either 220 kV or 400 kV.

41 - 45	Due to increasing RES generation meeting the goals of European, particularly in Germany, new connections between areas with high installed capacities of RES and areas with high consumption and storage capabilities are necessary. For this reason the development of new North-South and northeast-southwest electricity transmission capacity in Germany is necessary. For the mid-term time horizon the necessary grid development in Germany is covered by common projects in the western and eastern corridors. The German West corridor starts in the North-West of Germany, an area with high surplus of RES production (planned and existing) and connections with Scandinavia (planned and existing). It continues to the Rhine-Ruhr area (high consumption and a large amount of a conventional power generation). The German East corridor begins in the North-East of Germany, an area with high RES generation (planned and existing), conventional generation and connections with Scandinavia (planned and existing). Both corridors end in the South of Germany, an area with high consumptions and connections to Austria and Switzerland (for transit to Italy and pumped storage in the Alps). In additional to the mid-term projects German West and East Corridor, for the long term time horizon the foreseen RES generation (especially wind) in northern Germany, the increasing geographical imbalance between generation and consumption, as well as the long distances separating generation and consumption regions would require additional grid extension inside Germany. The needs for transportation over long distances as well as the need to improve grid stability regarding dynamic and static voltage play favour HVDC technology. For this reason, the German TSOs are a considering several DC-connections, allowing the North–South and Northeast–Southwest power flows and enhancing the grid stability. Due to the significant change of the German energy scenarios and policies (finalized in December 2011) and the upcoming grid development plan 2012 (NEP) modifications / additions in the project planning are expected. There are two major projects planned for the North of Germany, to connect and evacuate up to 10 GW of offshore wind generation.
69	A new project planned to accommodate the expected growth in offshore wind and nuclear generation around **Norfolk/East Anglia (GB),** including a new 400kV double circuit between Bramford and Twinstead and the connection of the Norfolk offshore wind.
70	**Skagerrak 4** – a 700 MW VSC-HVDC link between Denmark West and Norway, expected to be commissioned in 2014. This is the fourth interconnector between these two systems and will increase the current transfer capacity between the countries from 1000 to 1700MW, increase market and energy coupling between the Continental and Scandinavian systems, allow increased RES integration and greater diversity of supply by creating a connection from a hydro to a thermal power system.
71	**COBRA** – a 700 MW HVDC 320 kV link between Denmark West and the Netherlands is expected to be brought into commercial operation by 2016, The project will investigate the possibility to connect new offshore wind farms to the cable, which could be the first step towards a North sea offshore grid. Regardless, it will allow for the exchange and integration of wind energy and increase the value of RES in the Dutch and Danish power systems and increase security of supply in both countries. It has been awarded a grant from the EEPR.

72	**Denmark West** 400 kV transmission system upgrade. When completed in 2020, the project will increase GTC by 950 MW, improve security of supply and provide better integration of the electricity market allowing for larger power transport between the Continental and Scandinavian systems via Denmark, providing grid-connection access of future Danish offshore wind power plants in the North Sea to the Danish transmission system.
73	**The Zealand system upgrade** will establish new 400 kV cable connections to increase the security of supply and eliminate congestion risks in Denmark East. It is a pre-requisite to grid-connection of the offshore wind turbines at Kriegers Flak to the east Danish system.
74	**Nemo** - Elia and National Grid are considering the construction of an interconnector (1000 MW, bidirectional) based on the HVDC technology, which connects to Zeebrugge (BE) and Richborough (GB). This new interconnection could be connected in Belgium to the 380 kV network through the Stevin-project which extends the 380 kV grid to the Belgian coast to evacuate offshore wind by the end of 2014. The new interconnection could be achieved by 2018. The upgrade of the southeast transmission system of GB involves the addition of a new 400 kV circuit route from Canterbury to Richborough and the reconductoring of the Dungeness to Sellindge circuits. It is required to facilitate flows over the new BritNed interconnector and the planned Nemo interconnector between BE and GB.
75	**Stevin** - in order to connect approximately 2160 MW wind farms in the North Sea close to Belgium, a new double-circuit 380 kV line is necessary between the shore and the existing 380 kV grid. This onshore development could be prolonged by an optimized offshore grid made of two offshore platforms belonging to the meshed transmission system. Investigations have proven that it would be more cost effective, less environmental intrusive and more redundant. Legal and regulatory frameworks have to evolve to make it happen.
76	The upgrading of three main 275 kV circuit routes into **London** to 400kV and the rating upgrade of existing circuits are needed due to a combination of age related asset replacement, increasing power flows and changing customer demand connection requirements. One driver for these projects is that power flows through London increase during interconnector export to Europe as power feeds down from the north through London to the interconnectors near the Thames Estuary.
77	The **West Coast HVDC link** will significantly reinforce the grid between Scotland and England accommodating increasing RES generation in Scotland. A new 2000 MW HVDC offshore cable reinforcement along the West coast is on track for 2015 completion. A similar 2000 MW HVDC circuit along the East coast joining the SHETL transmission system to England is expected for completion in 2018 (the **East Coast HVDC link**). Other works involve reinforcement of the areas around the HVDC circuit connection points and replacement of the conductors from Harker to Hutton and Quernmore to permit higher currents and the insertion of series compensation on the longer circuit sections to improve system stability limits.
78	The requirement for the new **Hinkley Point–Seabank** circuit (GB) remains unchanged from the 2010 TYNPD associated with the connection of new nuclear generation.
79	New generation around **North Wales** (GB) including replacement of nuclear plant and connection of new offshore wind generation is driving several reinforcement projects in the area. This includes a new 400kV circuit route and substation to connect new wind farms in mid Wales, expected 2016, a HVDC reinforcement circuit from Wylfa to Pembroke, expected 2020; and an upgrade of the Trawsfynydd to Treuden-T circuit with a larger conductor.

80	**The East West Interconnector** – a new 500 MW VSC-HVDC 200 kV interconnector between Woodland (IE) and Deeside (GB) is expected to be completed in the second half of 2012. It will double the existing interconnection capacity between the two islands, improve security of supply to the island of Ireland and allow for increased penetration of non-synchronous RES generation. It has been awarded a grant from the European Energy Program for Recovery (EEPR) of the European Commission.
81	The **North South 400 kV Interconnector** – a new 400 kV circuit between Ireland and Northern Ireland, expected to be commissioned in 2016, will strengthen the links between the Ireland and Northern Ireland systems and facilitate the all-island single electricity market (SEM), the connection of renewable generation and increase the security of supply on the island in addition to removing market constraints, will improve the security of supply to the north east area of Ireland.
82	The **RIDP** and **Grid West 400 kV** investments are required to facilitate connection of renewable generation in the North West of the island of Ireland. EirGrid, SONI and NIE are carrying out a joint study to identify the best transmission solutions for the Donegal and Northern Ireland areas. Grid West provides a connection for a large cluster of wind farms in north Mayo (IE).
83	The **Grid Link** project and the Moneypoint to North Kerry projects are essential to facilitate the connection of RES and thermal generation in the South and South West of Ireland. When completed in 2019, Grid Link will also facilitate future interconnection connecting to the grid in the southeast of Ireland.
84	The **"Dublin Ring"** project (IE) consists of four new 400 kV circuits in a ring around the Dublin city to improve security of supply to the city, and to avoid overloads in the city network arising from new generation patterns.
86	**East Coast GB** – These investments are required to accommodate significant volumes of offshore wind expected to connect in this area. The projects will consist of multiple offshore HVDC and AC circuits and connecting offshore platforms to multiple onshore connection sites (and associated reinforcement requirements). Each stage of this RES development could be considered as a major project in its own right and will be interactive with neighboring projects, but at this time a definite design is not decided
88	**Offshore wind (FR)** – RTE is planning construction of several 220 kV cables and associated substation works to connect offshore wind farms to the main grid in France. 6 GW of offshore wind generation are included in the French NREAP, and a call for tenders is currently in progress for 3 GW.
89	**The Brittany "safety net" project** involves construction of a 100 km AC 220 kV cable between Calan and Plaine-Haute 400/225 substations, with two PSTs and T-connection of a 225 kV substation. This project will improve the security of supply of northern Brittany.
92	**ALEGRO** - 1000MW HVDC link between Germany and Belgium. Depending on further investigations and the development of technologies the capacity could be extended to about 1600 MW. In Belgium, the connection of the new BE-DE interconnection will be enabled by the construction of a second two-circuit 380 kV Lixhe-Herderen overhead line, the use of the second circuit of the existing line between the substations, the extension of the 380 kV station of Lixhe with two bus bars, and the installation of a transformer in Lixhe and in Zutendael (380/150kV).

103	The project consists of major investments in the **Dutch Grid,** including a new 380 kV double-circuit from Maasvlakte to Beverwijk (including 20 km of underground cable) and two new double circuit 380 kV AC overhead lines Eemshaven-Diemen and Borssele-Geertruidenberg connecting new generation to the Dutch central ring. Further, the upgrade of two existing 380 kV double circuit overhead lines is included. The project also comprises a new **Germany – Netherlands** interconnector between Doetinchem (NL) and Niederrhein (DE), expected to be commissioned not before 2013 increasing the cross border capacity in the range of 1000 to 2000 MW. It will increase security of supply and make RES integration possible by facilitating higher North-South power flows through the auctioned frontier between the NL and DE during peak hours of wind in-feed and transit flows.
106	Sensitivity studies on the reference RgIP scenarios, carried out by EirGrid, indicate that there is an economic opportunity for greater interconnection between **Ireland and GB.** EirGrid and National Grid have entered into discussions on further bilateral studies to better define the costs and benefits of potential interconnections.
107	Sensitivity studies on the reference RgIP scenarios, carried out by EirGrid, indicate that there is an economic opportunity for greater interconnection between **Ireland and France.** EirGrid and RTE have entered into discussions on further bilateral studies to better define the costs and benefits of potential interconnections.
109	**Offshore wind (IE and NI)** – EirGrid and SONI are planning connections of several wind farms in the Irish Sea to the main grid on the island of Ireland.
110	**NSN** – A 700 km HVDC connection between Norway and GB is planned to be commissioned in a period 2018/21. The interconnector will probably be operated at 500 kV with a capacity of approximately 1000-1400 MW.
(Investment 465)	In Ireland, the Laois-Kilkenny 400 kV project (named Loughteeog in the pilot TYNDP) (Inv. 465) involves connecting a new 400/110 kV substation into the existing Moneypoint – Dunstown 400 kV line and connecting the Kilkenny 110 kV station to the new substation at 110 kV. This investment is required for the security of supply to counties of Kilkenny, Carlow Laois and Kildare. Completion is expected in 2014. This investment measured as marginal only against the criteria defining Projects of European Significance, and so is not included in the main table of Projects.

12.5 Abbreviations

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

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