European Network of
Transmission System Operators
for Electricity

Regional Investment Plan – Continental Central South region

- Draft for consultation

24 June 2015

Summary

1 EXECUTIVE SUMMARY

1.1 Regional Investment Plans as foundation for the TYNDP

The TYNDP for Electricity is the most comprehensive and up-to-date planning reference for the pan-European transmission electricity network. It presents and assesses all relevant pan-European projects at a specific time horizon as defined by a set of scenarios. The TYNDP is a biennial report published every even year by ENTSO-E and acts as an essential basis to derive the next Projects of Common Interest (PCI) list, in line with the Regulation (EU) No. 347/2013 ("the Energy Infrastructure Regulation").

ENTSO-E is structured into six regional groups for grid planning and other system development tasks. The countries belonging to each regional group are shown in Figure 1-1.

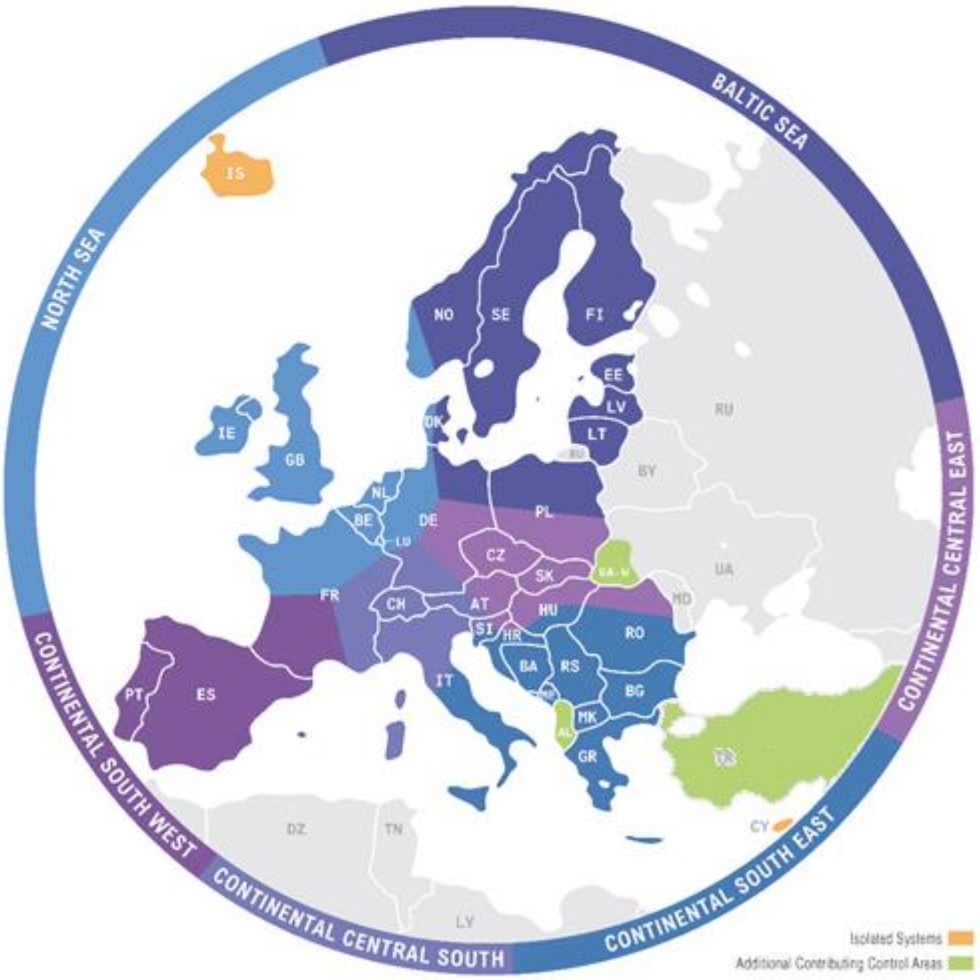

Figure 1-1 ENTSO-E System Development Regions

The TYNDP 2016 and the six Regional Investment Plans associated are supported by regional and pan-European analyses and take into account feedback received from institutions and stakeholder associations. The work of TYNDP 2016 has been split in two key phases:

- The first phase (summer 2014 to summer 2015) is devoted to common planning studies and results in the six Regional Investment Plans and the identification of a list of TYNDP2016 project candidates. During this phase also a set of TYNDP scenarios are developed.
- The second phase (summer 2015 to end 2016) will be dedicated to coordinated project assessments using the Cost Benefit Analysis Methodology (CBA) and based on common 2020/2030 scenarios. The results will be published in the TYNDP2016 report.

The common planning studies as basis of the Regional Investment Plans report are built on past TYNDP, on recent national plans, and follow a consolidated European network planning approach. It is worth noting that this is an intense and continuous work, where during the finalization of one TYNDP, the development of the next is already being initiated.

These common planning studies aim to identify the grid bottlenecks and potential investment solutions of pan-European significance for a 2030 time-horizon, in a robust, unified and consistent manner based on best available joint TSO expertise. Specifically, this report identifies cross-border and internal projects of regional and/or European significance, which allow the main European energy targets to be met with particular regard to the strengthening of the Internal Energy Market (IEM), the integration of Renewable Energy Sources (RES) and addressing security of supply (SoS) issues.

Proposed cross-border interconnections will also build on the reasonable needs of different system users, integrate long-term commitments from investors, and identify investment gaps.

The European Council has recently (October 2014 and March 2015) sent a strong signal that grid infrastructure development is an essential component of Europe's Energy Union goals, by confirming the need of an interconnection ratio of at least 10% of the installed generation capacity in every Member State by 2020. In addition, the Council also endorsed the objective of reaching a 15% level by 2030 "while taking into account the costs aspects and the potential of commercial exchanges", aiming at strengthening security of supply and facilitating cross-border trade and mandated the EC to report on their implementation. According to the Council, this is one of the pre-requisites to accomplish an effective internal market for electricity.

This panorama is one of the challenges for ENTSOE in order to establish the most efficient and collaborative way to reach all defined targets of a working Internal Energy Market and a sustainable and secure electricity system for all European consumers.

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1.2 Key messages of the region

The Continental Central South (CCS) region is composed of Austria, France, Germany, Italy, Slovenia and Switzerland. This region covers an area that ranges from the North Sea via the Alps in the very heart of continental Europe to the Mediterranean area.

Figure 1-2 CCS Region

The already ongoing transformation of the electricity system with large developments of variable wind and photovoltaic power especially at the corners of the CCS region, the nuclear phase-out and the pump storage potentials in the Alps are some of the outstanding characteristics of the region that will challenge the whole future electricity system and especially the transmission system.

The CCS Region at present imports energy from the rest of Europe, but in the long term time horizon this feature becomes less structural, due to the expected evolution of load and generation profiles (especially RES development) that are strongly dependent on the considered scenarios.

The CCS region is characterised by intense interaction and interrelation between the countries of the region and their neighbours as the transmission networks are quite highly meshed, especially in the central-western part of the Region. Therefore, developments, even if they are concentrated in a specific part of the region, strongly influence the whole CCS regional area.

The *main drivers for power system evolution* are summarised as follows:

- massive RES integration;
- integration of storage plants to facilitate the efficient use of RES;
- nuclear phase-out;
- wide area power flows;
- system security and security of supply.

The increasing *penetration of variable renewable generation* leads to fluctuating and high utilisation of the transmission network and a more flexible transmission grid is needed as result. In particular the geographical concentration of the RES development at the corners of the region (mainly in DE, IT and FR) far away from the centres of consumption and the Alpine storages leads to amplified power exchanges in a wide transmission area.

The divergence in the generation time and demand resulting from the integration of volatile RES is another rising and sustainable challenge for the overall power system, leading to the necessity for additional transport and storages capacities as well as other innovative measures.

The *integration of storage plants* can facilitate the efficient use of RES: in this respect, considerable storage potential is available in the very centre of the region, particularly in the form of existing and planned hydro pumped storage power plants located mainly in the Alps. Further opportunities could be considered concerning development of distributed storage systems within or near peripheral areas with expected higher RES penetration to reduce local congestions.

The nuclear phase-out, specifically the reduction of the share of nuclear capacities in the generation mix – according to the assumptions of the different Visions mainly in Germany, Switzerland and France – has a significant structural impact on the electricity systems and therefore the countries' power and energy balances. The availability of an adequate grid infrastructure constitutes the basis for coping with those structural changes.

The progressing discrepancy in the time and location of generation and consumption, especially the integration of RES at the corners of the region and storage in the Alps, as well as structural market congestion between price zones will lead to *wide area power flows* through the region, requiring investment within the countries and at the borders.

Due to the fundamental changes in the entire electricity system (massive RES integration, nuclear phase-out, limited - and in the longer run uncertain - availability of conventional power plants caused by changing market conditions) security of supply investigations into single demand centres are no longer sufficient. The whole *system security* has become a key issue, and a broad consideration of all relevant parameters is necessary. Numerous projects in the CCS RgIP are being supported to ensure a secure electricity system in this changing environment, especially in the peripheral and scanty meshed network areas of the Region.

As highlighted also in the previous TYNPs, several *boundaries* have been already identified for the CCS region starting from the present network constraints and based also on the expected evolution of the power system in the coming years (unless new transmission assets are developed).

The main boundaries due to market integration needs refer to the Italian northern border and the boundary between Italy and the Balkans, the internal bottlenecks among the six different Italian price zones, the Swiss roof, the French north-eastern border and the Austrian-German border. Moreover, a need for the transmission capacity increase within the same price zone can be recognized in Germany (due to high north to south flows), in the south-western part of France.

Critical sections due to connection of generation (especially RES) and its integration, relate to already public and mature applications for connecting large generation plants, storage PCIs, and areas with high penetrations of RES. The primarily concerned boundaries of the region are: the connection of offshore wind in North Sea and Baltic Sea in Germany; the connection of additional hydro power plants in Switzerland and Austria and the connection of wind in eastern part of Austria; integration of renewable generation expected in the north of the region (mainly wind onshore and offshore in Germany and France), solar in the southern part of Germany, France and especially in Italy.

Generation is generally sufficient to balance load. Security of supply remains a concern especially locally, in peripheral areas with scarcely meshed network (like Sicily in southern Italy).

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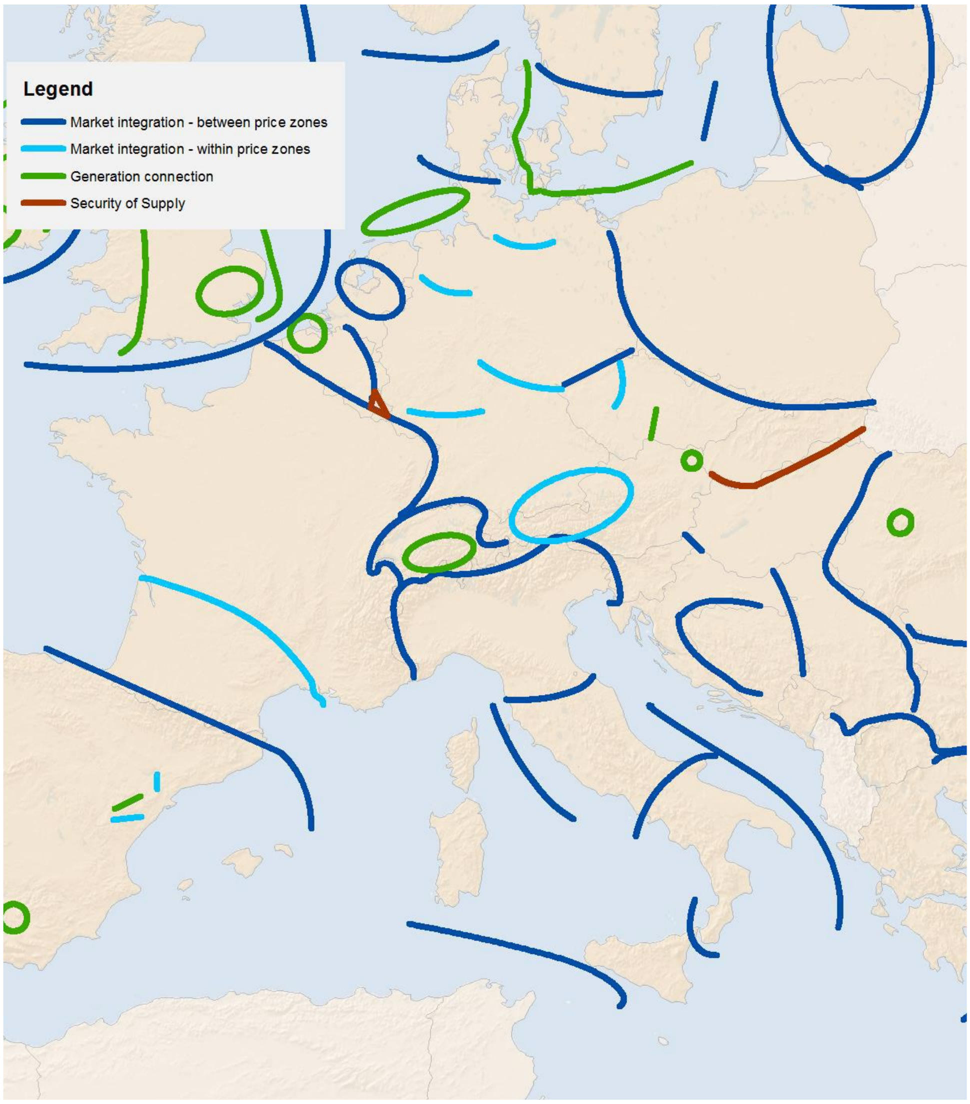

Figure 1-3 Map of main boundaries in CCS region perimeter

Caused by the main drivers and network constraints explained above, several transmission expansion projects have been already planned, and *common planning studies (CPS)* have been performed within the CCS Region to find out additional transmission investment needs, set target capacities accordingly, and propose relevant network development solutions. Market and network analyses have been focused on the borders and internal sections with transmission capacities which would not be fully adequate in the future scenarios.

Based also on the results of coordinated planning activities, several projects classified as mid and long-term planned covering the next years till 2030 have been nominated for the inclusion in the next TYNDP 2016, and further *concept projects* have been envisaged in the framework of a very long-term future development perspective covering the next time horizon after 2030 towards 2050.

As a result, the following new future transmission projects were proposed for the inclusion in the next TYNDP 2016, on top of TYNDP2014 projects:

- FR-CH border: a new 400 kV line (with a PST) Génissiat – Verbois and a new HVDC line between Lyon area and the Romandie area - to achieve a 2 GW transmission capacity increase;

- CH-DE border: upgrade Beznau – Tiengen (from 220 kV to 400 kV) and internal reinforcements in CH and in DE - to achieve a 1 GW transmission capacity increase.

On the FR-DE border, projects Eichstetten – Muhlbach (upgrade of second circuit from 220 kV to 400 kV) and Vigy - Ensdorf – Uchtelfangen (increase of the thermal capacity), already part of the TYNDP 2014 (project 152), were reconsidered as two separate projects to allow in the long term almost a further 1 GW transmission capacity increase with respect to TYNDP 2014 estimation.

It is worth also mentioning CPS performed in other Regions lead to capacity increases on the borders of CCS region.

In addition, Terna proposed a new future 250 MW battery storage project in Southern Italy for its assessment in the next TYNDP 2016.

Out of the coordinated planning activities, a few candidate transmission and storage projects have been nominated also by non-ENTSO-E members.

Concerning the projects of pan-EU relevance already planned in the CCS Region in the last TYNDP 2014, they were all reconfirmed, except from transmission project n. 148 (400 kV Udine – Okroglo line crossing IT-SI border) and two non-ENTSO-E hydro-pumped storage projects (n. 223 Limberg III Salzburg in Austria and n. 226 Riedl in Germany).

2 INTRODUCTION

2.1 General and legal requirements

The TYNDP 2016 package, developed over the course of two years, will be composed of the following documents:

- The **TYNDP report** provides a helicopter view on the grid development in Europe, it shows where progress is made and where support is still needed, and it provides a standardized assessment of all projects of pan-European significance.
- The **six Regional Investment Plans** analyse the power system development from a regional perspective, based on common guidelines, and identify investment needs linked with a set of proposed projects.
- The **Scenario Development Report** sketches a set of possible futures, each with their own particular challenges, which the proposed TYNDP projects must address. All TYNDP projects are assessed in perspective of these scenarios.
- The **Scenario Outlook & Adequacy Forecast (SO&AF)** is delivered every year and assesses the adequacy of generation and demand in the ENTSOE interconnected power system on mid- and long-term time horizons.
- The **Cost Benefit Analysis Methodology (CBA)** as developed by ENTSO-E and adopted by the EC, allows the assessment of infrastructure projects in an objective, transparent and economically sound manner against a series of indicators which range from market integration, security of supply, integration of renewable energy sources (RES-E) to environmental impact.

The Regional Investment Plans are published in summer 2015 and focus on regional planning studies and the identification of the pan-European project candidates. It provides key information to understand the need for new projects, which are listed and published for public consultation until mid-September.

The Regional Investment Plans are complemented by a monitoring update of the TYNDP 2014 investments, providing insight in the changed status of these items and possible reasons.

The TYNDP report will be delivered by end of 2016 and will concentrate on individual project assessments based on common scenarios, data and CBA methodology.

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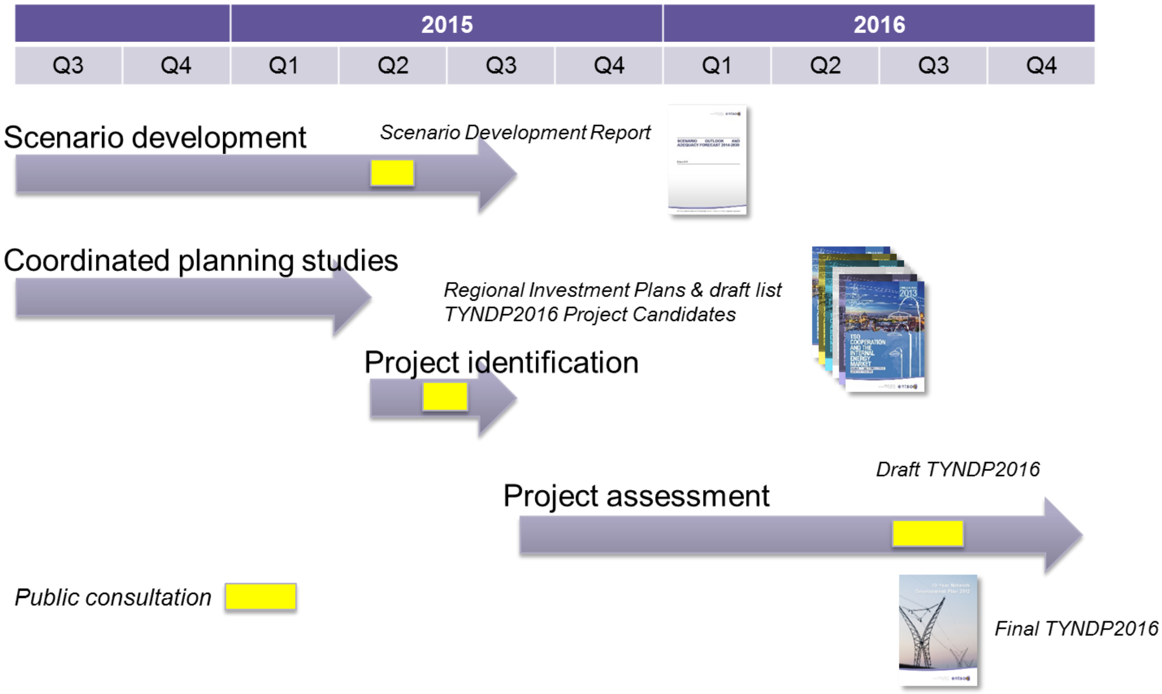

Figure 2-1 Overview of a two-year TYNDP process

The present publication complies with Regulation (EC) 714/2009 Article 12, where it is requested that TSOs shall establish regional cooperations within ENTSO-E and shall publish a regional investment plan every two years. TSOs may take investment decisions based on that regional investment plan. ENTSO-E shall provide a Community-wide ten-year network development plan which is built on national plans and reasonable needs of all system users, and identifies investment gaps.

As of 2016, the TYNDP package must also comply with Regulation (EU) 347/2013 ("the Energy Infrastructure Regulation"). This regulation organises a new European governance to foster transmission grid development. It establishes Projects of Common Interest (PCIs), foresees various tools (financial, permitting) to support the realisation of these PCIs, and makes the TYNDP the sole basis for identifying and assessing the PCIs according to a Cost-Benefit-Analysis (CBA) methodology. The ENTSO-E CBA methodology has been developed since 2012, based on stakeholder consultation, and the opinions of ACER, Member States and EC; it has been adopted by the EC in February 2015. Work continues to further improve the methodology.

This Regional Investment Plan as such is to provide information on future European transmission needs and projects to a wide range of audiences:

- Agency for the Cooperation of Energy Regulators (ACER) who has a crucial role in coordinating regulatory views on national plans, providing an opinion on the TYNDP itself and its coherence with national plans, and giving an opinion on the EC's draft list of PCI projects;
- European institutions (EC, Parliament, Council) who have acknowledged infrastructure targets as a crucial part of pan-European energy goals, to give insight in how various targets influence and complement each other;
- Energy industry, covering network asset owners (within ENTSO-E perimeter and the periphery) and system users (generators, demand facilities, and energy service companies);

- National regulatory authorities and ministries, to place national energy matters in an overall European common context;
- Organizations having a key function to disseminate energy related information (sector organizations, NGOs, press) for who this plan serves as a "communication tool-kit";
- The general public, to understand what drives infrastructure investments in the context of new energy goals (RES, market integration).

2.2 The scope of the report

The scope and focus of the present Regional Investment Plans has evolved as compared to the past editions of 2014. This Regional Investment Plan focuses on a set of common planning studies performed across ENTSO-E's regions with particular attention for the context of each individual region.

The Regional Investment Plan presents the methodologies used for these studies, relevant results and assumptions, and the resulting list of the project candidates as nominated by project promoters.

At present no detailed CBA analysis is provided in the Regional Investment Plan. This will be a key element of further studies leading to the final TYNDP2016 report to be released next year. This regional report takes the opportunity also to inform readers on regional context, studies and projects.

These studies re-confirm the main findings past TYNDP studies as well as others in terms of main corridors, general scenarios, and the key conclusion that an energy shift requires targeted future-proof infrastructure.

2.3 General Methodology

This Regional Investment Plan 2015 builds on the conclusions of a Common Planning Study carried out jointly across the six regions of ENTSO-E's System Development Committee. The aim of this joint study is to identify investment needs triggered by market integration, security of supply, RES integration and interconnection targets, in a coordinated pan-European manner building on the expertise of all TSOs. These investment needs are translated to new project candidates where possible, and give in most cases a re-confirmation of past TYNDP2014 projects. This chapter explains the overall planning process of how project candidates have been identified by market studies, network studies and regional knowledge. More details about this process as well as regional intermediate steps can be found in Appendix 7.1 and 7.2.

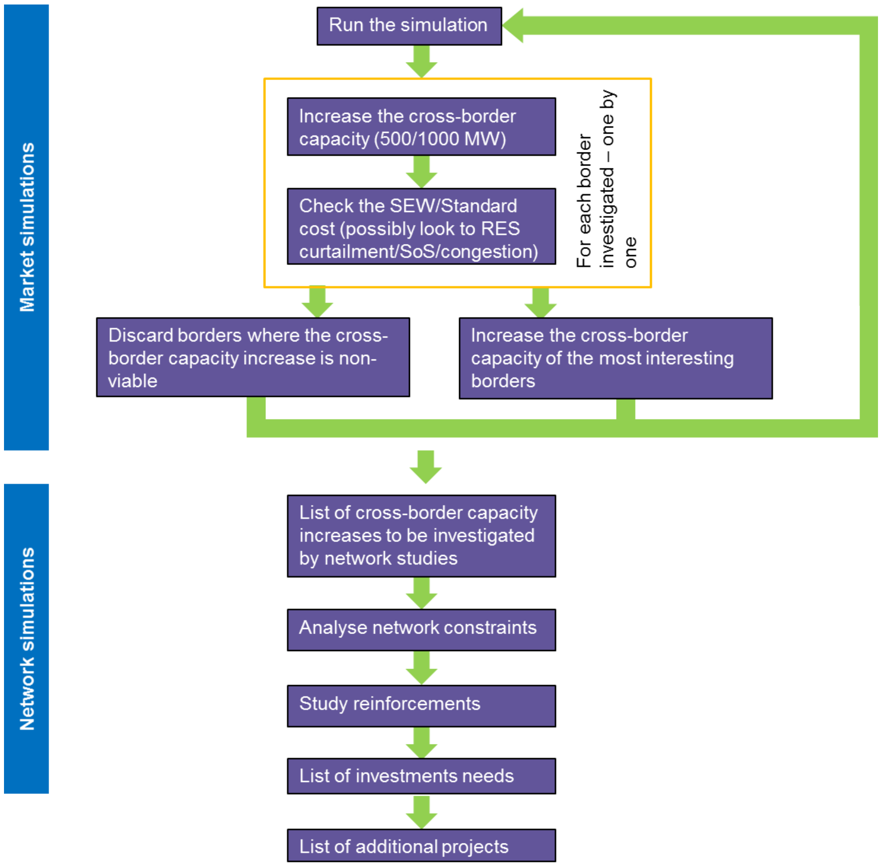

Figure 2-2 Common Planning Study workflow

Market Studies

All regions have jointly investigated all borders in order to identify the most beneficial ones based on a criteria of SEW/cost-ratio. The SEW indicator represents the socioeconomic welfare of a full-year market simulation. The cost indicator is an estimation of the capex of a potential cross-border capacity increase, including necessary internal reinforcements. Note that both indicators for a given capacity do not represent the same level of detail as the cost and SEW indicator retrieved in a CBA assessment for a specific project.

The analysis is carried out across the ENTSO-E perimeter in several iterations, each time increasing border capacities identified as being most valuable for the European system.

It is worth pointing out that this approach includes some simplifications. The most important one is that it simplifies the benefits just as SEW, without taking into account additional benefits, which are possibly more difficult to monetize than the savings in variable generation cost. Another one is the fact that the candidate projects are not yet defined by the time they are simulated. Therefore the expected GTC increase is a standard value (e.g. 1 GW) and the costs of the projects are assessed by expert view, taking into account the specificity of the area (e.g. mountain, sea). Cost of internal grid reinforcements considered as needed to get the expected GTC increase is also included in the cost of the candidate projects.

As a reference scenario the TYNDP2014 Vision 4 is taken, which represents the most challenging scenario coming from the present day situation and the most useful to identify new investment needs. Even if this scenario does not become reality by 2030, it can for the purpose of this planning study still be seen as a step between 2030 and 2050. In addition to the pan-European study iterations, regions repeated the exercise or performed a sensitivity analysis on the outcome to gain additional insight in relevant investment needs that trigger project candidates.

In the following figure, the results of the 1st iteration of coordinated market simulations under high RES development conditions (based on TYNDP 2014 Vision 4) are reported, as an example of the common planning activities performed at ENTSO-E level.

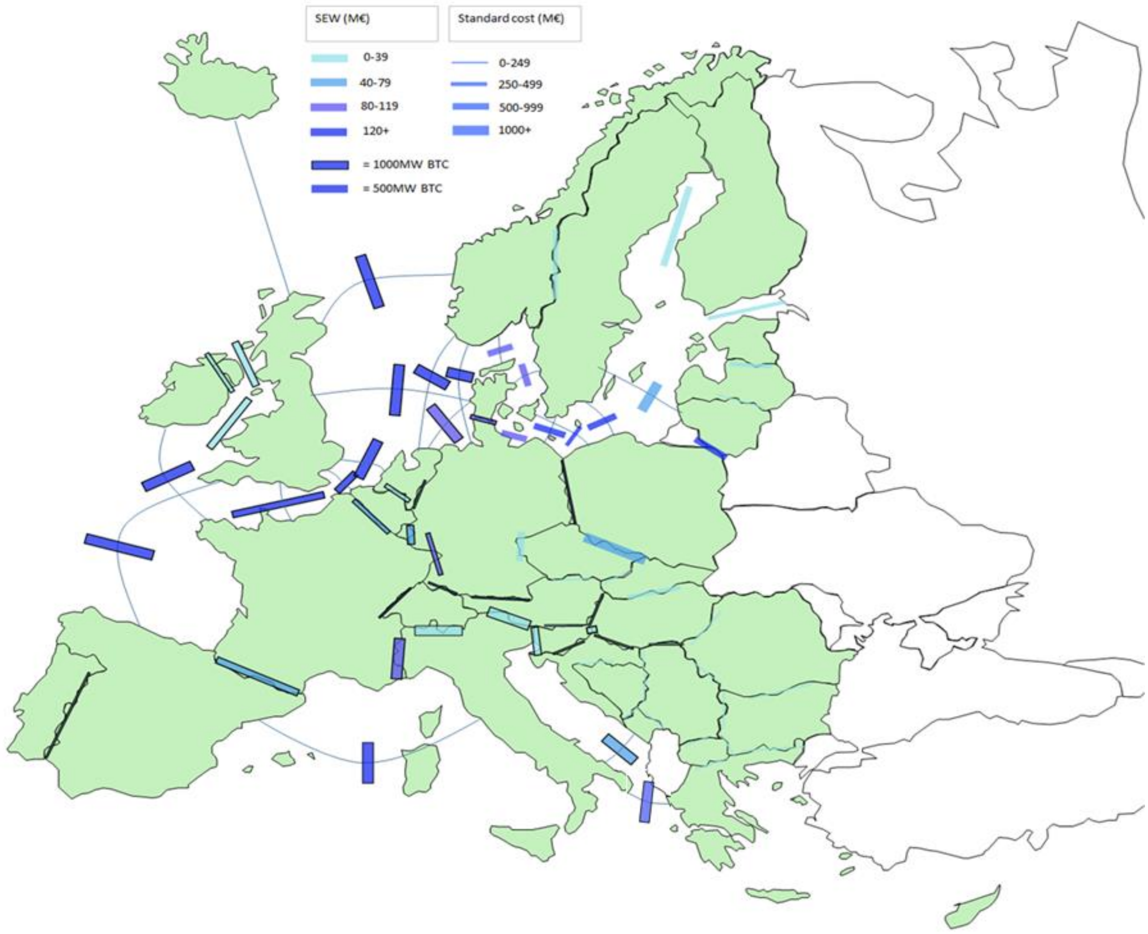

Figure 2-3 – Results of the first round of market studies performed

Network Studies

Following these market simulations, network studies on detailed grid models show possible bottlenecks that would not allow the result from the market studies come true. This allows to explore reinforcements, to design suitable project candidates and update market-based target capacities resulting from the initial market study iterations. Depending on the models and tools used in a region, the translation from market to network studies can be done in two ways:

1. Select and study an adequate number of representative Points In Time (PiTs), based on the flow duration curves for the each studied border. Complemented this with a second analysis of the regional grid by means of a Power Transfer Distribution Factor (PTDF) matrix which gives approximate flows.
2. Compute all 8760 hours in a year with demand and generation dispatch profiles obtained from market studies in full DC load flow calculations.

These network analyses allow to test **project candidates**, as suitable grid reinforcements to eliminate bottlenecks.

Regional knowledge

Market studies focus primarily on SEW/cost-ratios. Network studies identify additional (internal) capacity needs. Sensitivity studies of market simulations (e.g. an extreme condition) and in particular network studies allow to capture additional views and model interpretations based on regional experts, and in many cases complementing the findings of national development plans and/or past studies.

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2.4 How to read the report depending on the audience

This chapter describes how the report is built up and the content of the different chapters.

Chapter 1 – Executive Summary

In this section the key take-aways of the region are presented and it is explained how the development of the report fits into the TYNDP2016 process.

Chapter 2 - Introduction

This chapter sets out in detail the general and legal basis of the TYNDP work, the overall scope of the report and its evolutions compared to the previous regional and TYNDP plans. The reader is presented with a short summary of the planning methodology used by all ENTSO-E regions.

Chapter 3 – Regional Context

This chapter describes the general characteristics of the region, in the as-is situation and in anticipated evolutions up to 2030 and beyond. It gives a general overview of TSO collaboration efforts in regional planning based on pan-European methodologies and coordination.

Chapter 4 – Regional results

It gives a synthetic overview of the basic scenarios and assumptions used in common planning and the overall results. The results are also placed in perspective of further ahead challenges and roadmaps leading up to 2050.

Chapter 5 – Project candidates

This chapter gives an overview of all projects proposed by promoters in the region, labelled as either TYNDP projects or projects of regional relevance. It links these projects to investment needs identified in ENTSOE joint TSO studies, clarifies possible barriers to address these system needs, and gives the baseline for future project CBA assessments (e.g. by means of boundary reference capacities).

Chapter 6 – Next steps

This chapter presents a look forward on how the TYNDP work will continue in the next year, leading to a full TYDNP2016 report.

Chapter 7 – Appendices

This chapter gives more insight in the used methodologies, as well conducted market and network studies.

3 REGIONAL CONTEXT

The Continental Central South Regional Group (CCS RG) under the scope of the ENTSO-E System Development Committee is among the 6 regional groups for grid planning and system development tasks. The Member States belonging to each group are shown in Figure 3-1**Error! Reference source not found.** below. CCS RG itself consists of six countries: Austria, France, Germany, Italy, Slovenia and Switzerland.

The list of ENTSO-E countries and TSOs in the CCS RG outlined here is presented in Table 3.1 below:

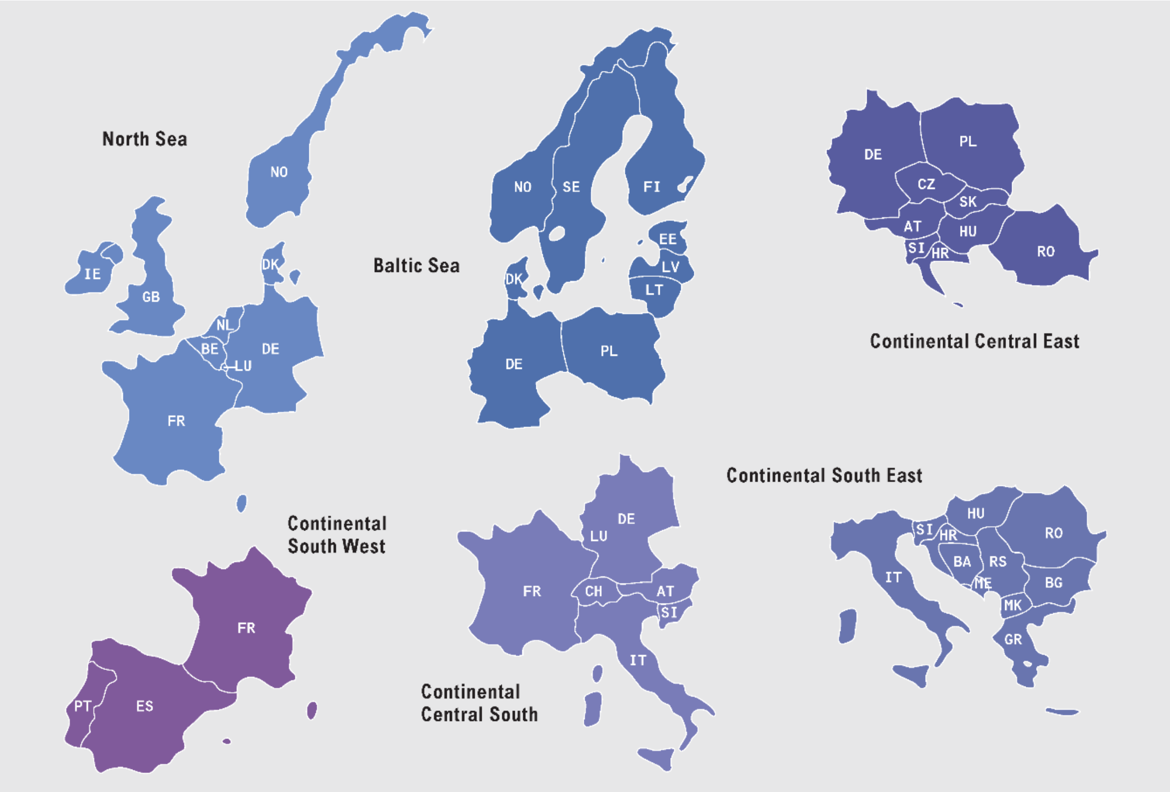

Figure 3-1 ENTSO-E regions (System Development Committee)

Table 3-1 ENTSO-E Regional Group CCS membership

Country	Company/TSO
Italy	Terna
Austria	APG – Austrian Power Grid AG
	Vorarlberger Übertragungsnetz GmbH
France	RTE
Germany	50Hertz Transmission GmbH
	TenneT TSO GmbH
	Amprion
	TransnetBW
Slovenia	ELES
Switzerland	Swissgrid

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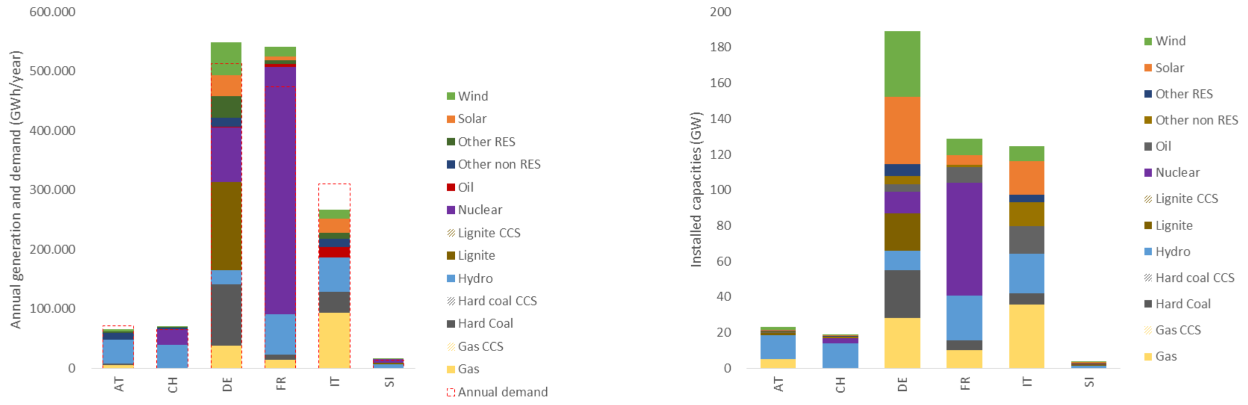
3.1 Present situation

The Continental Central South Region (CCS) comprises six countries: Austria, France, Germany, Italy, Slovenia and Switzerland.

In the following figures the total installed capacity as well as the generation mix in 2014 it is shown:



(a) (b)

Figure 3-2 Present situation (a) energy [GWh/year], (b) installed capacity [GW]

Concerning the annual generation in CCS countries, the main contributions to cover the demand varies from country to country: in France it is from nuclear generation, in Austria and Switzerland is from hydro, in Slovenia from nuclear and hydro, in Italy from gas and hydro and in Germany is from fossil fuels (hard coal and lignite), nuclear and RES (wind and solar).
The generation results are potential for export within many CCS countries, in particular France and Germany, having the greatest surplus in generation respect to the local demand. Conversely Italy has the greatest deficit in generation with respect to the local demand.

In Figure 3-3 the current levels of Net Transfer Capacities (NTC) in the Continental Central South region are illustrated. The NTC is the maximum total exchange program between two adjacent control areas that is compatible with security standards and applicable in all control areas of the synchronous area, whilst taking into account the technical uncertainties on future network conditions. The values are representing the maximum capacity. In operation values can vary hour by hour based on the availability of grid elements (reconstruction, revision, etc.) and expected unplanned flows. Such deviations between planned and realised programs (e.g. caused by inaccuracy in the forecasts) are happening already today and one can expect even higher variation in the future due to expected higher variability of electricity generation.

NTC values for the same border and the same grid change according to different conditions, e.g. the topology of the network or the generation and load pattern for the considered point in time.

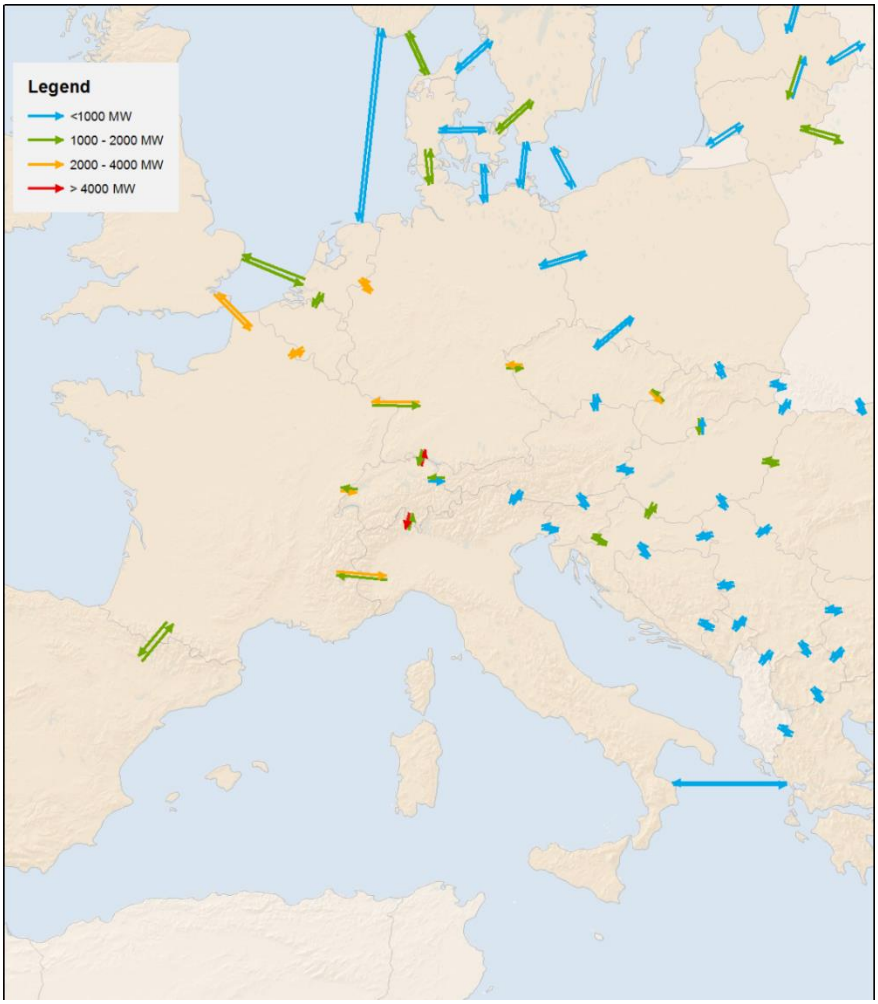


Figure 3-3 Illustration of Net Transfer Capacities in CCS region

At present time highest NTC values are located in Central-West part of CCS area.

Looking at recent development of interconnection capacities, it is important to highlight the increase of capacity on the northern Italian borders achieved by beginning of 2014 due to the commissioning of the new double circuit 400 kV Italian internal line Trino – Lacchiarella.

The CCS region is characterised by strong interaction and interrelation between the countries of the region and their neighbours as the transmission networks, especially in the central-western part of the Region are quite highly meshed. On the other hand, a few network portions in the central-eastern part and especially in the peripheral areas of the Region are less developed and therefore they are affected by a few boundaries already limiting, in some conditions, power transits in the Region.

Boundaries are present not only on the borders among different countries, but also internally to some countries where they affect power exchanges within price zones (like between northern and southern Germany, and in the south-western part of French network) or even market structure (like in Italy, where the day ahead energy market is split in 6 different bidding zones due to internal congestions on the south to north axis and between the main Islands and the Italian peninsula, as illustrated in the following figure).

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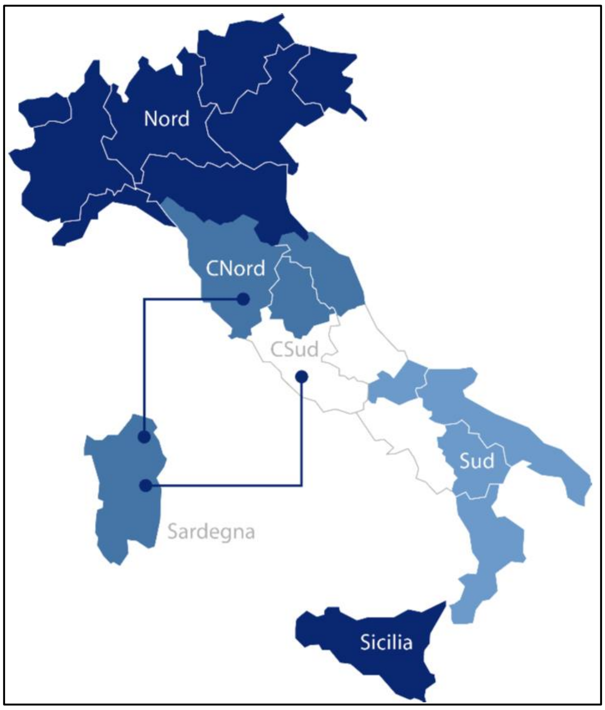

Figure 3-4 Italian market areas

3.2 Main network development drivers

Having in mind the key power system trends and the most important boundaries mentioned previously, the main drivers for network development in the CCS region have been shortly recalled in this section.

The most important drivers are classified and listed hereafter based on the *bulk power flows*[1] expected in the typical working conditions of the system, especially under high RES development circumstances like in TYNDP 2014 vision 4.

Generation Connections

In the next 15 years many new generation units in the CCS area have to be integrated to the transmission grid. New wind power plants are planned to be built at the coastal areas of the CCS region. Especially in the north of Germany (North Sea and Baltic Sea) new offshore wind-farms are planned with large installed capacities. These wind farms are also one of the main drivers for the necessity of grid expansion. In addition to offshore related investments also onshore wind-farms are planned in the eastern part of Austria, France and Southern Italy. The close interaction between wind farms, existing and also planned pump storage plants require the reinforcement of both interconnection and internal transmission lines in Austria. In this respect and in order to ensure security of supply it is essential to close the 380-kV-Ring in Austria. In Switzerland there are plans and decisions to build new hydro and pump storage plants.

Market Integration

The creation of the Internal Electricity Market (IEM) will eventually require the harmonisation of all cross-border market rules, so that electricity can flow freely in response to price signals. Market integration is leading to more and larger power flows across Europe, it is therefore a driver of grid development. The main bulk power flows appear from the market integration of RES, especially Wind, in the northern part of the region and solar in the South. The load is in the centre of the region, including pumped storage in the

[1] A *bulk power flow* is the typical power flow expected to trigger grid development across a boundary.

Alps. This leads to market exchange on the German border towards Austria, Switzerland and France and the northern borders of Italy.

Within Germany, the flows will stress the internal transmission lines in north-south direction towards the borders. In Austria and Switzerland, these flows will add some stress inside the country. In Italy, flows will converge in the south-north direction to the load areas in the central/north of the country, especially for low load periods with high solar generation. Based on these conditions, internal grid congestion would occur without the planned grid extensions. Accommodating these flows triggers further investment needs not only on the borders but also inside the countries.

Under large RES development, the power flows become even higher and more volatile, triggering the need for further grid development, especially for interconnections. The borders between Great Britain and mainland become heavily stressed, but also the French north-eastern border (with Benelux and Germany), as well as the boundaries in Germany. Under these high RES conditions, the size and volatility of the power flows in the region may not only trigger additional grid development, but also raise specific problems regarding voltage and frequency control as well as grid stability and operability.

Security of Supply

Preventing a rupture of the energy supply is naturally a crucial matter in the region. The energy transition of the regional power system leads to increased high north-south power flows. In order to ensure security of supply and to improve system stability not only new DC and AC grid expansion measures are needed, but also additional reinforcements such as VAR-compensation. In order to prevent a lack of supply it is essential to increase cross boarder capacities between European countries. Especially the increase of interconnection capacity between France, Germany and Benelux will provide these countries with mutual support. Besides that, internal reinforcements are of major importance to guarantee the security of supply, especially where the grid is rather scarcely meshed like between Sicily the mainland and in southern Italy.

The issues mentioned above mainly concern higher load conditions and situations with higher unbalances between the distribution of load and production (especially under high RES generation) in time and space, which bring not only specific need for grid development, but also new stability and operability concerns that were not experienced before.

Based on the classes of drivers listed above, several transmission expansion projects of pan-European and of Regional significance were already planned within the CCS Region in the past TYNDPs.

The identification of any further network development need triggered by bulk power flows, especially under high RES conditions - as it is in the scope of this document - cannot leave behind and in fact should start from the analysis of the *target capacities* and consequently of the transmission *adequacy needs* reported in the last TYNDP 2014.

For every boundary, the target capacity corresponds in essence to the transmission capacity above which additional development would not be profitable, i.e. the economic value for the system derived from any additional capacity quantum cannot outweigh the corresponding costs. Then, comparing the target capacity and the project portfolio for every boundary, a transmission adequacy index can be supplied.

In order to identify a wider spectrum of further potential needs, it is particularly relevant to refer to the most “network demanding” conditions. In this respect, the TYNDP 2014 vision 4 scenario under highest RES development conditions has been chosen as starting reference, leading to intensified interactions between market areas, higher usage of the transmission capacity and therefore to a higher target.

The transmission adequacy prospect in the CCS region is depicted in the following figure, showing that for some of the boundaries, the TYNDP 2014 project portfolio have provided already the appropriate solutions to meet the target capacity, whereas for a few borders there is still room for potential development needs to be investigated in the framework of common planning activities.

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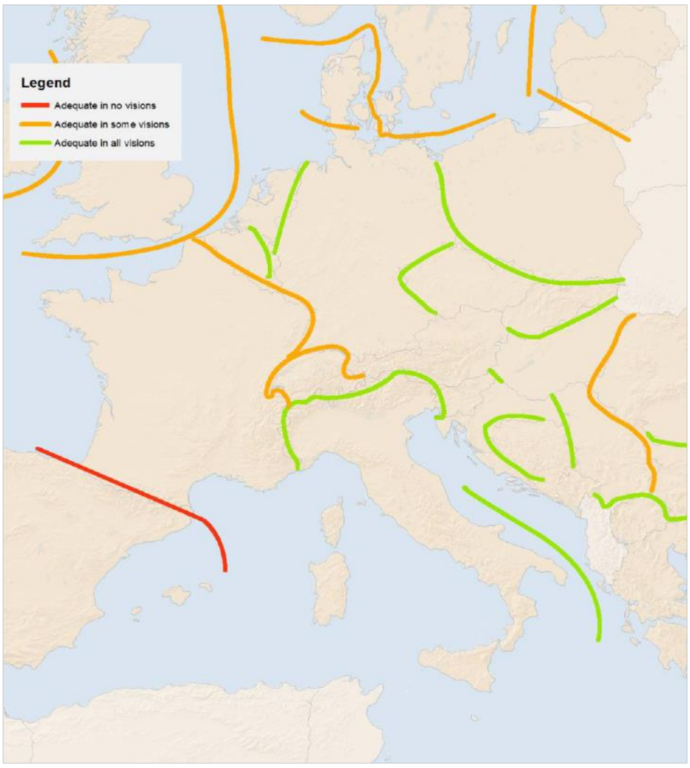


Figure 3-5 Transmission adequacy by 2030

In the CCS Region, no boundary is red. This underlines the TYNDP 2014 project portfolio is generally adequate within the assumed ENTSO-E scenarios. However, concerning the orange boundaries, all the listed projects are prerequisite to meet target capacities goals, but some additional grid reinforcements need still to be verified to cover possible investment needs specific to the most ambitious scenarios of RES development by 2030. This affects in particular the boundary between Germany and France as well as the Swiss roof.

Starting from this *basic scenario (TYNDP2014 Vision 4)*, *common planning studies* have been performed within the CCS region in order to:

- identify in a complete, consistent and transparent manner any further transmission development needs (especially from a market perspective)
- assess the robustness of the additional needs by means of market and network studies including regional sensitivities, to properly set future target capacities
- define conceptual development projects to achieve target capacities
- provide information on gaps or additional investigations that are necessary in case it is not possible to propose any even conceptual project to meet the target.

The results of the CPS studies, reported in detail in the following chapter, confirmed the preliminary findings of the TYNDP 2014 and especially the opportunity to consider - further to the projects already planned in the TYNDP 2014 - additional transmission capacity increases on the borders between Switzerland and France, between Switzerland and Germany and between France and Germany.

4 REGIONAL RESULTS

4.1 Description of scenarios

As already mentioned, common planning studies have been performed within the CCS region since October 2014 in order to:

- identify any further potential transmission development needs – especially from a market perspective – starting from the most demanding scenarios made available with the TYNDP 2014
- assess the robustness of the additional needs by means of market and network studies including regional sensitivities with different scenarios, to properly set future target transmission capacities
- define conceptual development projects to achieve target capacities
- provide information on any gap or additional investigation that could be necessary in case it is not possible to propose any conceptual project to meet the target.

In this respect, the following scenarios have been taken as references in the common market and network studies:

1. *TYNDP 2014 V4*: this basic scenario representing the highest RES development conditions, was already available when the CPS were launched; therefore it has been used as starting point to preliminarily highlight any possible network development need (additional to the TYNDP 2014 projects) for the market and network studies perspective.
2. *TYNDP 2016 draft V3* and *TYNDP 2016 draft V4* (both released in April 2015[2]): used in sensitivity market and network studies to challenge the robustness of the results provided in 1.

All the scenarios considered in this report are consistent with the TYNDP 2014 and TYNDP 2016 Visions, also in terms of assumptions and parameters, as reported in the following table:

Table 4-1 Main assumptions

		TYNDP 2014 – V4	TYNDP 2016 – draft V3	TYNDP 2016 – draft V4
Fuel prices (€/NetGJ)	Nuclear	*0.4*	*0.5*	*0.5*
	Lignite	*0.4*	*1.1*	*1.1*
	Hard Coal	*2.2*	*2.8*	*2.2*
	Gas	*7.9*	*7.2*	*7.2*
	Light Oil	*16.7*	*13.3*	*13.3*
	Heavy Oil	*9.9*	*9.9*	*9.9*
	Oil Shale	*2.3*	*2.3*	*2.3*
CO2 prices (€/ton)		*93*	*71*	*76*

In all of the three scenarios considered, the CCS region is characterized by a relevant presence of RES, although – with respect to the TYNDP 2014 – in the two TYNDP 2016 draft scenarios there is a significant reduction of wind power installed capacity (about –16% in TYNDP 2016 V3 and –11% in TYNDP 2016 V4), and a reduction of the solar power installed capacity (about –32% in both TYNDP 2016 draft scenarios).

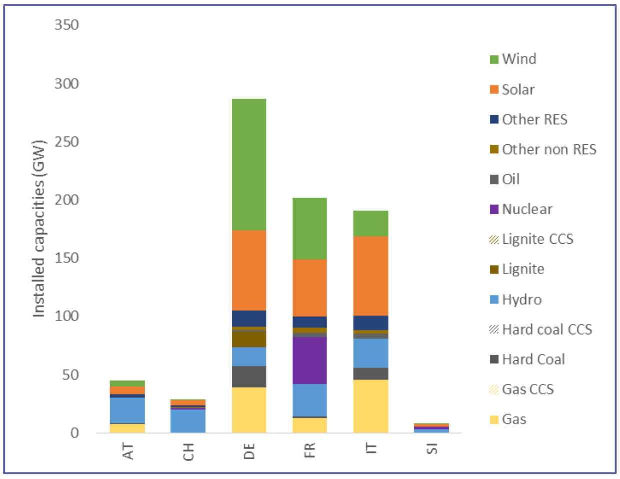
[2] Both scenarios were provisionally released in April 2015 for internal ENTSO-E use, before public consultation. Afterwards they have been included in the TYNDP 2016 Scenario Development Report, made publicly available in the ENTSO-E website.

The main reductions in terms of RES capacity come from Germany (from 181 GW of TYNDP 2014 V4 to 151 GW of TYNDP 2016 V3), France (from 100 GW of TYNDP 2014 V4 to 61 GW of TYNDP 2016 V3) and Italy (from 90 GW of TYNDP 2014 V4 to 62 GW of TYNDP 2016 V3).

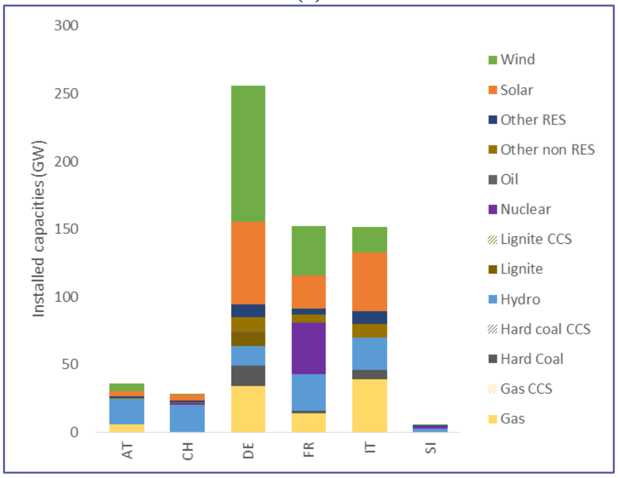
Hydro power capacity is about 110 GW in TYNDP 2014 V4, while in the two additional draft scenarios analysed it is lower: about 105 GW in TYNDP 2016 V3 and about 84 GW in TYNDP 2016 V4.

Concerning thermal power:

- most of installed nuclear power capacity is still expected to be in France (about 40 GW in TYNDP 2014 V4 and about 38 GW in TYNDP 2016 V3 and V4). Minor shares of nuclear capacity are from Switzerland and Slovenia;
- coal power capacity (hard coal and lignite) is mainly located in Germany (about 31,7 GW in TYNDP 2014 V4 and about 24,9 GW in TYNDP 2016 V3 and V4) and Italy (from 9,9 GW in TYNDP 2014 V4 to 4 GW in TYNDP 2016 V4)
- gas power capacity is mainly installed in Italy (from 46 GW in TYNDP 2014 V4 to 39 GW in TYNDP 2016 V4 and V3).



(a)



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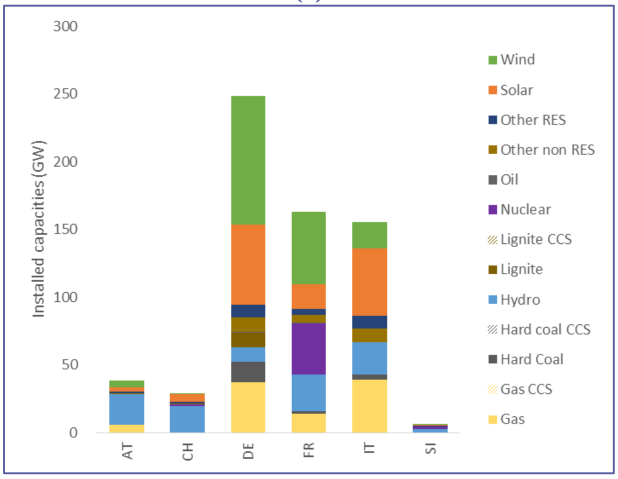
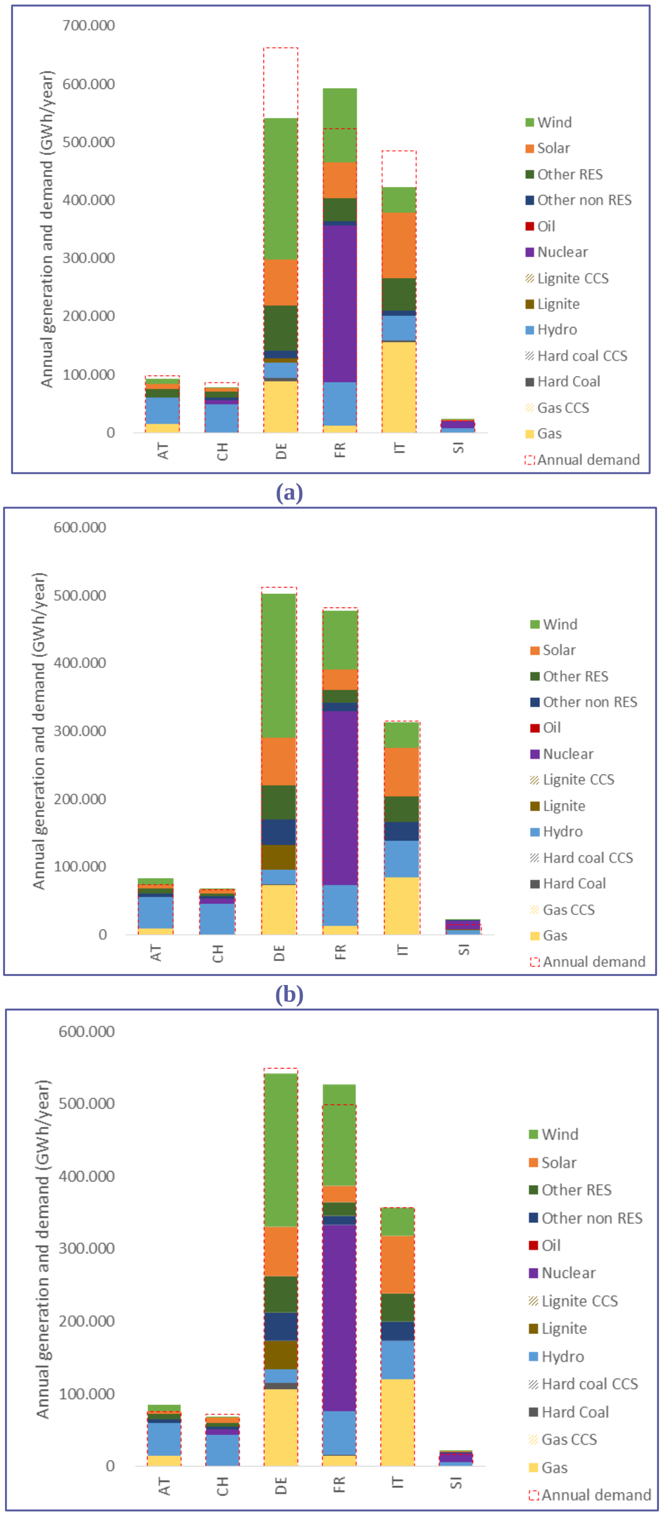


(c)

Figure 4-1 - installed generation capacity [GW]

(a) TYNDP 2014 V4; (b) TYNDP 2016 V3 (c) TYNDP 2016 V4

Concerning the annual generation, taking into account that all scenarios analysed have high CO2 prices (see Table 4-1 Main assumptions) the main contributions to cover the demand come from RES (about 65% in TYNDP 2014 V4, 60% in TYNDP 2016 V3 and 58% in TYNDP 2016 V4), nuclear and gas generation.



(a)

(b)

(c)

Figure 4-2 – generation [GWh/year]

(a) TYNDP 2014 V4; (b) TYNDP 2016 V3; (c) TYNDP 2016 V4

Also concerning balances, it is important to highlight the main differences between the TYNDP 2014 V4 and the new TYNDP 2016 draft scenarios analysed:

- Germany is still a net importer country, but with a significant decrease of the imported energy (leading the yearly national generation and demand balance close to the parity in the new draft scenarios) mainly due to a significant reduction of the demand forecast from TYNDP 2014 V4 to TYNDP 2016 V3 and V4;
- the behaviour of France is quite different in TYNDP 2016 V3, where it is a net importer country (mainly due to the demand and RES generation assumptions), compared to the other scenarios where France is still as usual a net exporter;
- Italy is no more a structural net importer country in the new TYNDP 2016 V3 and V4 draft scenarios, providing a national net balance close to zero; this is quite different from the TYNDP 2014 visions, mainly due to the significant reduction of the demand forecast not fully counterweighed by the difference in the RES generation;
- in addition it is possible to remark the different behaviour of Austria, as it becames a net exporter in the two TYNDP 2016 draft visions analysed; while Switzerland remains more or less "neutral" in both TYNDP 2016 Visions and Slovenia confirms its slightly net positive balance also in TYNDP 2016 V3 and V4.

In the following figure the net annual country balance in the three scenarios analysed for CCS region are reported.

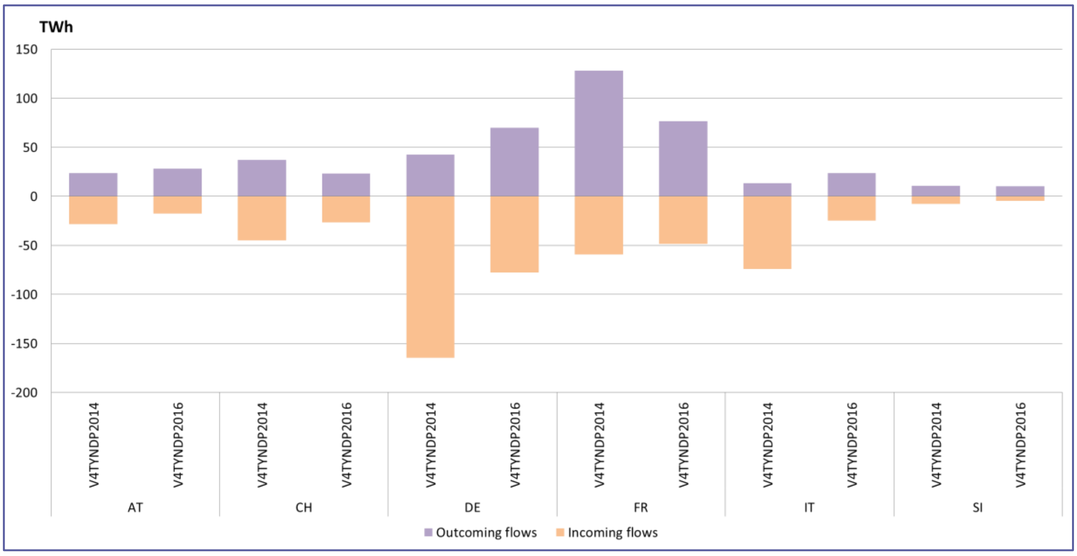


Figure 4-3 Balances (export is positive)

For any further information on the TYNDP 2016 draft scenarios, it is suggested to refer to the Scenario Development Report published on the ENTSO-E website.

4.2 Market results

Common Planning Studies (CPS) performed in the CCS region have been coordinated with other ENTSO-E regions to determine the opportunities for additional transmission capacities within the region.

Market studies have been performed, since October 2014, according to the general methodology developed at ENTSO-E level (described in chapter 2). In this context, the common starting point was the TYNDP 2014 V4 scenario, considered as the base case representing the highest RES development conditions which are conventionally assumed as the most demanding circumstances for the transmission network.

Indeed, as it possible to see in the figure below, the generation marginal cost differences among the CCS countries do not get so much high values in the TYNDP 2014 V4: there are about 5-10 €/MWh on average between France and Eastern countries, including Italy, and less than 5 €/MWh on the Italian north-eastern border. Among the central countries of CCS the average differences are between 2 and 5 €/MWh.

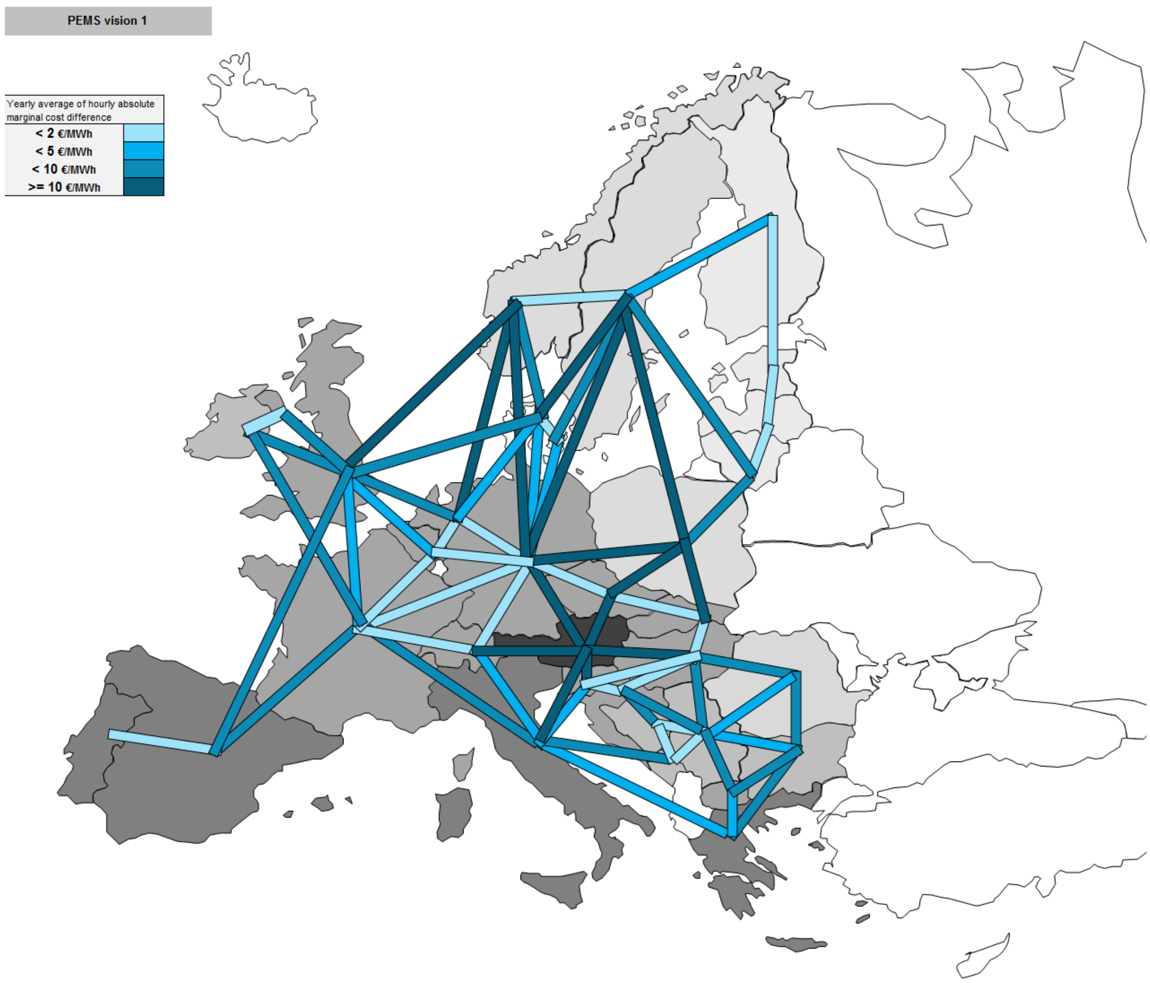


Figure 4-4 Yearly average of hourly absolute marginal cost difference in TYNDP 2014 Vision 4

The market model used for the studies was based on the TYNDP 2014 list of projects. In this respect, it is necessary to specify that in some cases a simplified market model, not including all internal bidding zones, has been used (for example Italy has been modeled with only 2 price zones: Italy-North and Italy-South)[3].

These basic market simulations were aimed at finding further potential network development needs (on top of the TYNDP 2014 project list).

The Project Group Market Models and the Regional Group CCS in charge for these studies screened 13 borders in total (3 of them jointly with other Regions). Cross-border capacity increases were simulated through the PINT approach, by increasing step by step the transmission capacity on each border one by one. Several set of iterations have been performed, by increasing in each of them the cross-border capacity increases starting from the cross-border capacity values which were proved rentable in the previous iteration.

In each iteration, benefits and theoretical standard costs relevant to any additional cross-border capacity increase have been compared to prove the economic sustainability of the potential transmission development need. In this respect

- a hypothetic cost has been estimated by expert view for each standard (e.g. 1 GW) cross-border capacity increase, taking into account the existing grid, the projects already planned and the specificity of the area (e.g. mountains or sea to cross the border);
- the main benefit indicators (SEW, RES integration, CO2 reduction) have been calculated as results of the market simulations, according to the CBA methodology
- the discounted SEW/standard cost ratios for all borders have been evaluated.

In the following figure a summary of the main results after four market iterations concerning the CCS region are reported.

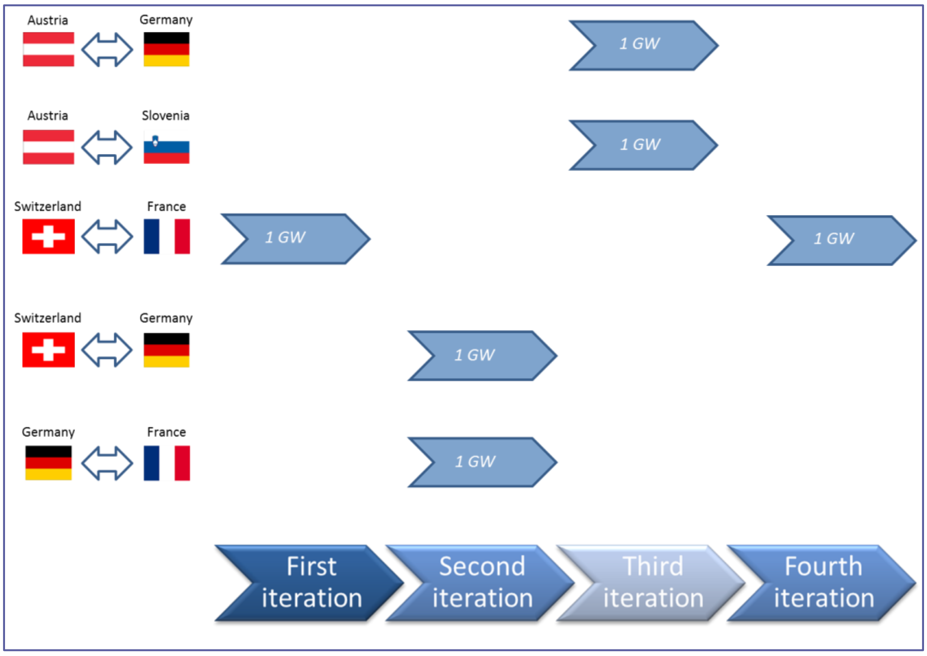


Figure 4-5 summary of CPS iteration in CCS region

[3] Additional details on the market model and the tool used in the CPS are reported in Appendix.

As it can be seen in the figure, after the above mentioned market studies under high RES conditions, further needs concerning the following five beneficial borders have been preliminarily envisaged, to be analyzed more in detail:

- AT-DE: additional 1 GW cross-border capacity increase in both directions
- AT-SI: additional 1 GW cross-border capacity increase in both directions
- CH-FR: additional 2 GW cross-border capacity increase in both directions
- CH-DE: additional 1 GW cross-border capacity increase in both directions
- FR-DE: additional 1 GW cross-border capacity increase in both directions.

France is the country mainly interested, with additional 3 GW of interconnection capacity on the borders with the other CCS countries.

In the following map, the total cross-border capacities resulting from the base case market simulations under high RES development conditions (TYNDP 2014 V4) are described.

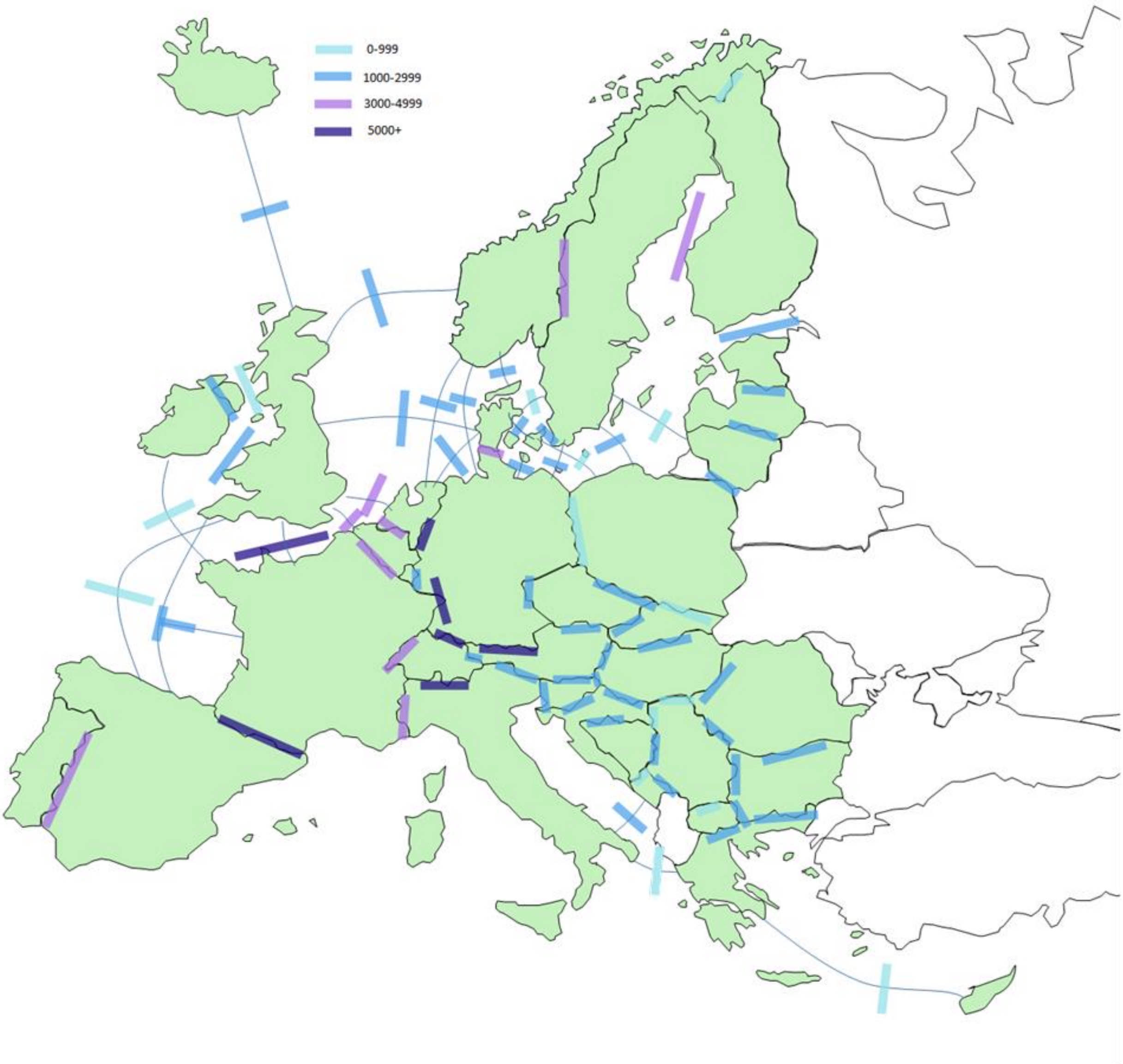


Figure 4-6 Preliminary transmission development needs

The Regional Group CCS also conducted a few sensitivity analyses in order to challenge the results of the base case market simulations and to test the robustness of the above mentioned additional development needs.

The choice of scenarios to be used for these sensitivities was made at regional level, focusing on the following three main parameters/variables:

- load: reduced with respect to the TYNDP V4
- RES: wind and especially solar reduced with respect to TYNDP V4
- thermal power: reduced to better assess the effect of the recent dismissing/mothballing politics from the generation companies.

In this respect, taking also into account of the limited time and resources available to build up some new ad hoc scenarios, it was verified that TYNDP 2016 draft V3 and draft V4 scenarios were generally able to meet the above mentioned criteria. Moreover, these draft scenarios were particularly interesting because they already offered the possibility to anticipate the assessment of the network development needs in the perspective of the TYNDP 2016.

The aim of the sensitivities in the CCS region was mainly challenging the results of the base case simulations under TYNDP 2014 V4 (considered as the most demanding scenario), rather than to find additional needs. Therefore the sensitivity analyses have been performed

1. starting from the results of the base case (with the cross-border capacities increased accordingly)
2. TOOT-ing one by one each of the 5 cross-border capacity increases under the new TYNDP 2016 draft scenarios
3. evaluating again the benefits on each of the 5 borders under these different conditions.

In the following tables the main results of the sensitivities performed are reported.

Table 4-2 Common Planning Studies – Sensitivity results

Border	TOOT [GW]	SEW [M€/year]	
		TYNDP 2016 V3	TYNDP 2016 V4
AT - SI	1	<10	<10
CH - FR	2	<10	25÷30
DE-FR	1	10÷15	<10
AT-DE	1	10÷15	10÷15
CH-DE	1	10÷15	10÷15

In both scenarios, the potential cross-border capacity increase needs on the above mentioned borders provided in general much lower benefits (SEW, RES integration, CO2 emissions) leading to the conclusion that additional investigation – also from a network perspective – would be necessary before to establish increased target capacities on those borders.

4.3 Network studies results

The network studies performed in the CCS region are aimed at identifying and validating further network development needs (on top of the TYNDP 2014 project list) based also on the results of the market studies, in order to set target capacities. The network simulations are also necessary to define additional (even conceptual) projects enabling to meet the established transmission capacity targets.

As a first step, power flows have been calculated to detect bottlenecks in N and N-1 conditions. In that purpose, *two different studies* have been performed, based on a grid model including the reference grid of the TYNDP 2014 (all the TYNDP2014 projects only in the model):

1. base case: load flow simulations based on the market outputs coming from the iteration process, meaning TYNDP2014 Vision 4 scenario under high RES conditions with increased cross-border capacity on some borders:
   - AT ←→ DE: + 1000 MW
   - AT ←→ SI: + 1000 MW
   - CH ←→ DE: + 1000 MW
   - CH ←→ FR: + 2000 MW

- DE ←→ FR: + 1000 MW

By this way, it was possible to assess the ability of the TYNDP 2014 network to withstand increased power flows, highlighting any bottlenecks due to overloads that can be detected.

2. additional case study: load flow simulations with the market outputs coming from TYNDP 2016 draft Vision 3 with the same cross-border capacities as in the TYNDP 2014.

The 2 case studies used correspond to 2 different perspectives:

- the first one concerns the assessment by network studies of the robustness of the five cross-border capacity increase coming out from the basic market studies under high RES conditions;
- the second should be considered as a different investigation, rather independent from the common planning market studies results, aimed to find additional bottlenecks in the TYNDP 2016 draft V3 scenario, starting from the TYNDP 2014 network configuration. This second perspective was considered also because the new V3 market sensitivity analysis revealed the five cross-border capacity increases were not so much beneficial.

As already mentioned, according to the *methodology used*, the inputs of the network studies are the market simulations outputs (that are necessary to establish the hourly datasets consistent with the load and generation yearly profiles in the considered scenarios). Based on the hourly data of generation and load for each country, the CCS network study group achieved to launch load flows simulations to have physical flows on each hour of the year. Then, the results have been analysed in terms of both frequency and severity of overloads[4]. The combination of these analyses is presented in the maps below.

The monitoring of bottlenecks is done on all the lines of the modelled grid but the *perimeter* of the maps is reduced: we focused on the interconnection lines of CCS but also on internal 400 kV lines (eastern part of France, northern part of Italy, Switzerland and Slovenia), and relevant 220 kV lines if there are used for international flows.

The most important *overloads*, having higher frequency and intensity, are on the lines marked in red in the maps (when they happen in N conditions they are highlighted with bold red lines). Some overloads (yellow lines) could be managed by properly setting existing and planned control devices. In a few cases they need additional investigations to be confirmed because they are rather occasional or they could be due to provisory network configurations.

In the first map, the main *bottlenecks* are located on the FR-CH border (including internal French lines) due to the fact that the market capacity was increased by 2 GW on that border on top of the existing projects. Most of the time, this is due to high flows coming from France[5] to Switzerland, Italy and Germany which create overloads. Physical flows (loop flows) created by the increase of 2 GW of the FR-CH market capacity cause also overloads on the FR-IT border. As better explained below, both problems can be addressed with new projects (including an HVDC link) between FR and CH.

Further bottlenecks are present also close to the FR-DE and CH-DE borders both in N and N-1 conditions.

[4] By using PTDF matrixes, in each of the above mentioned case studies the most representative point in times (PiTs) were selected, and their representativeness weighted (as a %) with respect to the 8760 hours of the year. Then in each PiT the bottlenecks with their severity (% overloads) were detected on each relevant network element.

[5] With also the capacity increased between ES and FR and between GB and FR allowing to have higher flows from the peripheral areas to the central Europe.

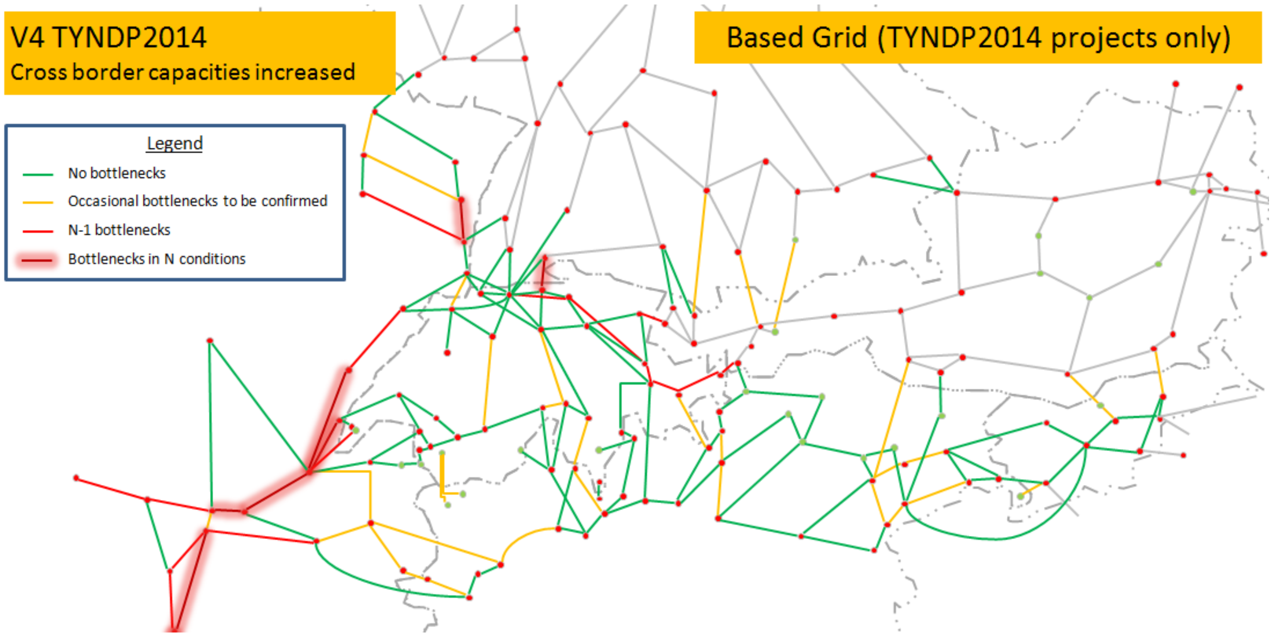


Figure 4-7 Base case 1. - Map of bottlenecks (power flows from TYNDP 2014 Vision 4 and increased market-based cross-border capacities)

In the second map, overloads are detected only in N-1 conditions, meaning that power flows due to the TYNDP 2016 draft scenario are too high sometimes during the year compared to the physical capacities under security conditions of the TYNDP 2014 grid. Structural problems appear again on the FR-CH border, confirming that additional network developments are needed to overcome bottlenecks. While only occasional issues can be observed near the FR-DE and CH-DE borders.

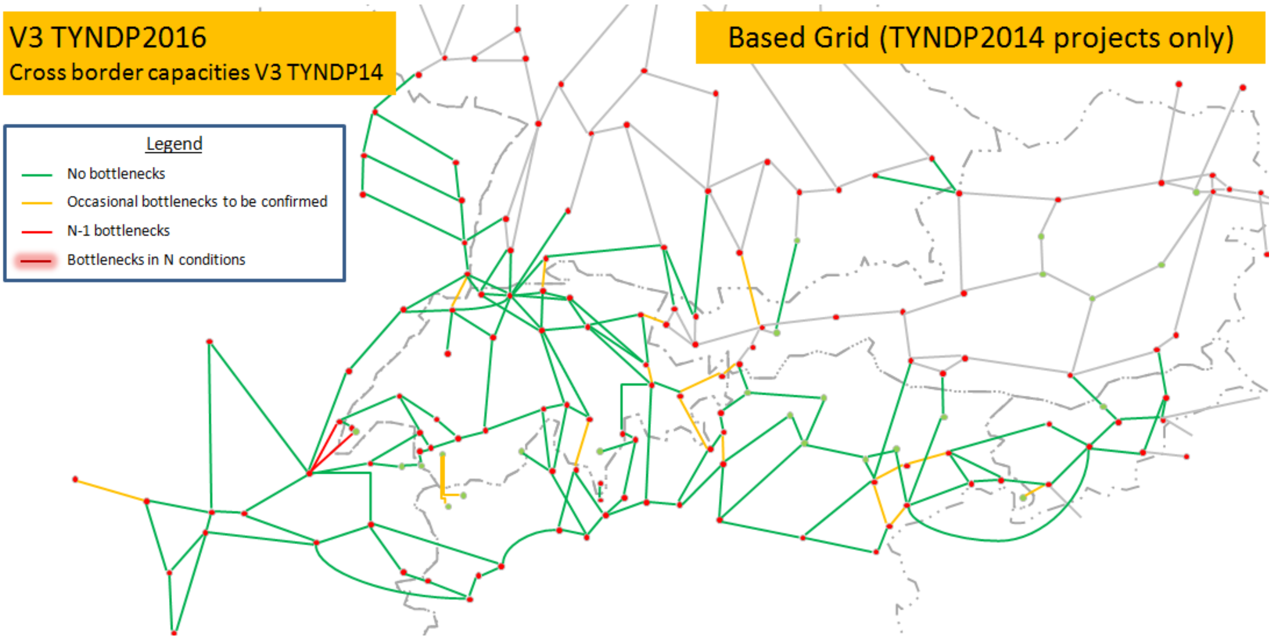


Figure 4-8 Case study 2. - Map of bottlenecks (power flows from TYNDP2016 draft Vision 3 and TYNDP 2014 cross-border capacities)

In both of the examined case studies, a few overloads occur in N-1 conditions on the AT-IT and AT-DE borders, needing further investigations due to the fact that they are confirmed only under very high RES circumstances and they could be linked also to the transmission capacity on SI-IT and AT-IT borders (where 2 projects, namely the 400 kV double circuit line Udine – Okroglo and the interconnector Austria – Italy that were included in the TYNDP 2014, have not been confirmed anymore in the list of candidate projects for the TYNDP 2016 mainly due to feasibility problems).

Based on the results of the network simulations, the borders in the western part of the CCS Region (FR-CH, FR-DE and CH-DE) appear as the most congested, especially in the scenario under high RES conditions (base case study), leading to confirm higher target capacities and the need of additional investment to be assessed in the TYNDP 2016.

A few additional simulations have been performed to address these needs by identifying new projects able to solve the overloads detected (and checking, at the same time, the consistency of the assumptions concerning standard costs used in the market studies).

On that purpose, a few additional reinforcements have been studied and in the end the following concept projects have been proposed to be assessed during the assessment phase of the TYNDP 2016 (they have been included in the list of projects of TYNDP 2016):

- on the CH-FR border, to cover the 2 GW increase expected by the market, two projects have to be coincedent
    - first one is a new 400 kV line between Génissiat (FR) and Verbois (CH) with a cost of about 120 M€
    - then to reach the 2 GW, in order to address also the internal overloads in France, it is proposed to implement a HVDC line of 1000 MW between the area of Lyon (FR) and the Romandie area (CH). This investment should cost at least 500 M€
- on the CH-DE border, the upgrade of the 220 kV line Beznau – Tiengen to a 400 kV line, coupled with internal reinforcements in Switzerland and Germany, cover the need to achieve the 1 GW transmission capacity increase. The cost of this investment is assumed as about 145 M€.

In addition, on the FR-DE border, the market capacity target after the common planning studies iterations with the TYNDP 2014 Vision 4 is almost reached with the already planned long term projects (increased capacities of the lines Vigy – Uchtelfangen and Eichstetten – Muhlbach).

As already mentioned, additional investigations are necessary to address possible congestions to be confirmed on the other network portions.

4.4 Definition of target capacities and new projects

In the CCS region target capacities have been set based on the results of the common market and network simulations, including sensitivity analyses.
In this respect, as already mentioned:

a. preliminary market simulations based on TYNDP 2014 V4 scenario were used to identify further market based potential development needs
b. sensitivity (under TYNDP2016 V3 and TYNDP2016 V4 draft scenarios) market simulations and network studies (including sensitivities under TYNDP2016 V3 draft scenario) were used to assess the robustness of the potential needs identified in point a. and to properly set future target capacities.

Summarizing, the above mentioned approach led to the following:

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a. preliminary needs based on TYNDP 2014 V4 basic market simulation are the following cross-border capacity increases
   - AT ←→ DE: + 1000 MW
   - AT ←→ SI: + 1000 MW
   - CH ←→ DE: + 1000 MW
   - CH ←→ FR: + 2000 MW
   - DE ←→ FR: + 1000 MW

b. market and network studies, including sensitivities, confirmed only the last 3 increases concerning borders CH-DE, CH-FR and FR-DE in order to establish the following increased target capacities

Table 4-3 Increased target capacities

Country 1	Country 2	From 1 to 2 [MW]	From 2 to 1 [MW]
Switzerland	Germany	6000	6000
Switzerland	France	4800	6700
Germany	France	5100	5100

Further needs on other borders (like AT-DE and AT-SI) have still to be confirmed after additional investigations because sensitivity analyses based on TYNDP2016 draft Visions have shown that increasing the cross-border capacity on those borders would not be profitable and they could be affected by the different conditions due for example to the elimination of some developments on the AT-IT and SI-IT borders (namely the 400 kV double circuit line Udine – Okroglo and the phase 2 interconnector Austria – Italy) from the TYNDP 2016 project list.

Given the above, the results of the CPS studies, confirmed the of the TYNDP 2014 and especially the opportunity to consider - further to the projects already planned in the TYNDP 2014 - additional transmission capacity increases on the borders between Switzerland and France, between Switzerland and Germany and between France and Germany.

To meet the identified targets, based on the results of common planning studies performed in the Region, RGCCS proposed the following additional “concept projects”:

- FR-CH border: a new 400 kV line (with a PST) Génissiat – Verbois and a new HVDC line between Lyon area and the Romandie area - to achieve a 2 GW transmission capacity increase;
- CH-DE border: upgrade Beznau – Tiengen (from 220 kV to 400 kV) and internal reinforcements in CH and in DE - to achieve a 1 GW transmission capacity increase.

New projects proposed to be assessed in the TYNDP 2016 are described in the following figure.

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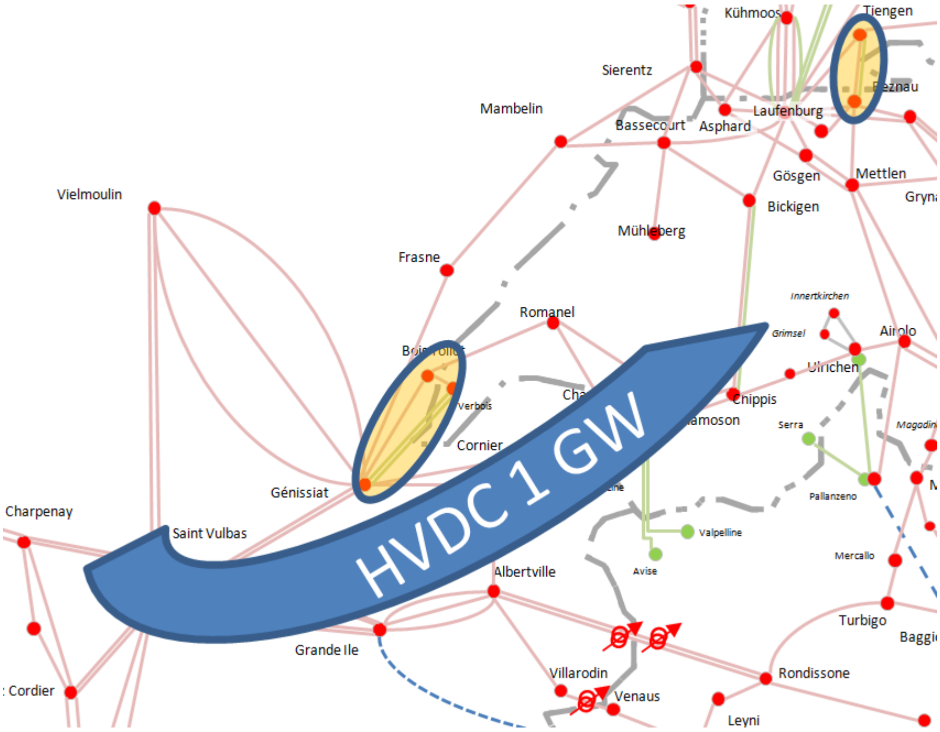

Figure 4-9 Future concept projects proposed

In addition to the above, on the FR-DE border, projects Eichstetten – Muhlbach (upgrade from 220 kV to 400 kV) and Vigy - Ensdorf (Uchtelfangen) (increase of the thermal capacity), already part of the TYNDP 2014 (project 152), were reconsidered as two separate projects allowing in the long term almost a further 1 GW transmission capacity increase with respect to TYNDP 2014 estimation, making possible to come very close to the target.

4.5 e-Highway 2050 scenarios perspective

The e-Highway2050 project is supported by the EU Seventh Framework Programme and aims at developing a methodology to support the planning of the Pan-European Transmission Network. The study project started in September 2012 and will end in December 2015.

The main goal is to develop a top-down methodology for the expansion of the pan-European electricity grid from 2020 to 2050, with a view to meeting the EU energy policy objectives. Concretely, the methodology will ensure that future EU grids can host large quantities of electricity from renewable energy sources and transport it over long distances as well as foster market integration.

The E-Highway2050 project is based on five future power system scenarios (Example, see figure below), which are extreme but realistic for a 2050 perspective. The corridors identified provide a modular development plan for a possible long-term architecture. The five scenarios span uncertainties (technical, economics, political, social...) as well as different future choices (RES incentives, energy market integration, regulations, industry standards...).

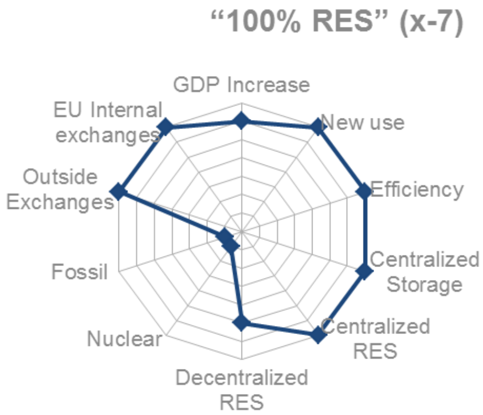

Figure 4-10 - Example of scenario characteristics

The methodology used in the e-Highway project, though different from the TYNDP planning, is still built around market and network studies. To focus on 2050 pan-European adequacy and efficiencies, it is based on stochastic analysis of unsupplied energy, energy spillage and thermal generation re-dispatching. The network model used is much simplified, based on a limited number of clusters all interconnected by equivalent impedance links (see figure below).

Figure 4-11 - Reduced European grid

A comparison between 2030 and 2050 scenarios is subjective and in essence a fast evolving energy domain can always move from one 2030 Vision to any 2050 scenario. Therefore the four TYNDP Visions all show rather different ways to move forward to the 2050 goals. Regardless of the scenario perspective taken, it is important to see the TYNDP2016 projects as no-regret options across the common corridors identified in the e-Highway project, meaning that TYNDP2016 projects are the first steps to be considered by 2030 in order to match with 2050 very long term perspectives.

The regional results in this report provide further insight on this.

In the following figure, the draft results concerning additional reinforcements throughout the five EH2050 visions are displayed (colour codes represent the number of appearances in the different scenarios). It is possible to see that national borders are first object for reinforcements, but huge needs to transport RES from pan-European periphery to central Europe are envisaged as well.

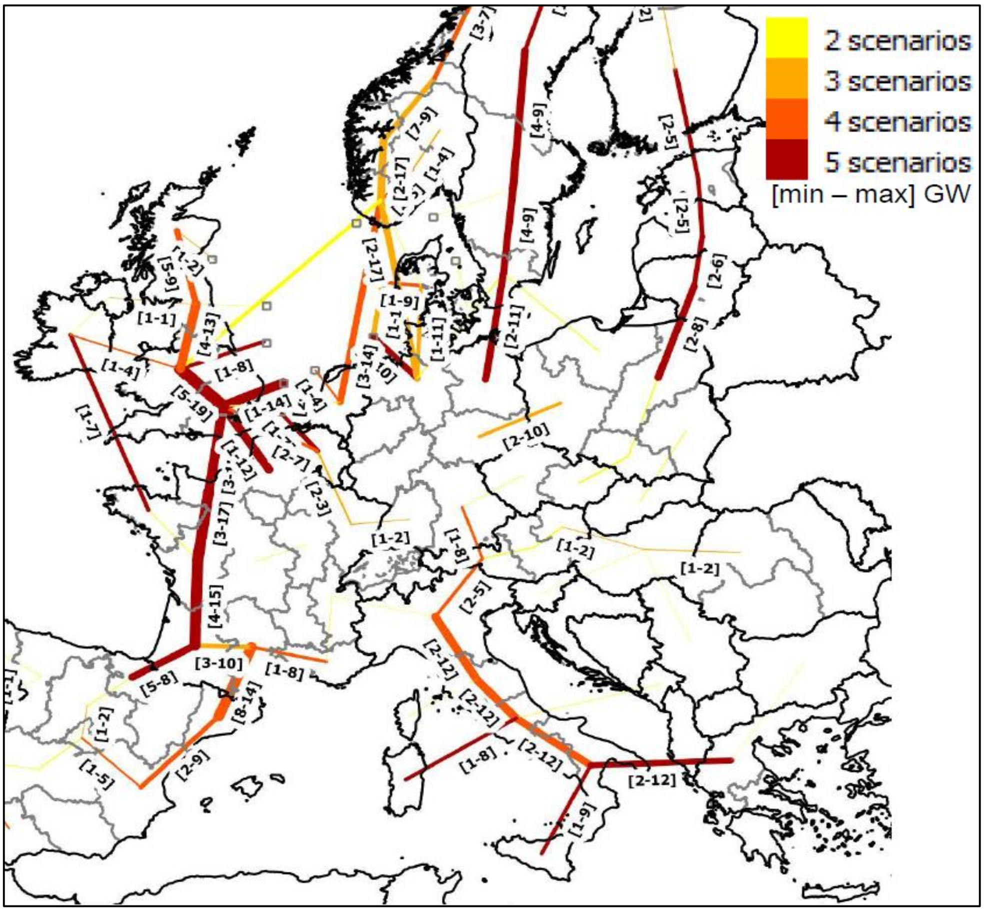

Figure 4-12 EH2050 common reinforcements (number of appearances in the different scenarios)

In general, the reinforcements yielded by EH2050 (to be performed from 2030 to 2050) are to be considered <u>on top of the TNYDP projects</u> (to be performed from now to 2030).
Concerning especially the CCS Region, EH2050 draft results confirm the need in the long run to develop the French-German border by 1 to 6 GW compared to existing grid, depending on the scenario. Especially the “100% RES scenario” shows the highest need for additional capacity. In this respect, the modular development of this West to East axis is supported also by the results of the current Regional Investment Plan report, which already proposes two projects for increasing the capacity on the FR-DE border.

EH2050 investigations do not show any significant need for additional grid development on top of that already considered in TYNDP2014 in the eastern part of France, nor through the Alps.

Concerning the South to North axis, the draft EH2050 results depict huge reinforcements (additional to the ones highlighted in the TYNDP and in the present report)

- of internal corridors
  - from South to North all along Italy
  - from Sardinia and from Sicily to the Mainland

- and of additional interconnections to export high extent of power
  - from Italy to Austria
  - from Italy to Greece

that appear strongly dependent on scenario's assumptions concerning solar development in North Africa (up to 150 GW under large scale RES development circumstances) and on assumptions on the connection points for the injection of this power in the Italian transmission system.

Also on the North to South axis, EH2050 corridors including additional links going

- from UK through France to Spain;
- from Ireland to France;

play a central role in all scenarios.

In the same way, development of additional interconnection from North and Baltic Sea areas towards Germany and central Europe represents in the long run a strategic axis, to build on further to the implementation of the project already planned, including the internal German lines labelled 2030 in the TYNDP 2014.

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5 PROJECT CANDIDATES

5.1 Introduction

This chapter lists all TYNDP project candidates which after finalization of the list will be assessed by ENTSO-E as part of the TYNDP2016 process. In addition, projects that have impact on the region but are not of pan-European significance are also presented in this chapter; these are not part of the TYNDP list and will not be further assessed in the final TYNDP report.

A project is defined as the smallest set of assets that effectively add capacity to the transmission infrastructure that can be used to transmit electric power, such as a transformer + overhead line + transformer. In situations where multiple projects depend on each other to perform a single function (i.e. a single project cannot perform its function without a certain other project) they can be clustered in order to be assessed as a group providing that they achieve a common measurable goal.

TYNDP2016 projects as well as regional projects are based on earlier TYNDP2014 projects, result from recent common planning studies, and/or are driven by political targets.

TYNDP project candidates in this list are structured by

- **Boundary** – which can be a specific border, a combination of borders, or an internal boundary;
- **Maturity** – based on commissioning date and national approval projects are grouped as
    - Mid-term projects: Project to be commissioned by 2022 will be assessed by TOOT method against the expected 2020 network if is acknowledged in the latest national plans or is having intergovernmental agreement;
    - Long-term projects: Project to be commissioned by 2030 will be assessed by TOOT method against the expected 2030 network and PINT method against the expected 2020 network if the project is acknowledged in the latest national plans or is having intergovernmental agreement;
    - Future project candidates: All other projects which do not fall under the previous categories will be assessed with PINT method against the expected 2030 network.

The following map shows all cross-border projects to be analyzed during TYNDP2016. The projects are categorised by the following colour code:

- Dark blue – new TYNDP project candidates (among which the ones identified during the Common Planning Studies)
- Light blue – re-confirmed TYNDP2014 projects
- Grey – Regional projects (if specified)

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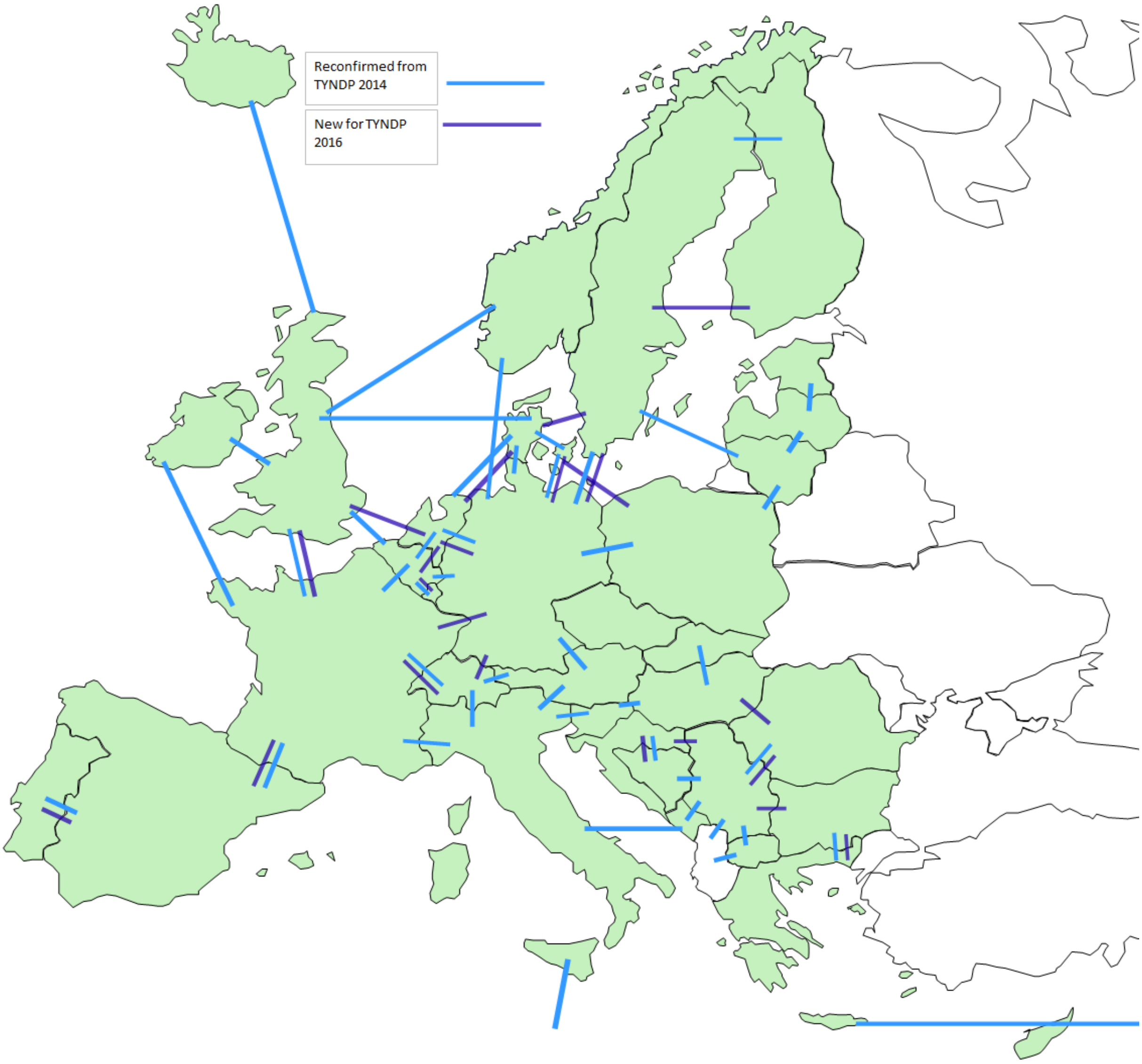

Figure 5-1 Borders with reconfirmed or new projects

5.2 List of TYNDP 2016 project candidates

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
Austria - Germany	**St. Peter - Pleinting**	Increase of the cross border transmission capacity by erecting a new 380kV line between St. Peter (Austria) and Pleinting (Germany). This leads to an improved connection of the very high amount of RES in Germany and the pump storages in the Austrian Alps.	1500	187	new 380-kV-line Pleinting (DE) - St. Peter (AT) on existing OHL corridor	2022	Long-term Project	APG;TENNET-DE
Austria - Italy	**Wurmlach (AT) - Somplago (IT) Interconnection**	"Somplago - Wurmlach interconnection is a third party cross-border electrical line promoted by Alpe Adria Energia SpA. The project concerns a 220kV a.c. merchant line, 300 MVA from Somplagosubstation to Wurmlach substation, including a 300MW Phase Shift Transformer, located in Austria ."	275[6]	210	(tbc)	2018	Mid-term project	Alpe Adria Energia SpA
Austria - Italy	**Austria - Italy**	Reinforcement of the interconnection between Italy and Austria via two new single circuit crossborder lines and closure of the 380-kV-Security Ring in Austria.	Direction A: 1100 - Direction B: 1000	26	The project supports the interaction between the RES in Italy and the eastern part of Austria with the pump storage power plants in the Austrian Alps.	2023	Long-term Project	APG;TERNA
France - Germany	**Muhlbach - Eichstetten**	Operation of a second circuit at 400kV OHL Muhlbach - Eichstetten, instead of the currently operated circuit Eichstetten - Vogelgrun at 225kV. Some restructurations on the existing grid may be necessary in the area. Reinforcement of the existing circuit at 400kV OHL Muhlbach - Eichstetten in order to increase the thermal capacity of the line.	300	Security of supply (mutual support), Exchange capacity improvement between France and Germany	TYNDP2014 and Common Planning Studies. Reclustering of TYNDP2014 project 152. Both investments of project 152 (Muhlbach - Eichstetten and Vigy - Uchtelfangen) have been studied and assessed in a common study performed by the concerned TSOs in the framework of TYNDP2014 and German National Grid Development Plan	2025	Long-term Project	RTE;TransnetBW
France - Germany	**Vigy - Uchtelfangen area**	Upgrade of existing transmission OHL between Vigy and Uchtelfangen (or beyond) to increase its capacity	1500	Positive impact on the exchange capacity between France and Germany	TYNDP 2014 and Common Planning Studies. Reclustering of TYNDP2014 project 152. Both investments of the project 152 (Muhlbach - Eichstetten and Vigy - Uchtelfangen) have been studied and assessed in a common study performed by the concerned TSOs in the framework of TYNDP2014 and German National Grid Development Plan. Details of the technical realisation are currently under investigation.	2030	Long-term Project	Amprion;RTE

[6] The reported value is what was communicated by the Promoter in 2015. The GTC value assessed by ENTSO-E in TYNDP 2014 is 150 MW; it is preliminary used for calculating the new reference capacity on the relevant border.

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
France - Italy	**Italy-France**	The Project comprises a new HVDC interconnection between France and Italy as well as the removing of limitations on existing 380 kV internal Italian lines. The removing of limitation is necessary to take full advantage of the increase of interconnection capacity provided by the cross-border line.	Direction A: 1200 - Direction B: 1000	21	The project favours the market integration between Italy and France as well as the use of the most efficient generation capacity; it also increases possible mutual support of both countries. In addition, the project can contribute to RES integration in the European interconnected system by improving cross border exchanges. Such benefits are ensured within different future scenario.	2019	Mid-term Project	RTE;TERNA
France - Switzerland	**Lake Geneva South**	This project comes on top of "Lake Geneva West" and "upstream grid reinforcement in France" projects. It consists in upgrading to 400-kV the existing 225-kV overhead line south of Lake Geneva.	FR-> CH 400 ; CH -> FR 1000	199	Main benefits are expected in terms of market integration and better integration of Swiss hydro generation, especially storage.	2026	Future Project	RTE;SWISSGRID
France - Switzerland	**Lake Geneva West**	The project consists of uprating the existing 225-kV double circuit overhead line Genissiat- (FR) - Verbois (CH) in order to increase its capacity.	FR->CH 500 ; CH->FR 0	22	The project will increase the capacity from France to Switzerland and secure the supply of Geneva.	2020	Mid-term Project	RTE;SWISSGRID
France - Switzerland	**Upstream reinforcement in France to increase FR-CH capacity**	The project consists in attracting the flows to the interconnection south of Lake Geneva in order to alleviate the congestion on the link west to Lake Geneva . It is necessary before implementing "lake Geneva South" project but could not be clustered due to the 5-year clustering rule. It consists in a phase-shifter in Cornier substation (FR) together with an uprate of the existing Creys-St Vulbas 400-kV double-circuit OHL to increase its capacity.	FR->CH 1100; CH->FR 500	Market integration also Swiss hydro generation integration, including pump storage	The studies followed up those conducted in the framework of TYNDP2014, aiming at better defining the project "lake Geneva South" and its integration in the grid.	2020	Future Project	RTE
France - Switzerland	**Concept project France-Switzerland 400kV AC**	The project consists of a new 400-kV cross-border line between France and Switzerland. Although this project is at vey conceptual stage, for the assessment, connections could be considered in Genissiat (FR) and Verbois (CH).	1000	Market integration,also Swiss hydro generation integration, including pump storage.	Common Planning Studies showed the interest to develop the France-Switzerland profile by 2 GW in the Long Term High RES scenario on top of "Lake Geneva West" and "Lake Geneva South" already included in TYNDP2014. This project contributes to this objective.	>2030	Future Project	RTE;swissgrid
France - Switzerland	**Concept project France-Switzerland HVDC**	This concept project is a new HVDC between France and Switzerland.	1000	Market integration, also Swiss hydro integration including pump storage.	Common planning Studies showed the interest to develop the France-Switzerland profile by 2 GW in the long term scenario wiht high RES on top on the TYNDP2014 "Lake Geneva West" and "Lake Genevaz South" projects. This project contributesd to this objective.	>2030	Future Project	RTE;swissgrid

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
Germany - Austria	**AT - DE**	This project reinforces the interconnection capacity between Austria and Germany. The national investments comprised are a precondition to achieve the full benefit of the cross border investments and are vital for the Austrian security of supply (e.g. part of the Austrian 380-kV-Security Ring). It supports the interaction of RES in Northern Europe (mainly in Germany) and in the eastern part of Austria with the pump storages in the Austrian Alps and therewith facilitates their utilisation.	2900	47		2021	Mid-term Project	AMPRION;APG;TENNET-DE
Germany - Austria	**Area of Lake Constance**	The transmission capacity of the 380-kV-grid in this grid area and especially the cross-border lines between Germany and Austria are extended significantly by this project. Capacity overloads with existing lines are eliminated and therefore connection between the German and the Austrian transportation grid is strengthened.	1000	198		2023	Long-term Project	AMPRION;TRANSNET-BW
Germany - Switzerland	**Concept project Germany-Switzerland**	The project will have a significant relation to the projects Swiss Roof I and Swiss Roof II and therefore will have relation to the border CH-DE. The effect of the border CH-DE has been already considered within the projects Swiss Roof I and Swiss Roof II.	1000	The TYNDP 2016 Common Planning Studies showed the interest to increase the Germany-Switzerland capacity by 1 GW on top of the 'Swiss Roof I' and 'Swiss Roof II' projects that correspond to the 'Swiss Roof' project of TYNDP 2014. This project contributes to this objective.	The TYNDP 2016 Common Planning Studies showed the interest to increase the Germany-Switzerland capacity by 1 GW on top of the 'Swiss Roof I' and 'Swiss Roof II' projects that correspond to the 'Swiss Roof' project of TYNDP 2014. This project contributes to this objective.	> 2030	Future Project	swissgrid;TransnetBW; Amprion
inside-DE	**OWP Northsea TenneT Part 4**	Connection of offshore wind parks in the North Sea to Germany. Mainly subsea DC cable. The OWP will help to reach the Eropean goal of CO2 reduction and RES integration	3600	129		2031	Future Project	TENNET-DE
inside-DE	**OWP TenneT Northsea Part 2**	Connection of offshore wind parks in the North Sea to Germany. Mainly subsea DC cable. The OWP will help to reach the Eropean goal of CO2 reduction and RES integration	5400	191		2022	Mid-term Project	TENNET-DE
inside-DE	**OWP Northsea TenneT Part 3**	Connection of offshore wind parks in the North Sea to Germany. Mainly subsea DC cable. The OWP will help to reach the Eropean goal of CO2 reduction and RES integration	4500	192		2027	Future Project	TENNET-DE
inside-inside	**Reinforcement Northwestern DE**	Integration of on- and offshore RES in Lower Saxony	5500	207		2024	Long-term Project	50HERTZ;AMPRION; TENNET-DE

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
inside-inside	**N-S Western DE_section North_1**	Integration of on- and offshore RES in Lower Saxony	5500	208			Mid-term Project	50HERTZ;AMPRION; TENNET-DE
inside-inside	**Reinforcement Northeastern DE**	New 380-kV-lines in the area of Schleswig-Holstein mainly for integration of Onshore-Wind.	12000	209			Mid-term Project	50HERTZ;AMPRION; TENNET-DE
inside-inside	**N-S transmission DE_par_line_2**	new 380-kV-OHL between Thuringa and Bavaria due to increase of RES in Northen Germany	11800	204		2024	Long-term Project	50HERTZ;TENNET-DE
inside-inside	**N-S transmission DE_par_line_1**	new 380-kV-OHL between Thuringa and Bavaria due to increase of RES in Northern Germany	11800	205		2015	Mid-term Project	50HERTZ;TENNET-DE
inside-inside	**N-S Eastern DE_central section**	North-South transmission in Germany. AC links from Northern Germany towards the load centers of Bavaria and Baden-Württemberg.	11800	164		2022	Mid-term Project	AMPRION;TENNET-DE
inside-inside	**Reinforcement Southern DE**	"AC-busbar" in Southern Germany for energy dispatching within Bavaria and Baden-Württemberg and gathering solar energy.	11800	206		2024	Long-term Project	TENNET-DE;TRANSNET-BW
Internal boundary in Germany	**HVDC Brunsbüttel/Wilster to Großgartach/Grafenrheinfeld**	4 GW HVDC connection from Northern Germany (areas of Brunsbüttel/Wilster) to Bavaria / Baden-Württemberg (areas of Großgartach/Grafenrheinfeld)	4000	Integration of RES and security of supply of Southern Germany	NEP (German NDP)	2022	Mid-term Project	TenneT TSO;TransnetBW
Internal Boundary in North-East Germany	**380-kV-grid enhancement between Area Güstrow/Bentwisch and Wolmirstedt**	380-kV-grid enhancement between the areas Güstrow/Bentwisch and Wolmirstedt.	1500	This Project will help to transport the expected amount of RES to the South of Germany. It will also help to increase the technical possibility in this area to integrate the expected new Interconnectors to Scandinavia (e.g. Hansa Power Bridge or Kontek 2).	NEP (German NDP)	2020	Mid-term Project	50Hertz Transmission
Internal Boundary in North-East Germany	**Offshore Wind Baltic Sea (I)**	AC grid connections connecting Offshore Wind Farms in Cluster 1 of the Baltic Sea (see German Offshore Grid Development Plan). Cluster 1 is located north east of Rügen in the German Exclusive Economic Zone.	750	RES connection	German Offshore Grid Development Plan	2018	Mid-term Project	50Hertz Transmission
Internal Boundary in North-East Germany	**Offshore Wind Baltic Sea (II)**	AC grid connections connecting Offshore Wind Farms in Cluster 1, 2 or 4 of the Baltic Sea (see German Offshore Grid Development Plan). Clusters are located north east of Rügen	500	RES connection	German Offshore Grid Development Plan	2026	Long-term Project	50Hertz Transmission

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
		mainly in the German Exclusive Economic Zone.						
Internal Boundary in West-Germany	**Ultranet**	2 GW HVDC-connection from the Region of Osterath (Rhineland) to the Region of Philippsburg (Baden-Württemberg). New circuit on an existing route on the same pylons as AC lines.	2000	Integration of RES and security of supply of South-Germany.	NEP (German NDP)	2019	Mid-term Project	Amprion;TransnetBW
Italy - Tunisia	**Italy-Tunisia**	The project consists in a new interconnection between Tunisia and Sicily to be realized through an HVDC submarine cable.	600	29	The project favours the use of the most efficient capacity in the PAN European interconnected system. The project also increases the system operational flexibility. Such benefits are ensured according to different future scenarios.	2030	Future Project	TERNA
Italy - Switzerland	**Greenconnector**	Greenconnector is an HVDC interconnector project between Italy and Switzerland for power transport using DC cables rather than overhead lines. The route length is about 150 km. The design power is 1000 MW (1200 MW in overload condition), while the DC voltage is +/- 400 kV DC. Two cables will be installed, working with a bipolar scheme. Great part of the cables route will exploit a section of an existing oil pipeline, no longer in service since January 1997. This pipeline crosses the Italian and Switzerland border at Splügenpass and is running close by the two end stations of the Greenconnector project (Sils in Graubunden Canton and Verderio Inferiore, Lecco). The cables will be pulled inside the pipeline itself, reducing the amount of civil works required before and after cable laying and therefore limiting even temporary environmental impact. For about 47 km the cables will run across the Como lake.	1000[7]	174	(tbc)	2021	Mid-term project	Worldenergy SA

[7] The reported value is what was communicated by the Promoter in 2015. The GTC value assessed by ENTSO-E in TYNDP 2014 is 800 MW; it is preliminary used for calculating the new reference capacity on the relevant border.

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
Italy - Switzerland	**Merchant line "Castasegna (CH) - Mese (IT)"**	"The planned Transmission project is a merchant line on the swiss-italian border between Castasegna (CH) and Mese (IT). The planned Cable connection in 220 kV AC has a length of around 14 km, 13.5 of witch in Italy. In connection with the realisation of the project a Rationalisation of the 380 and 132 kV Grid in the region Mese (Provincia di Sondrio) is planned. The expected NTC increase is around 200 MW. The main Project elements are (merchant line):220 kV Connection to the Swiss HVG in Castasegna220 kV Cable line of around 14 km between Castasegna and Mese220/380 kV Substation with PST 250 MVA in Mese The Grid Rationalisation in the Region of Mese foresees the following actions:Displacement of 2 km of the 380 kV Line ""Soazza – Bulciago""Realisation of a new 380/132 kV Substation in Mese (Transformation 2 x 250 MVA)Displacement of 0.8 km of 132 kV LinesRealisation of 2.6 km of 132 kV Cable connectionsDemolition of 2.45 km of 380 kV line and 2.3 km of 132 kV lines"	200	The project has a relevant impact on the 3 pillars of EU energy policy:Address the market integration increasing the interconnection capacity between CWE and Italy;Improve significantly the sustainability promoting a better dispatching of the existing hydro generation in the region as well as the rationalisation of the existing HV Grid in Mese --> substitution of existing 132 kV overhead transmission line with underground transmission cables and unlock valuable municipal land;Improve the security of system operation removing existing bottlenecks in the north Italian HVG and easing dispatching of local hydro generation.	The project is in authorisation process. All preliminary studies have been done. Project Status: design and permittini phase.	2018	Mid-term project	Repower
North-South	**Offshore Wind Baltic Sea**	Grid connections of offshore wind farms (AC), connecting offshore wind farms in the Baltic Sea to the German transmission grid in Bentwisch, Lüdershagen and Lubmin.	4500	46			Future Project	50HERTZ
Italy South - Italy Center	**Central Southern Italy**	The project consists in the reinforcement of southern Italy 400 kV network through new 400 kV lines as well as upgrading of existing assets. The activities will involve the network portions between the substation of Villanova and Foggia, Deliceto and Bisaccia as well as Laino and Altomonte.	Direction A: 0 - Direction B: 1000	127	The projects allows removing internal bottlenecks and increases market and RES integration.	2019	Mid-term Project	TERNA
Italy Center-Italy South	**Central Northern Italy**	The project consists in the strengthening of interconnection between the northern and the central part of Italy. It will involve the upgrading of existing 220 kV over-head line to 400 kV between Colunga and Calenzano substations as well as the removing of limitations on the existing 220 kV network in Central Italy.	600	33	The projects allows removing internal bottlenecks and increases market and RES integration.	2020	Mid-term Project	TERNA

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
North-South	**HVDC Wolmirstedt to area Gundremmingen**	2 GW HVDC-connection from Wolmirstedt to the area of Gundremmingen. Capacity extension to 4 GW is under investigation.	2000	130			Mid-term Project	50HERTZ;AMPRION
North-South	**Longterm German RES**	internal German DC-Link for RES integration	18000	133	This project becomes necessary in case of further long-term strong increase in RES generation like in Vision 3 and 4. The project is not in Vision 1 and 2. It connects areas with high installed capacities of RES and areas with high consumption and storage capabilities. For this reason the development of new North-South and Northeast- Southwest electricity transmission capacity in Germany is necessary. This project begins in the North and North-East of Germany, areas with high RES generation (planned and existing) and connections with Scandinavia (planed and existing).The project ends in the South of Germany, an area with high consumptions and connections to Austria and Switzerland (transit to Italy and pump storage in the Alps).	2034	Future Project	50HERTZ;AMPRION; TENNET-DE;TRANSNET-BW
North-South	**N-S Western DE_parallel lines**	Grid reinforcement between North-West-Germany and South-West-Germany to integrate RES.	5500	135	RES integration and system stability.	2022	Mid-term Project	AMPRION
North-South	**N-S Western DE_section North_2**	New 380-kV-OHL and one DC-Link in North-West Germany for integration of RES, mainly on- and offshore wind.	5500	132		2022	Mid-term Project	AMPRION;TENNET-DE
North-South	**N-S Western DE_section South**	North-South transmission Western Germany - AC reinforcements and upgrades towards the load centers of Baden-Württemberg and Switzerland	5500	134	RES integration and system stability	2021	Mid-term Project	AMPRION;TRANSNET-BW
North-South	**OWP TenneT Northsea part 1**	Connection of offshore wind parks in the North Sea to Germany. Mainly subsea DC cable. The OWP will help to reach the Eropean goal of CO2 reduction and RES integration	5750	42		2017	Mid-term Project	TENNET-DE
outside-inside	**east of Austria**	To allow the grid integration of the planned renewable energy generation (mainly wind power) in the north-eastern part of Austria ("Weinviertel") the transmission grid infrastructure (currently a rather weak 220kV line) has to be enforced and new substations for the connection need to be erected.	1500	186	To allow the grid integration of the planned renewable energy generation (mainly wind power) in the north-eastern part of Austria ("Weinviertel") and to cover the foreseen load growth in that region the transmission grid infrastructure has to be enforced and new substations for the connection need to be erected	2021	Mid-term Project	APG

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
Slovenia - Italy	**Italy-Slovenia**	The project consists in a new HVDC link between Salgareda (Italy) and Divača\Beričevo (Slovenia) which will strengthen the connection between Slovenia and Italy.	Direction A: 800 - Direction B: 700	150	The project increases the transmission capacity between Slovenia and Italy and allows stronger market integration between Italy and Slovenia and broader region. Such benefits are ensured according to different future scenarios. The project could also improve the reliability and security of supply by allowing mutual support of both countries.	2022	Mid-term Project	TERNA;ELES
Hungary - Slovenia	**CSE3**	The project consists of a new double circuit 400 kV line Cirkovce-Pince and a new 400 kV Cirkovce substation (Slovenia) by which a new connection to one circuit of the existing double circuit interconnection line between Hungary and Croatia will be made, thus creating two new cross border interconnection between Slovenia and Hungary and between Slovenia and Croatia. Existing 220 kV lines of the corridor Cirkovce-Divaca will be upgraded to 400 kV level.	HU->SI: 1700 - SI->HU: 2000	141			Mid-term Project	ELES;MAVIR
Sicily - Italy South	**Sicily-Mainland**	The project consists in the strengthening of Sicily - mainland 400 kV interconnection through a new double circuit line which will be realized partly as a subsea cable as well as over-head line.The activity is part of the wider network reinforcement program which involves the Sicilian 400 kV grid.	1000	30	The project allows removing internal bottlenecks and increases market and RES integration. The expected commissioning date is 2015 therefore afterwards it will be dropped from TYNDP 2016	2015	Mid-term Project	TERNA
Switzerland	**Swiss Ellipse I**	The project helps accommodate new pump storage units which mainly support the increasing RES generation in the European areas with solar and wind generation.	3350	Market integration, RES connection	re-clustering of TYNDP2014 project 91	2022	Mid-term Project	swissgrid
Switzerland	**Swiss Ellipse II**	The project helps accommodate new pumping storage units which mainly support the increasing RES generation in the European areas with solar and wind generation.	1650	Market integration, RES connection	re-clustering of TYNDP2014 project 91	2029	Long-term Project	swissgrid
Switzerland - Germany; and Switzerland - Austria	**Swiss Roof I**	This project increases the capacity between CH and its neighbours DE and AT. This enables to connect large renewable generation in Northern Europe to pump storage devices in the Alps, thus noticeably increasing the mutual balancing between both regions.	DE > CH: 1700 MW AT > CH: 500 MW CH > DE: 700 MW CH > AT: 500 MW	Market Integration, Security of Supply, RES connection	re-clustering of TYNDP2014 project 90	2022	Mid-term Project	swissgrid

Boundary	Project name	Description	Provisional GTC [MW]	TYNDP2014 reference (if applicable) or motivation for new project candidates	Detailed studies	Expected Commissioning Year	Classification	Project promoter(s)
Switzerland - Germany; and Switzerland - Austria	**Swiss Roof II**	This project increases the capacity between CH and its neighbours DE and AT. This enables to connect large renewable generation in Northern Europe to pump storage devices in the Alps, thus noticeably increasing the mutual balancing between both regions.	DE > CH: 1700 MW AT > CH: 500 MW CH > DE: 700 MW CH > AT: 500 MW	Market Integration, Security of Supply, RES connection	re-clustering of TYNDP2014 project 90	2022	Future Project	swissgrid
Switzerland - Italy	**Italy-Switzerland**	The project consists of a new 400 kV line San Giacomo-Pallanzeno, conversion from AC to DC of the 220 kV line, including the realization of the 2 AC/DC converter stations and 220 kV to 400 KV substation upgrade. Additional internal lines in Italy and in Switzerland are required to get full advantage from the interconnection capacity provided by the cross-border line.	Direction A: 1000 - Direction B: 950	31	The project significantly increases interconnection capacity between Switzerland and Italy; favours the market integration; helps to use of the most efficient generation capacity and could potentially contribute to RES integration. Such benefits are assured according to different future scenarios.	2022	Mid-term Project	SWISSGRID;TERNA
Inside Germany	**Westcoast line**	New 380-kV-line Brunsbüttel – Niebül inside Schleswig – Holstein. Main focus of the project is the integration of onshore-RES – mainly wind – in Western Schleswig-Holstein. The project is labeled as PCI 1.3.2. It is the southbound connection of PCI 1.3.1. and is necessary to increase the GTC between Dänemark/West and Germany by 500 MW.	3000			2018	Mid-term Project	Tennet-DE
Inside Germany	**Audorf-Dollern**	New 380-kV-line Audorf – Hamburg/Nord – Dollern" in existing 220-kV-corridor. Main focus of the project is the integration of onshore-RES – mainly wind – in Schleswig-Holstein. The project is labeled as PCI 1.4.2. and 1.4.2. It is the southbound connection of PCI 1.4.1. and is necessary to increase the GTC between Dänemark/West and Germany by 720/1000 MW.	3000			2017	Mid-term Project	Tennet-DE

In addition, the following storage projects have been promoted as TYNDP2016 project candidate:

Name of the project	Country	Type of storage	Maximum active power [MW]	Total storage capacity [GWh][8]	Expected commissioning date
Hydro Pump Storage Power Plant Pfaffenboden in Molln	Austria	Hydro Pump Storage	300	1,8	2019
Battery storage in South Italy[9]	Italy	Battery Energy Storage System (BESS)	250	1,7	2022
Kaunertal Extension Project	Austria	Pumped Hydro Storage	1076	152,0	2028

[8] defined as total energy delivered to the grid when reservoir is totally emptied, starting at reservoir full condition
[9] project proposed by Terna as Italian TSO and ENTSO-E member.

5.3 List of projects and investments of Regional significance

By 2030, the main drivers for power system evolution and grid development are:

- increasing the interconnection capacity on the electrical borders, which have the primary goal of reducing procurement costs, increasing exchanges of electrical energy;
- reducing congestion between market zones, contributing to a more competitive electricity market, increasing the utilization of more efficient capacity, including renewable sources;
- reducing internal congestions and capacity constraints;
- safety and reliability of the grid in metropolitan areas with high concentrations of consumers;
- quality, continuity and security of supply of electrical power system in order to reduce risks of not supplied energy, improve voltage profiles, reduce losses on the transmission grid.

Project name	Investment ID	from substation name	to substation name	Description	Main driver	Expected commissioning date	Commissioning date in the TYNDP/RgIP 2014	Evolution driver description since TYNDP/RgIP 2014
	208	Pulgar (DE)	Vieselbach (DE)	Construction of new 380kV double-circuit OHL in existing corridor Pulgar-Vieselbach (103 km) Support of RES and conventional generation integration, maintaining of security of supply and support of market development.		2024	2024	Progress as planned
	474	Ravne (SI)		Construction the new substation 220/110 kV Ravne with new double 220-kV OHL Ravne-Zagrad (the length is approximately 4 km) and it will be included in existing interconnection 220-kV OHL 220 kV Podlog(SI)-Obersielach(AT)	Security of supply	2019		New Investment
		Gießen/Nord	Karben	new 380-kV-line Gießen/Nord - Karben in existing corridor for RES integration		2025		New investment
	959	Lubmin (DE)	Güstrow (DE)	380-kV-grid enhancement and structural change Lubmin-Lüdershagen-Bentwisch-Güstrow		2024	2030	Rescheduled
	960	Lubmin (DE)	Pasewalk (DE)	380-kV-grid enhancement and structural change area Lubmin-Iven-Pasewalk.		2024	2030	rescheduled
TNG-012		Stalldorf		New 380 kV substation between Kupferzell and Grafenrheinfeld	RES integration	2016		New investment
P177		Höpfingen/Kupferzell		New transformers 380/110 kV in existing stations	RES integration	2019		New investment
P179		Heidelberg Nord		New 380 kV substation including 380/110 kV transformer	Security of supply	2018		New investment
	965	Hamburg/Nord (DE)	Hamburg/Ost (DE)	AC Enhancement Hamburg		2024	2023	Rescheduled
	966	Krümmel (DE)	Hamburg/Nord (DE)	AC Enhancement Krümmel		2024	2023	Rescheduled

	967	control area 50Hertz		Contructions of new substations, Var-compensation and extension of existing substations for integration of newly build power plants and RES in 50HzT control area		2024	2023	Rescheduled
	974	Elsfleht/West	Ganderkesee	new 380 kV OHL in existing corridor for RES integration between Elsfleth/West, Niedervieland and Ganderkesee	RES integration	2021	2030	Rescheduled
	975	Irsching	Ottenhofen	new 380-kV-OHL in existing corridor between Irsching and Ottenhofen	RES integration	2030	2030	progress as planned
	976	Dollern	Alfstedt	new 380-kV-OHL in existing corridor in Northern Lower Saxony for RES integration	RES integration	2024	2030	Rescheduled
	977	Unterweser	Elsfleth/West	new 380-kV-OHL in existing corridor for RES integration in Lower Saxony	RES integration	2024	2030	Rescheduled
	978	Conneforde	Unterweser	new 380-kV-OHL in existing corridor for RES integration in Lower Saxony	RES integration	2024	2030	Rescheduled
	993	Röhrsdorf (DE)		Installation of new PSTs in Röhrsdorf		2023	2016	Rescheduled
	1067	Klostermannsfeld (DE)	Lauchstädt (DE)	TBA		2024	2020	Rescheduled
	1083	S.Teresa (IT)	Budduso (IT)	New 150 kV line connecting the substation of S.Teresa, Tempio and Buddusò, allowing the realization of a new 150 kV backbone in Sardinia	RES integration, Security of supply	2018	2018	Investment on time

	1084	Cagliari Sud (IT)	Rumianca (IT)	New 150 kV cable connecting the substation of Cagliari Sud and Rumianca	RES integration, Security of supply	2015	2015	Investment on time
	1088	Mengede (DE)	Wanne (DE)	Reconductering of existing 380kV line Mengede - Herne - Wanne.		2016	2014	Delays due to private law negotiation
	1089	Point Ackerstraße	Point Mattlerbusch	Reconductering of existing 380kV line between Point Ackerstraße-Mattlerbusch		2017	2014	Delays due to costumer power supply
	1090	Niederhein (DE)	Utfort (DE)	New lines and installation of additional circuits, extension of existing and erection of several 380/110kV-substations.		2018	2018	Progress as planned
	1091	Günnigfeld (DE)	Wanne (DE)	Reconductering of existing 380kV line		2018	2018	Progress as planned
	1092	Landesbergen (DE)	Wehrendorf (DE)	Installation of an additional 380-kV circuit between Landesbergen and Wehrendorf		2022	2023	Progress as planned
	1093	Point Okriftel	Farbwerke Höchst-Süd	The 220kV substation Farbwerke Höchst-Süd will be upgraded to 380kV and integrated into the existing grid.		2021	2022	Progress as planned
	1094	Several		This investment includes new 380/220kV transformes in Walsum, Sechtem, Siegburg, Mettmann and Brauweiler.		2019	2024	rescheduled
	1095	Lippe (DE)	Mengede (DE)	Reconductering of existing 380kV line between Lippe and Mengede.		2025	2024	Delays in planning process
	1096	Lüstingen and Gütersloh	Gütersloh	The subsations Lüstingen to Güthersloh will be upgrade to use the line Lüstingen to Güthersloh with 380 kV.		2020	2024	rescheduled
	1097	Several		This investment includes several new 380/110kV transformers in order to integrate RES in Erbach, Gusenburg, Kottigerhook, Niederstedem, Öchtel, Prüm and Wadern. In addition a new 380kV substation and transformers in Krefeld Uerdingen are included.		2019	2019	Progress as planned
	1100	Herbertingen (DE)	point Neuravensburg (DE)	Between the 380-kv-station Herbertingen and point Neuravensburg a new line with a significantly higher transmission capacity will be		2023	2034	rescheduled

				constructed (Grid enhancement).				
	1101	Büttel	Wilster	new 380-kV-line in extisting corridor in Schleswig - Holstein for integration of RES especially wind on- and offshore	RES integration	2021	2019	rescheduled
	1102	junction Mehrum	Mehrum	new 380-kV-line junction Mehrum (line Wahle - Grohnde) - Mehrum including a 380/220-kV-transformer in Mehrum	RES integration	2019	2019	Progress as planned
	1103	Borken	Mecklar	new 380-kV-line Borken - Mecklar in existing corridor for RES integration	RES integration	2021	2021	Progress as planned
	1104	Borken	Gießen	new 380-kV-line Borken - Gießen in existing corridor for RES integration	RES integration	2022	2022	Progress as planned
	1105	Borken	Twistetal	new 380-kV-line Borken - Twistetal in existing corridor for RES integration	RES integration	2021	2021	Progress as planned
	1106	Wahle	Klein Ilsede	new 380-kV-line Wahle - Klein Ilsede in existing corridor for RES integration	RES integration	2018	2018	Progress as planned
	1108	Metzingen-Oberjettingen	Oberjettingen-Engstlatt	New 380kV OHL Metzingen-Oberjettingen (32 km) and new 380kV OHL Oberjettingen-Engstlatt (34 km)	Security of supply	2020	2020	Progress as planned
	1109	Großgartach	Pulverdingen	New circuit 380kV OHL Großgartach-Pulverdingen (30 km) combined with reconductering existing circuit 380kV OHL Großgartach-Pulverdingen (30 km)	Security of supply	2024	2024	Progress as planned
	110	Restructuring of Sorrento Peninsula network		It is planned a new 380/220/150kV substation in East Vesuvius area (near Naples) connected in and out to the existing 380 and 220kV lines "Montecorvino-S. Sofia" and "Nola-S. Valentino". Related to this project, it has been programmed also some reinforcements and restructuring of the existing 220kV and 150 kV network in the area of Sorrento Peninsula.	Security of supply	2022	2020	New investment (already planned in NDP)
	105	Treviso (IT)		New 380/132kV substation in Treviso area, connected in and out to the existing 380kV line "Sandrigo - Cordignano".	Security of supply	2022	2022	Investment on time-Long permitting process (request for building and

								operation)
	118	Porto Ferraio (Elba Island)(IT)	Colmata (IT)	New 40km 132kV connection via subsea cable between the existing substation of Porto Ferraio and Colmata.	Security of supply	2020	2020	Investment on time
	119	Capri (IT)	Missing data	New 150kV subsea connection of Capri Island to the existing substations of Cuma and Torre Annunziata (mainland Italy). New 150 kV substation in Capri island.	Security of supply	2016	2020	Investment on time- The commissioning date only refers to the interconnection between Capri island and mainland.
	135	220kV nodes (CH)	Missing data	Many 220kV reinforcement around the urban areas.				
	168	Goldshöfe (DE)	Dellmensigen (DE)	Upgrade the line Goldshöfe - Dellmensigen from 220kV to 380kV . Line length:114km. Included in the investment : 3x 380kV substations, 2 transformers.	RES integration	2015	2014	rescheduled
	101	Turin (IT)		Restructuring of the 220kV network in the urban area of Turin. Some new 220kV cables, some new 220/132kV substations and some reinforcements of existing assets are planned.	Security of supply	2019	2019	Investment on time
	66	Brennero (IT)		New 132 kV substation with a 110/132kV PST.	market integration	2016	2016	Investment on time
	613	Prati di Vizze (IT)	Steinach (AT)	Upgrade of the existing 44km Prati di Vizze (IT) – Steinach (AT) single circuit 110/132kV OHL, currently operated at medium voltage.	market integration	2016	2016	Investment on time
	93	Dolo (IT)	Camin (IT)	New 15km double circuit 400kV OHL between existing Dolo and Camin 400kV substations, to be built in parallel with the existing line.	Security of supply	2025	2025	Investment on time-The authorization granted in 2013 was canceled by a State Council Resolution
	97	Polpet (IT)		Restructuring of the existing 220 and 132 kV network in the Media Valle del Piave with the realization of a new 220/132 kV substation. The substation will be connected by two shorts links to the existing Soverzene-Lienz 220kV line.	Security of supply, RES integration	2018	2017	Delayed - Delay in the permetting process due to the request of several integrations, during EIA, by the Authorities involved

	74	Ciminna area (IT)		For the realization of 400kV grid reinforcement, it will be realized the voltage upgrade of the existing Ciminna substation up to 400kV.	RES integration, Security of supply	2019	2019	Investment on time
	636	Assoro (IT)		For the realization of 400kV grid reinforcement, it will be realized a new 400/150kV substation Assoro.	RES integration, Security of supply	2019	2019	Investment on time
	637	Chiaramonte Gulfi (IT)	Ciminna (IT)	Realization of new 400 kV line: "Chiaramonte Gulfi -new station of Assoro- Ciminna"	RES integration, Security of supply	2019	2019	Investment on time
	638	Sorgente 2 (IT)		New 400/150 kV substation in Sorgente area will be temporally connected in and out to the existing 400 line kV "Paterno - Sorgente" and to the local 220 kV and 150 kV network.	RES integration, Security of supply	2019	2019	Investment on time
	916	Assoro (IT)	Villafranca (IT)	Realization of new 400 kV line "Assoro-Sorgente2-Villafranca"	RES integration, Security of supply	2019	2019	Investment on time
	917	Paternò (IT)	Priolo (IT)	Realization of new 400 kV line: "Paternò-Pantano-Priolo"	RES integration, Security of supply	2018	2017	Delayed- delay in the permetting process
	100	Milan (IT)	-	Restructuring of the 220kV network in the urban area of Milan. Some new 220kV cables (33km), a new 220kV substation (Musocco) and some reinforcements of existing assets (35km) are planned.	Security of supply	2019	2019	Investment on time
	102	Naples (IT)	-	Restructuring of the 220kV network in the urban area of Naples. Some new 220kV cables and some reinforcements of existing assets are planned. Total length: 36km.	Security of supply	2018	2018	Investment on time - The commissioning date refers to the main works within the metropolitan area of Naples.
	88	Montecorvino (IT)	Benevento (IT)	New 70km double circuit 400kV OHL between the existing 400kV substations of Montecorvino and Benevento II, providing in and out connection to the future substation to be build in Avellino North area, which will be also connected to the existing "Matera-S. Sofia" 400kV line.	market integration	2022	2021	Delayed- delay in the permitting process (EIA) related to part Montecorvino Avellino Nord; discussion of preliminary localization with local Authorities for Avellino Nord Benevento

	138	tbd (CZ)	tbd (DE) - South-Eastern 50 Hertz	Possible increase of interconnection capacity between CEPS and 50Hertz Transmission is under consideration: either a new 400kV tie-line (OHL on new route) or a reinforcement of the existing 400kV tie-line Hradec (CEPS) – Röhrsdorf (50Hertz Transmission).			2032	This investment item is possible after all projects in CZ area related to the are commissioned - still under consideration
	174	Bruchsal Kändelweg (DE)	Ubstadt (DE)	A new 380kV OHL Bruchsal Kändelweg - Ubstadt. Length:6km.	Security of supply	2014	2014	Progress as planned
	175	Birkenfeld (DE)	Ötisheim (DE)	A new 380kV OHL Birkenfeld-Ötisheim (Mast 115A). Length:11km.	Security of supply	2019	2020	Rescheduled
	178	Goldshöffe and Engstlatt		Installation of 2x250 MVAr 380kV capacitance banks (1x250 MVar Goldshöfe and 1x250MVar Engstlatt).	Security of supply	2014	2014	Progress as planned
	182	Kriftel (DE)	Obererlenbach (DE)	New 400 kV double circuit OHL Kriftel - Obererlebenbach in existing OHL corridor.		2016	2015	The project is delayed due to delays in public-law and civil-law licensing procedures.
	185	Hanekenfähr (DE) and Ibbenbüren (DE)	Uentrop (DE)	In order to facilitate the integration of RES (especially wind) several grid reinforcements in the area of Münsterland/Westphalia are needed. This project will affect mainly the following substations: Hanekenfähr, Uentrop, Gütersloh, Wehrendorf, Lüstringen, Westerkappeln and Ibbenbüren. Within this area new lines and installation of additional circuits are planned. In addition the necessity for extension of existing and erection of several 380/110kV-substations is given.		2020	2020	Progress as planned
	186	Gütersloh (DE)	Bechterdissen (DE)	New lines and installation of additional circuits, extension of existing and erection of 380/110kV-substation.		2014	2015	Main part is finished, some work still to be done in 2015
	187	Utfort (DE)	Rommerskirchen (DE)	New lines and installation of additional circuits, extension of existing and erection of several 380/110kV-substations.		2018	2018	Progress as planned
	190	St. Barbara (DE)	Mittelbexbach (DE)	New lins, extension of existing and erection of several 380/110kV-substations		2016	2014	Delays in planning process

	170	Großgartach (DE)	Hüffenhardt (DE)	New 380kV OHL Großgartach Hüffenhardt. Length: 23km. Included in the project : 1 new 380kV substation, 2 transformers.	RES integration	2014	2013	rescheduled
	172	Mühlhausen (DE)	Großgartach (DE)	Upgrade of the line Mühlhausen-Großgartach from 220kV to 380kV. Length: 45km.	RES integration	2015	2014	rescheduled
	173	Hoheneck (DE)	Endersbach (DE)	Upgrade of the line Hoheneck-Endersbach from 220kV to 380kV. Length:20km.	RES integration	2015	2014	rescheduled
	678	Hamm/Uentrop (DE)	Kruckel (DE)	Extension of existing line to a 400 kV single circuit OHL Hamm/Uentrop - Kruckel and extension of existing substations.		2018	2018	Progress as planned.
	681	Bürstadt (DE)	BASF (DE)	New line and extension of existing line to 400 kV double circuit OHL Bürstadt - BASF including extension of existing substations.		2021	2024	rescheduled
	673	Pkt. Metternich (DE)	Niederstedem (DE)	Construction of new 380kV double-circuit OHLs, decommissioning of existing old 220kV double-circuit OHLs, extension of existing and erection of several 380/110kV-substations. Length: 108km.		2021	2021	Progress as planned.
	672	Area of West Germany (DE)		Installation of reactive power compensation (eg. MSCDN, SVC, phase shifter). Devices are planned in Kusenhorst, Büscherhof, Weißenthurm and Kriftel. Additional reactive power devices will be evaluated.		2018	2016	Delays in planning process
	191	Neuenhagen (DE)	Vierraden (DE)	Project of new 380kV double-circuit OHL Neuenhagen-Vierraden-Bertikow with 125km length as prerequisite for the planned upgrading of the existing 220kV double-circuit interconnection Krajnik (PL) – Vierraden (DE Hertz Transmission).		2017	2016	longer than expected permitting procedure
	197	Neuenhagen (DE)	Wustermark (DE)	Construction of new 380kV double-circuit OHL between the substations Wustermark-Neuenhagen with 75km length. Support of RES and conventional generation integration, maintaining of security of supply and support of market development.		2018	2018	Progress as planned.

	199	Pasewalk (DE)	Bertikow (DE)	Construction of new 380kV double-circuit OHLs in North-Eastern part of 50HzT control area and decommissioning of existing old 220kV double-circuit OHLs, incl. 380-kV-line Bertikow-Pasewalk (30 km). Length: 135km.Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.		2018	2018	Progress as planned.
	200	Güstrow (DE)	Wolmirstedt (DE)	380-kV-grid enhancement and structural change Magdeburg/Wolmirstedt, incl. 380-kV-line Gustrow-Wolmirstedt (195 km).		2020	2020	Investment on time
	202	Bärwalde (DE)	Schmölln (DE)	Upgrading existing double-circuit 380kV OHL in the South-Eastern part of the control area of 50Hertz Transmission. Bärwalde-Schmölln length approx. 50km. Support of RES and conventional generation integration in North-Eastern Germany,maintaining of security of supply and support of market development.		2015	2014	Already in Commission

	206	Röhrsdorf (DE)	Remptendorf (DE)	Construction of new double-circuit 380-kV-overhead line in existing corridor Röhrsdorf-Remptendorf (103 km)		2021	2020	Rescheduled
	683	Wolmirstedt (DE)	Wahle (DE)	New double circuit OHL 380 kV; Line length 111 km	RES integration	2022	2022	progress as planned
	684	Vieselbach (DE)	Mecklar (DE)	New double circuit OHL 400 kV line in existing OHL corridor . (129 km)	RES integration	2022	2022	progress as planned
	78	Palermo area (IT)		Restructuring of the network in the Palermo area. The work consists of a large restructuring of the 150kV network in the Palermo area in order to increase the security and the quality of supply.	Security of supply	2016	2016	Investment on time- The commissioning date refers to the main works within the urban area of Palermo. Additional investments could be delayed due to secondary permitting procedures.
Boucle Nord		Galmiz (CH)	Mathod (CH)	220 kV connection between Galmiz and Mathod on the northern shore of Lake Neuchâtel	security of supply	2025		Was not included in TYNDP/RgIP 2014
Obfelden - Samstagern		Obfelden (CH)	Samstagern (CH)	220 kV connection between Obfelden and Samstagern	security of supply	2025		Was not included in TYNDP/RgIP 2014
Flumenthal - Froloo		Flumenthal (CH)	Froloo (CH)	220 kV connection between Flumenthal and Froloo	security of supply	2025		Was not included in TYNDP/RgIP 2014
	92	Udine West (IT)	Redipuglia(IT)	New 40km double circuit 400kV OHL between the existing substations of West Udine and Redipuglia,providing in and out connection to the future 400kV substation of South Udine	Security of supply, market integration	2016	2016	Investment on time
		Sorrentina Peninsula(IT) Restructuring		Restructuring of 150 kV grid in Sorrentina Peninsula including also the new 220/150kV substation of Scafati, a new 380/220/150 kV and related link to the existing network, new 150kV axes between Lettere and new 150 kV substation of Sorrento	Security of supply	2022	-	New investment (already planned in NDP)

	42	Lonny (FR)	Vesle (FR)	Reconstruction of the existing 70km single circuit 400kV OHL as double circuit OHL.	S Security of supply, RES integration Projet needed to cope with more volatile power flows through Champagne, triggered by the development of new generation sources that would naturally flow to consumptions areas (Paris, Reims...)	2016	2016	-
	44	Havre (FR)	Rougemontier (FR)	Reconductoring of existing 54km double circuit 400kV OHL to increase its capacity in order to integrate new generation.	New conventional generation integration Integration of new conventional generation in Le Havre area	2018	2018	the investment progresses according to the pace of new generation installation in the area.
	596	Cergy (FR)	Persan (FR)	Upgrade of an existing 35-km 225 kV line to 400-kV between Cergy and Persan (north-western Paris area) and connection to Terrier via an existing 400kV line.	Security of supply, Market integration, RES Project triggered by larger and more volatile power flow from new generation, and by new FR GB interconnection projects	2018	2018	-
	598	Fos (FR)	Gaudière (FR)	"Midi-Provence" project New 210-km subsea HVDC link between Fos area and Languedoc.	Security of supply, Market Integration, Generation integrationThis HVDC link will increase transmission capacity between south-eastern and south-western France, allowing for mutual support and taking benefit of complementarity of generation mixes	2020	2020	
	789	FR offshore wind connection		AC 225-kV subsea cables and substations works for connecting to shore French offshore windfarms in order to comply with the 2020 objective.	RES integration Integration of new offshore wind generation	2020	2020	Investment will develop step by step according to the pace of offshore wind generation installation; two calls for tenders have already been issued.

	53	Coulange (FR)	Chaffard (FR)	Reconductoring (with ACCS / ACCR) of two existing double circuit 400kV OHL (Coulange - Pivoz-Cordier - Le Chaffard and Coulange - Beaumont-Monteux - Le Chaffard). Total length of both lines: 275km	Security of supply, Market integration Contributes to improve the security of supply of south-eastern France. In addition this project is part of an overall package of reinforcements aiming at increasing the grid ability to withstand extreme climatic conditions	2017	2016	slight delay due to organisation of works that are made step by step all along the line, taking inot account grid congestion and environmental specificities.
	823	Sud-Aveyron (FR)		New 400-kV substation connected to existing 400-kV grid in Massif Central area and equipped with 400/225 transformers	RES integration This substation is needed to integrate new RES generation in the area, mainly wind.	2018	2018	-
	825	Ouest Amienois		New 400-kV substation connected to existing 400-kV network and equipped with transformers to 220 kV or high voltage networks in order to connect new on-shore wind generation.	RES integration New substation to ensure the integration of wind generation	2015	2015	-
Lille-Arras	603	Avelin (FR)	Gavrelle (FR)	An existing 30-km 400-kV single circuit OHL in Lille area will be substituted by a new double-circuit 400kV OHL.	Security of supply, RES integration The project aims at ensuring the security of supply taking into account RES generation volatility	2018	2017	Validation of the least impact corridor took more time than initially planned due to longer than expected consultation in part of the route.
	602	Avelin (FR)	Mastaing (FR)	Operation at 400 kV of existing line currently operated at 220 kV		2023	2017	Permitting issues and investment needs posponed; hence the investment is postponed.
Brittany "safety net"	790	Calan (FR)	Plaine-Haute (FR)	New 80km single circuit 220kV underground cable between existing stations Calan and Plaine Haute, with T-connection in Mur de Bretagne (existing HV substation where 220-kV voltage will be implemented)	Security of supply The project aims at ensuring the security of supply in Brittany, ans is part of the "Pacte Electrique Breton" which also includes demand side management and new generation in the area	2017	2017	-
	791	PST in Mur de Bretagne (FR)		New 220 kV phase shifter in Mur de Bretagne		2017	2017	-
	792	PST in Brennilis (FR)		New 220 kV phase shifter in Brennilis		2015	2014	The investment will be commissioned with a few months delay due to technical issues during the construction phase.

	794	New AT in Plaine-Haute (FR)		New transformer 400/220kV in existing substation		2015	2015	-
Grid adaptation in Alsace	1078	PST in Muhlbach (FR)		Two 400 kV phase-shifters will be installed in an existing substation in order to mitigate the flows.	Security of supply Following Fessenheim nuclear plant shutdown, the grid in Alsace has to be adapted in order to secure voltage control and mitigate increased power flows through the area	2016	2016	
	1079	MVARs in Alsace		Installation of 320 MVARs of capacitors and 2 reactances of 64-MVAR in Alsace for voltage support.		2016	2016	
	1080	Scheer (FR)		In-out connection of Scheer 400kV existing substation to the existing line Bezaumont-Muhlbach. This investment is needed for securing the area.		2016	2017	this investment is needed after Fessenheim nuclear power station decommisioning.
	1081	Muhlbach (FR)	Scheer (FR)	Ampacity increase of existing 400 kV Muhlbach-Scheer line.		2016	2016	
Long Term perspective in Eastern France	961	Muhlbach (FR)	Scheer (FR)	New 400kV line substituting to existing 225kV line in Alsace area. Several solutions are under consideration and some restructuration of the 225 kV grid may be needed in the area. This investment is only needed in vision 4.	Market integration, RES integration Long term reinforcements package needed in case of high development of RES generation in Northern part of Europe	2030	2030	This investment is needed only in long term high RES scenario; triggered by high north-west to south-east flows in eastern France (from Lorraine and northern border to Alsace, southern Germany and Switzerland)
	962	Vigy (FR)	Marlenheim (FR)	Operation at 400kV of the second circuit of a 112-km existing 400 kV line currently operated at 225kV, with some restructuration of the 225-kV grid in the area.		2030	2030	This investment is needed only in long term high RES scenario; triggered by high north-west to south-east flows in eastern France (from Lorraine and northern border to Alsace, southern Germany ans Switzerland)
	963	Vigy (FR)	Bezaumont (FR)	Operation at 400 kV of the second circuit of a 40-km existing 400 kV line currently operated at 225 kV.		2030	2030	This investment is needed only in long term high RES scenario; triggered by high north-west to south-east flows in eastern France (from Lorraine and northern border to Alsace, southern Germany ans

								Switzerland)
	1098	Mery(FR)	Creney (FR)	Reconductoring an existing 25-km single circuit 400 kV line in Bourgogne area.		2030	2030	Accurate scope of the investment to be defined taking into account congestion in specific long term high RES scenario and refurbishment needed on existing asset.
	964	Creney (FR)	Vielmoilin (FR)	Upgrade of an existing single-circuit 400 kV line in Bourgogne. Accurate scope of the investment should be defined taking into account congestion in specific scenarios (visions 3 & 4) and refurbishment needed on existing assets in the area.		2030	2030	Increase of grid capacity is needed only in long term high RES scenario, triggered by high north-west to south-east flows in eastern France; also possible needs for refurbishment of existing assets in the area.
long term perspective Haute-Normandy - southern Paris area	980	Rossignol (FR)		New 400kV substation east of Paris and associated connections to existing grid.	Security of supply, RES, Market integration Development of new RES generation, as well as new FR GB interconnection capacities, lead to increase flows from West of France to East through Paris Area	2030	2030	This investment is needed in the long run for high RES scenario to balance flows on the north-eastern Paris 400-kV ring.
	981	Chesnoy (FR)	Cirolliers (FR)	Reconductoring Chesnoy-Cirolliers existing 400kV OHL with high temperature conductors in order to strengthen the south-western part of Paris 400-kV ring.		2030	2030	This long term investment is needed only in long term high RES scenario in order to strentgthen the south-western part of Paris 400-kV ring.
	982	Changy (FR)	Dambron (FR)	New 26-km double circuit 400kV line in Loiret department, substituting to two existing 225kV lines. this investment is needed in order to cope with south-north flows to Paris area.		2030	2030	Recent studies for long term high RES scenarios showed the need to strengthen the grid in the area in order to cope with south-north flows to Paris area.
	983	southern Paris		Restructuration/development of the 400kV grid south of Paris area, needed for long term high RES scenarios. Several solutions are under consideration inlvolving either new axis or reconductoring of existing assets.		2030	2030	Recent studies for long term high RES scenarios have shown the need for strengthening the southern part of the Paris

							400 kV ring, either by creating a new line or by increasing the capacity of the existing assets.

5.4 Reference capacities

Reference capacities should not be confused with market based target capacities under a high RES scenario. These capacities were a result of the Common Planning Studies of TYNDP2014 vision 4 and they were one basis for promoted TYNDP2016 project candidates.
The aim of the reference capacities however, is to give a common ground for comparison and assessing benefits of the different projects. Reference capacities are formed by taking into account today's capacities and the capacity increases on the borders by taking into account mid- and long-term projects as described in chapter 5.1. Projects will be assessed based on either TOOT- or PINT-methodology and a detailed description of how this will be done with respect to the reference capacities, will be provided in the TYNDP-report.

In the following two tables are reported the references values for the mid and long term time horizons.

Table 5-1 Mid term reference capacity values

Country 1	Country 2	From 1 to 2 [MW]	From 2 to 1 [MW]
Austria	Switzerland	1700	1700
Austria	Germany	5000	5000
Austria	Italy	555	385
Austria	Slovenia	1200	1200
Switzerland	Germany	4700	3286
Switzerland	France	1300	3700
Switzerland	Italy	6240	3860
Germany	France	3000	3000
France	Italy	4350	2160
Italy	Slovenia	1380	1530
Italy	Montrenegro	1200	1200

Table 5-2 - Long term reference capacity values

Country 1	Country 2	From 1 to 2 [MW]	From 2 to 1 [MW]
Austria	Switzerland	1700	1700
Austria	Germany	7500	7500
Austria	Italy	1655	1385
Austria	Slovenia	1200	1200
Switzerland	Germany	4700	3286
Switzerland	France	1300	3700
Switzerland	Italy	6240	3860
Germany	France	4800	4800

France	**Italy**	4350	2160
Italy	**Slovenia**	1380	1530
Italy	**Montrenegro**	1200	1200

5.5 Interconnection ratios

The European Council in October 2014 called for speedy implementation of all the measures to meet the target of achieving by 2020 an interconnection level of at least 10 % of their installed electricity production capacity for all Member States[10]. The Energy Union package of 25 February 2015 responds to this call by presenting a strategy to ensure the full integration of the internal electricity market through adequate levels of interconnection.

At the invitation of the March 2014 European Council, the Commission proposed in May 2014 to extend the current 10% electricity interconnection target to 15% by 2030 while taking into account the cost aspects and the potential of commercial exchanges in the relevant regions. The October 2014 European Council mandated the Commission to report *"regularly to the European Council with the objective of arriving at a 15% target by 2030"*. This target is aimed to be achieved mainly through the implementation of the projects of common interest (PCIs).

In the European Commission's view, the EU energy policy goals and the 2020 and 2030 energy and climate targets will not be achievable without a fully interconnected European electricity grid with more cross-border interconnections, storage potential and smart grids to manage demand and ensure a secure energy supply in a system with higher shares of variable renewable energy. In this respect the gradual construction of the pan-European electricity highways will also be crucial. The Commission announced in January 2014 its intention to monitor the level of interconnections between Member States, with particular urgency between those that are furthest away from meeting the agreed objective of 10% of their installed production capacity.

At present, based on ENTSO-E Scenario Outlook and Adequacy Forecast 2014, the following Member States have an interconnection capacity level below the 10% EU target.

Table 5-3 EU interconnection target

Member States below 10% interconnection	
IE	9%
IT	7%
RO	7%
PT	7%
EE	4%
LT	4%
LV	4%
UK	6%
ES	3%
PL	2%
CY	0%
MT	0%

[10] In line with the European Council mandate established on 15 and 16 March 2002, this Communication focusses on electricity.

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Concerning the CCS Region, only Italy is still not able to meet the target due to its geographical configuration (rounded by sea and the Alps on the northern border) implying higher complexity with the realization of new interconnections. Nevertheless, the cross-border transmission capacity of Italy currently sums up to about 8,9 GW (about 8,4 GW on the northern border including CH-IT and 0,5 GW with Greece), corresponding to about 7% interconnection ratio. Only recently, after the realization and commissioning on March 2015 of the new 220 kV subsea cable interconnection between Malta and Sicily (IT), the Maltese system was synchronously interconnected with the European one, this enabling Malta also to easily meet the EU target.

Assuming that all the projects included in the first PCI list and in the TYNDP 2014 are realized, all CCS countries, including Italy, should be able to achieve in principle the target for 2020 of 10% interconnection ratio.

The following figures show the interconnection ratios based on the draft TYDNP2016 scenarios for 2020 (Expected Progress) and 2030 (four Visions)11.

The objective set by the European Council is to reach 10% for all Member States in 2020 and to aim at 15% for 2030 "while taking into account the costs aspects and the potential of commercial exchanges".

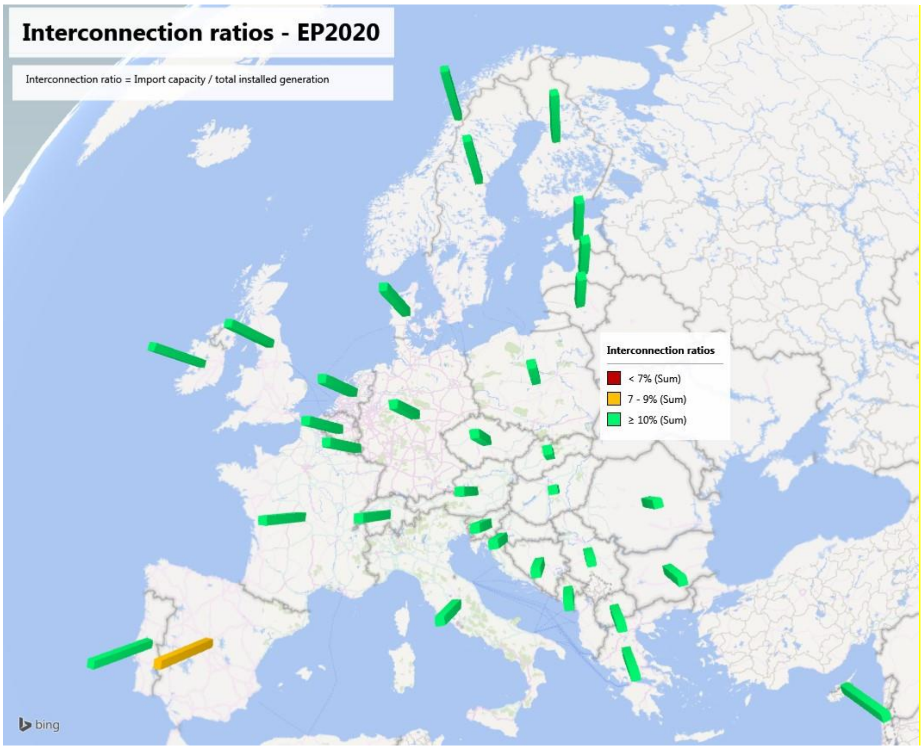

Figure 5-2 EP2020 Interconnection ratio

11 https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/150521_TYNDP2016_Scenario_Development_Report_for_consultationv2.pdf

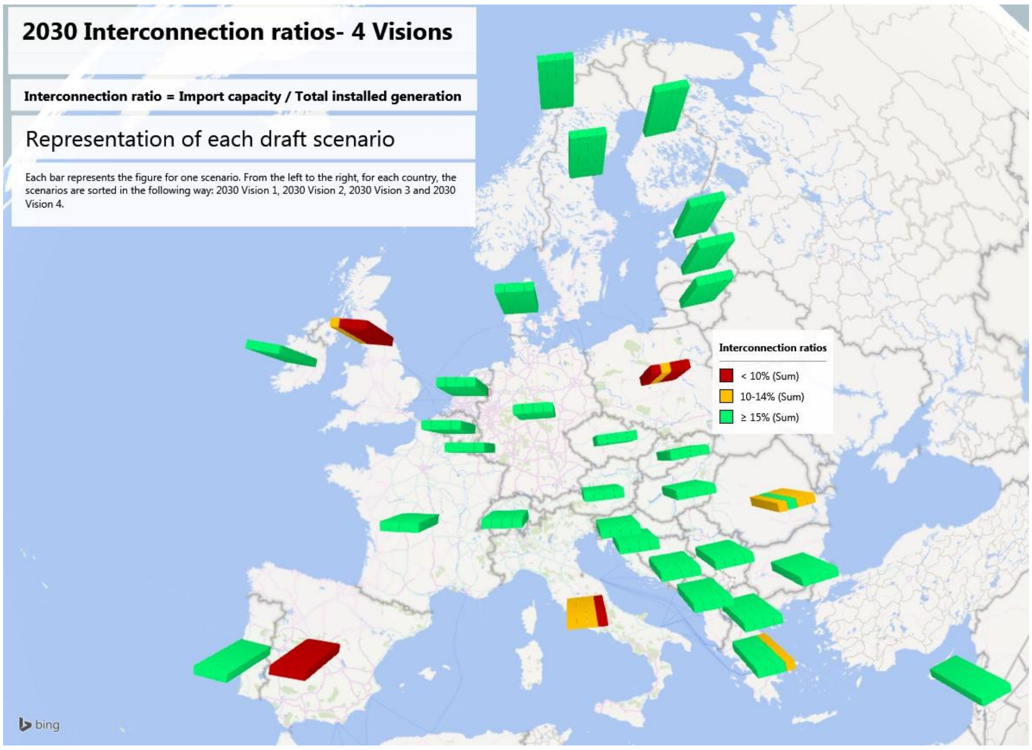

Figure 5-3 Interconnection ratio – 2030 Visions - import capacity divided by net generating capacity

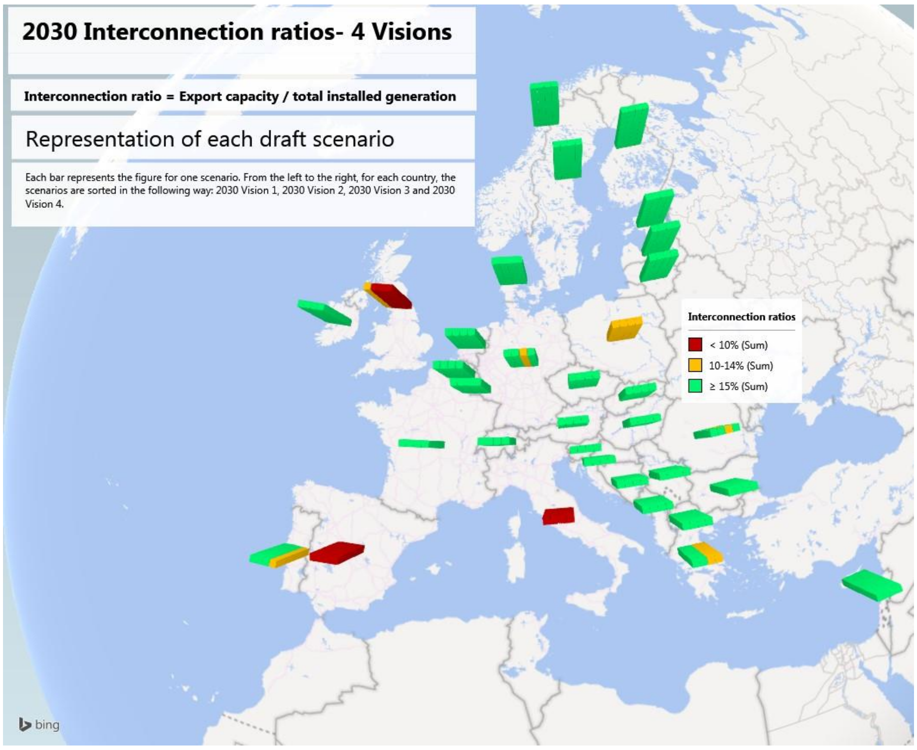

Figure 5-4 Interconnection ratio - 2030 Visions - export interconnection capacity divided by net generating capacity

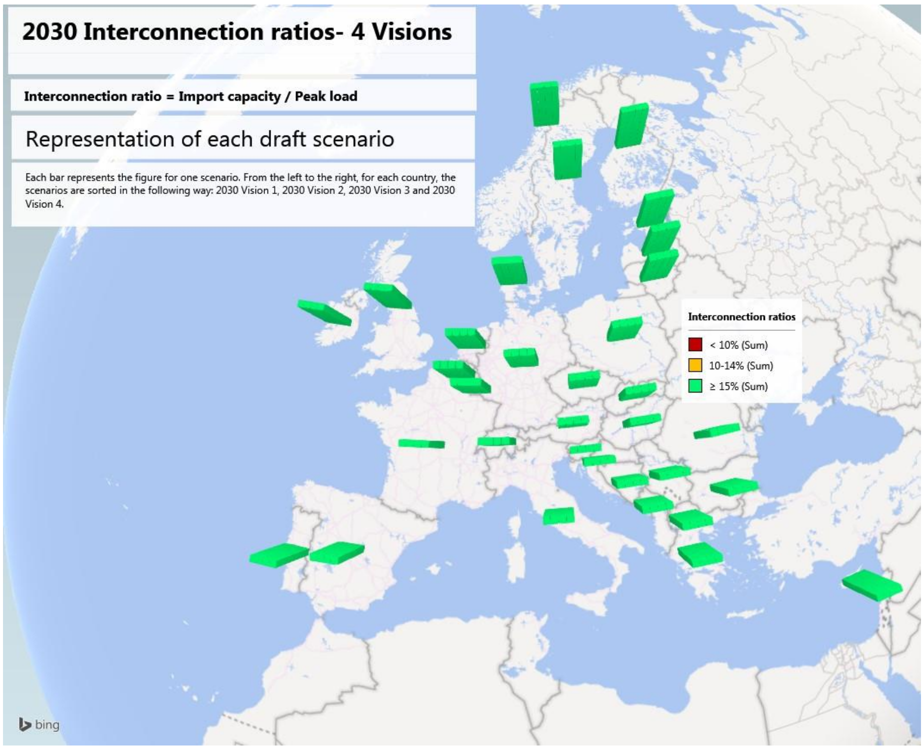

Figure 5-5 Interconnection ratio – 2030 Visions - import interconnection capacity divided by peak load

Three maps are presented for the 2030 interconnection ratios. These represent three different ways of defining the interconnection ratio for each country: the combined import capacity of its cross border interconnections divided by its total installed generation; the combined export capacity of its cross border connections divided by its total installed generation, and its import capacity divided by its peak load. The import and export capacities include planned mid and long term projects, but do not include future projects (those that would be commissioned beyond 2030).

Only one map is presented for the 2020 situation: this is as there is one accepted definition of interconnection ratio for the 2020 goal of 10% interconnection. This is import capacity divided by total installed generation.

To estimate the interconnection ratio, the reference capacities reported in section 5.4 of this document are used. It is thus obvious that the ratios depend on each scenario having different figures for 2030 installed generation and demand.

Regarding CCS Region, only Italy has two of the assumed 2030 interconnection ratios that are under the 15% target, namely:

- the ratio between import transmission capacity and installed generation (the default approach, as for the 2020 horizon);
- the ratio between export transmission capacity and installed generation (contribution to the trade flows in the market).

Concerning the third assumption related to the ratio between import transmission capacity and peak load (providing a rough indication of the security of supply extent) all the CCS countries are green, meaning they are able to meet the 15% target in 2030.

In this respect, it should be observed that planned projects presented in this report are assessed based on technical evaluations (market and network studies) which do not correspond necessarily to the established political targets.

Moreover, especially concerning Italy, it should be emphasised that from a technical perspective, future interconnections have to be developed not only with neighbouring Member States across the Italian northern borders (where present and planned transmission capacity is particularly high), but also with third countries, making possible to increase the interconnection level of Central and Southern Italy to fully exploit market resources and further improve security of supply.

Nevertheless, in the next coming years additional long-term projects proposed by TSOs and third parties could be further investigated to meet interconnection targets (in particular 15% by 2030), bridging also the draft EH2050 corridors, especially whether future scenarios will be confirmed to evolve in that direction.

5.6 Long term perspective, remaining challenges and gaps

In the CCS region, target capacities have been set based on the results of the common market and network simulations, including sensitivity analyses.

Respect to these target capacities, the results of the CPS studies confirm the preliminary findings of the TYNDP 2014 and especially the opportunity to consider - further to the projects already planned in the TYNDP 2014 - additional transmission capacity increases on the borders between Switzerland and France, between Switzerland and Germany and between France and Germany.

Further needs on other borders (like Austria-Germany and Austria –Slovenia) have still to be confirmed after additional investigations.

So, these target capacities for CCS borders are completely satisfied by TYNDP 2014 projects, CPS studies and projects promoted by third parties.

Although any estimations for the far future (i.e. beyond 2030 looking at a time horizon such as 2050) are of high uncertainty, taking into consideration the main policy lines towards a low carbon electricity sector, it is expected that the share of renewables on the electricity sector will increase and subsequently the conventional generation portfolio will be changed and adjusted to the new conditions. Given these expectations along with the potential for the further RES development in Europe, it is reasonable to consider in future possible high level very long-term project concepts that may come into focus for future scenarios. These conceptual ideas are driven by objectives such as electricity market and integration of RES, under very large scale development conditions.

Under this framework, any estimation for the far future should be based on the most ambitious visions regarding RES exploitation, going further what was analyzed in TYNDP 2014. It should be underlined that TYNDP 2014 Vision 4 is far beyond what the TSO’s National Transmission Development Plans usually considered up to now and will require important investments of national, regional and pan-European relevance on the network.

In general the reinforcements yielded by e-Highway project (to be implemented from 2030 till 2050) are to be considered on top of the TYNDP2014 projects (to be implemented from now till 2050).

In all scenarios, e-Highways results show a need for a strong South to North interconnection in Continental Central South Region (additional to the ones highlighted in the TYNDP and in the present report): from South to North all along Italy and from Sardinia and from Sicily to the mainland and of additional interconnections to export high extent of power from Italy to Austria and from Italy to Greece. In this respect, main drivers are also the assumptions concerning solar development in North Africa (up to 150 GW under large scale RES development circumstances) and on assumptions on the connection points for the injection of this power in the Italian transmission system.

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Besides, in all scenarios, e-Highways results show a need for a strong North to South interconnection in Western Europe, from the British Isles to European mainland, especially France and beyond to the Iberian peninsula. Main drivers are the installation of wind in the northern part of Europe (especially GB and Ireland) combined in some scenarios to large scale development of solar energy in North Africa.

It's important to highlight that to get the commissioning of this Regional Investment Plan on time, several barriers need to be removed, especially in the cross border projects, with a strong contribution and guidance from the European Commission, such as:

- Permitting procedures in order to clarify/harmonise projects approval decisions in the countries involved, given that the lack of harmonization increases social acceptance difficulties and costs of development;
- Regulatory issues related with interconnection projects cost acceptance by the different energy regulators involved allowing a fair but equivalent approach for investment recovery in the different national energy systems/
- The recognition of the setting of PCI priorities for the acceptance of these projects and the perspective of public financial support, if needed, taking into account the costs and benefits.
- Setting procedures and rules for the candidate new connectees.

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6 NEXT STEPS

6.1 A two-year cycle & CBA evolvement

Assessment methodology

The present version of the Cost Benefit Analysis (CBA) methodology, developed by ENTSO-E in close collaboration with stakeholders and ACER, was officially approved by EC in February 2015. The TYNDP2016 assessments of projects will be carried out based on this version as required by Regulation (EU) 347/2013. The previous TYNDP2014 was already to a large extent based on a nearly final CBA methodology, and the lessons learned in this process will contribute to the TYDNP2016 process. The CBA methodology provides for a multi-criteria assessment of all TYNDP projects across a wide range of indicators as presented in the figure below.

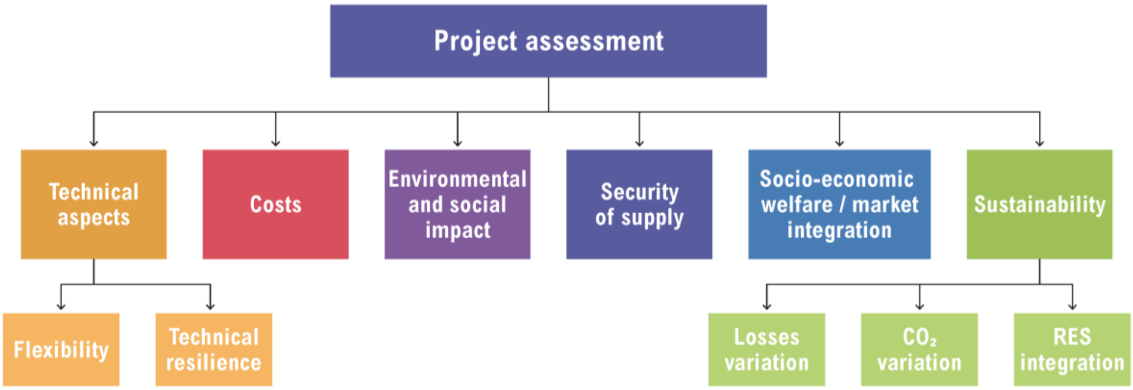


Figure 6-1 CBA Indicators

Even as an approved CBA methodology is ready for use in TYNDP2016, work is continuing to further improve the methodology for future TYNDPs. Several elements which are already being explored further is how storage, Security of Supply and Ancillary Services can be addressed in a transparent, objective, and European consistent manner.

In the final TYNDP2016 report, the reader can expect to see an assessment sheet for each individual TYNDP project in the following format:

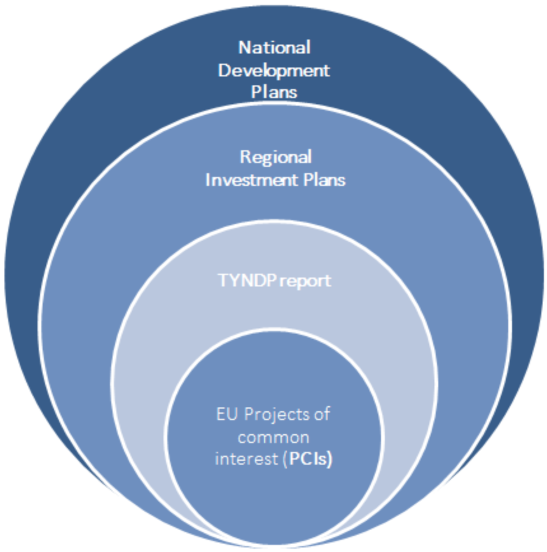
	CBA results non specific scenario		CBA results for each scenario								CBA results non specific scenario				
	GTC increase - direction 1 [MW]	GTC increase - direction 2 [MW]	TYNDP scenarios	Contribution to Intercon-nection rate [%]	B1 - SoS [MWh/y]	B2 - SEW [M€/y]	B3 - RES integration [MWh/y or MW/y]	B4 - Losses [MWh]	B5 - CO2 Emiss [kT/y]	B6 – Technical Resilience	B7 – Flexibility	S1 - protected areas [km]	S2 - urban areas [km]	C1 - Estimated cost [M€]
Assessment results CLUSTER															

Scenarios

While this set of Regional Investment Plans is being published in summer 2015, ENTSO-E recently concluded a public consultation on a proposed Scenario Development Report in May-June 2015[12]. This report proposes a set of possible futures, describing storylines, methodologies, assumptions, and resulting load/generation mixes. One best estimate scenario for 2020 and four possible contrasting visions for 2030 have been proposed. These provide the mid- and long-term horizons as referred to in the CBA methodology against which all TYNDP projects will be assessed.

Other infrastructure plans

It is worth highlighting how the TYNDP and the Regional Investment Plans are related to national plans and EU support measures.



- National Development Plans: provided by TSOs at specific time intervals and based on (national) scenarios which not always one-to-one relate to those of the Community-wide TYNDP. These are developed according to Article 22 of Directive 2009/72/EC.

- Regional Investment Plans: developed by TSOs in ENTSO-E's cooperation structure, following Article 12 of Regulation (EC) 714/2009.

- Community-wide Ten Year Network Development Plan: a key ENTSO-E deliverable as mandated by Regulation (EC) 714/2009. It inter alia needs to build on national investment plans, taking into account regional investment plans and, if appropriate, Community aspects of network planning.

- Projects of Common Interest: Procedure set forth in Regulation (EU) 347/2013, aiming to stimulate particular infrastructure projects with direct funding, financial leverage and/or permitting streamlining. PCIs are adopted by the EC in every year in between two TYNDP publication years. To be eligible for PCI labelling, inclusion in the last available TYNDP is an explicit condition.

[12] https://www.entsoe.eu/news-events/announcements/announcements-archive/Pages/News/TYNDP-2016--ENTSO-E-calls-for-views-on-the-scenarios-report.aspx

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7 APPENDICES

7.1 Detailed description of the market modelling

In chapter 2.3 General methodology, the overall process overview was described, for the readers for faster orientation and better understanding of the whole Common Planning Studies process. This chapter will describe both market and network methodologies used in more details, also with practical examples given.
The Common Planning Studies are an important part of the TYNDP2016 process. They were carried out jointly and coordinated by all regional groups of ENTSO-E for the TYNDP2014 Vision 4 model. Beside this, regional groups could carry out additional regional scenarios and sensitivities, to analyze specific impacts, issues or particularities of the regions, which they wanted to be shown in this report.

Market modelling description of the approach
The aim of the Common Planning Studies was to identify beneficial borders that will be increased in 500 or 1000 MW steps. Preliminary to the market studies members of the regional network-groups provided a list of costs for each possible increase and border. These costs included necessary internal reinforcements to make the additional cross-border capacity possible.
It was not necessary to specify costs for borders where new projects are not feasible. However – a good reason for why an increase of the cross-border capacity at this border is not feasible had be provided and agreed with the regional groups involved.
The following approach has been used.

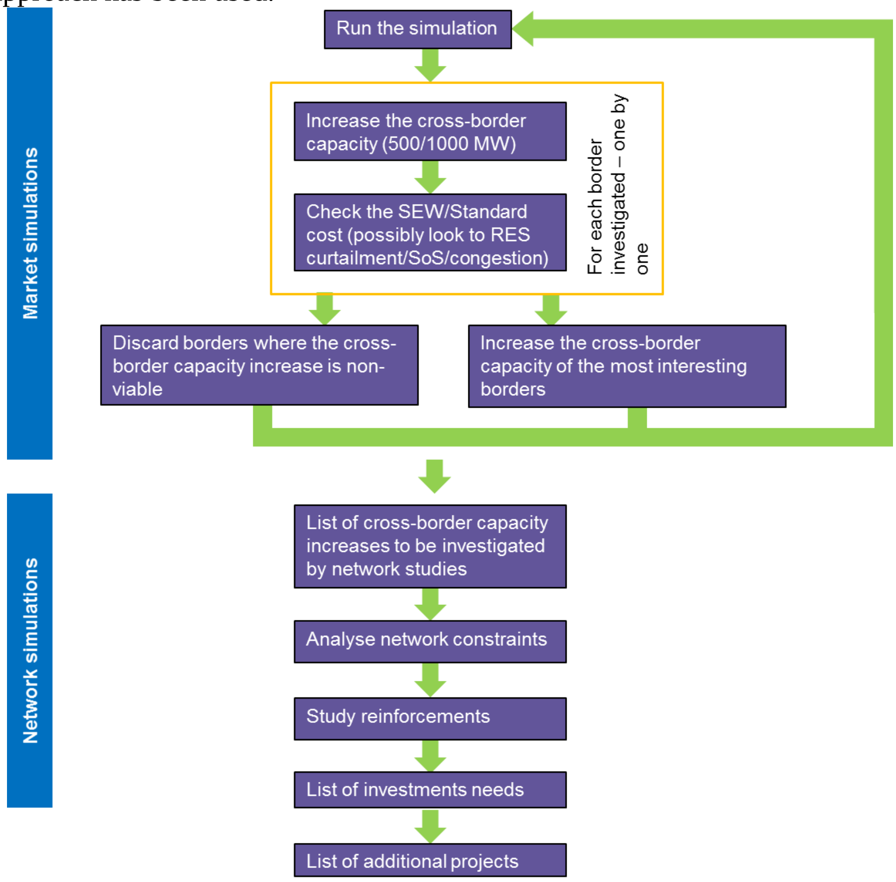


Figure 7-1 Overall overview of the Common Planning Studies process

1. The market simulation were run for the base case which was defined:

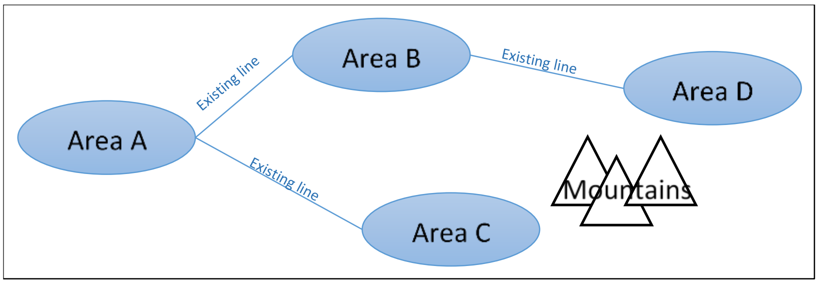
- on the base of data used TYNDP2014 V4 2030 Regional assessment (high RES conditions),
- on the base of an alignment performed by Project Group Market Modelling (PG MM) members respect the installed generation capacity and the generation profile (provided by PECD – Pan European Climate Database) for photovoltaics and wind,
- on the base of an update of the reference capacities (in order to guarantee consistency with the TYNDP 2014 projects list).

Additional details were permitted in the Regional area.

2. One market simulation was run for each border with an increased capacity of 500 or 1000 MW.
3. The socioeconomic welfare of all increases were calculated (by subtracting the SEW from the base case simulation of step 1 from each simulation of step 2)
4. The increase(s), which gave the highest SEW/cost ratio in the region ("the most interesting borders"), were put into the (new) base case
5. Some borders shown results that make further simulations and checks of these borders unnecessary. These borders could be removed from the list and were not analyzed any more in this process. However, it was needed to be careful which borders might be removed. A bottleneck can indeed move from one border to another when the border capacity is increased. It was important not to remove borders from the list too early.
6. Then the loop started again with the updated base case. Unless no more beneficial increases could be identified, process went back to step 2[13].
7. After every beneficial increases on all borders of the region were identified, the market groups could present a list of borders, which capacity should be increased and the amount of these increases (the same border can be chosen in more than one loop, increasing the capacity by 500MW each time).
8. Regional network subgroups investigated the new "target capacities" and converted these into possible project candidates.

Practical example

Purpose of this practical example is to visualize the above mentioned market modelling approach and process. This example assumes four market areas A, B, C and D. Areas A-B, A-C and B-D are already connected. Due to geographical constraints it is not possible to connect area C and D. To connect area A with area D is not possible either because of too large distances.



[13] New base case do not need to be re-calculated. This simulation has just been done!

1. The network group has specified the following list of costs for increasing cross border capacity (only as example):

Border	+500 MW (first increase of 500 MW)	+1000 MW (second increase of 500 MW)	+1500 MW (third increase of 500 MW)
A-B	100 M€	110 M€	100 M€
A-C	100 M€	120 M€	100 M€
B-C	70 M€	140 M€	200 M€
B-D	300 M€	300 M€	500 M€

2. The picture above shows the base case.
3. The market simulation is run for the base case.
4. Market simulations for all feasible borders (A<->B, A<->C, B<->C and B<->D) are run
5. Socioeconomic welfare are calculated for all border increases
6. Project B-C has for instance a SEW of 20 M€, giving a SEW/cost ratio of 2/7 which is the highest value of the four projects. Project B-C is put into the base case.
7. Project B-D has for instance only a SEW of 5M€ and with a cost of 300 M€ this gives a ratio of 1/60. This border is considered not necessary to be investigated further.
8. In this stage the market groups run again market simulations for all remaining feasible borders (A<->B, A<->C and B<->C) – by continuing the loop with step 4.

Network modelling description of the approach
This chapter describes the primary network studies performed by the regional groups during the Common Planning Studies for TYNDP2016. The aim was to simulate the impact of the increased border capacities, as simulated in the market simulations of the Common Planning Studies, on the European grid and detect the corresponding new concerns for grid development ("investment needs"). The outcome of this study was a map of internal bottlenecks in each country and a list of additional network reinforcement investments, with a brief technical description and the associated transfer capacity contribution (order of magnitude).
In the framework of the Common Planning Studies, the scope of Network Studies was to analyse, according to the market studies[14] findings, the most promising borders in terms of transfer capacity increase and identify the candidate projects which would achieve such potential transfer capacity increases in a feasible and cost efficient manner.
The work of the network studies during this phase is described below:

- The Common Planning Network Studies were based on market outputs results in each Region (8760 hours simulations).
- Duration curves were displayed directly using market study results. For example, by sorting out the hours according to exchange between 2 countries or Wind in North Sea and PV in Southern Europe. These curves were used as one of the indicators for selection of points in time.
- RG Network Studies selected a number of representative snap-shots so called points in time (PiT) directly using the market study outputs or after the use of a PTDF (Power Transfer Distribution Factor) Matrix. For instance wind production, high market exchanges on long distances, low load, high load etc. The selection of PiT was a regional specific process, according to the regional most important parameters.

[14] The input reference capacities data of Market Studies are aligned to Vision4 TYNDP14 and projects assessed in the TYNDP14, including several updates

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- Based on PTDF Matrix, the market data of each hour were transposed into the simplified grid represented by the PTDF Matrix. Then PTDF flows were calculated for each of the 8736 hours and on each synchronous border. Each synchronous area was represented through grid parameter duration curves showing loading of profiles. As mentioned above these PTDF flows were used to define detail points in time calculated by full AC load flow calculation to obtain particular line loadings together with voltage profile.
- The results of calculation were displayed on a regional map (based on a Pan European common tool), allowing possible further reinforcement identification. This map of bottlenecks was based on a visualisation of the combined frequency and severity of line loading (e.g. overloads).
- Project candidates with its investment items were identified based on the described process above without any preference whether internal or cross-border project.
- Expected grid transfer capacity per project candidate was appointed proceeding to load flows on already selected PiT. At this stage no detail calculation according to CBA were performed yet (carried out in assessment phase from mid 2015).

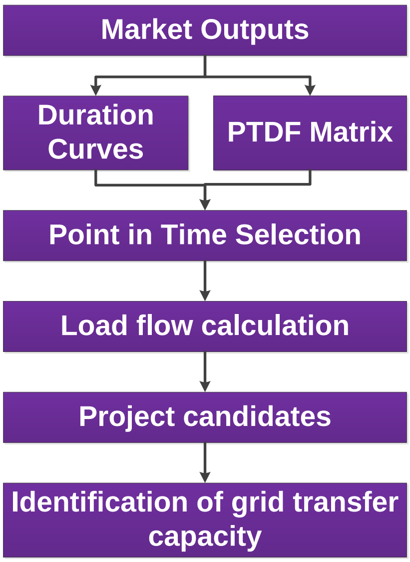

Figure 7-2 workflow of the Network Studies during Common Planning Studies

Network modelling

Network analyses were performed under the following framework:

- Network datasets used to perform network simulations: the starting point for each region was the 2030 Vision4 regional grid data set developed in TYNDP 2014 covering entire continental synchronous area.
- Models were updated according to the new projects listed in TYNDP 2014 and if relevant by other cross-border or national investment items.
- At the end of the Common Planning Studies, the network models will be updated accordingly.

Inputs from market results

The following detailed Market outputs from final market simulation run were required to create points in time (per country and per hour):

- Thermal generation per fuel type and efficiency

- Renewable generation sources (wind, solar, …)
- Hydro generation (pumping, turbine)
- Dump energy per country
- Demand
- Energy not supplied
- Balances
- Market exchanges on the border of the modelled perimeter (mostly HVDC connection to Northern countries or UK)

Load flow simulations

First of all, the main critical activities of the network simulation were an AC convergence after a PiT is implemented under the condition of scenario assumptions.

Bottleneck identification

In order to evaluate the importance of bottleneck, following "FS²" criteria can be used, where:

- F: frequency of occurrence (% of the year);
- S: severity (% of overload)

Example of calculation of FS² in N conditions for a line (based on 5 PiT, with winter and summer limits):

PiT (N condition)	Weight (%)	F	P (MW)	Limit (MW) N condition	Overload (%)	S
WINTER 1	0,10	10	750	1000	-	0
WINTER 2	0,40	40	1100	1000	0,10	10
SUMMER 1	0,30	30	850	800	0,06	6
SUMMER 2	0,15	15	550	800	-	0
SUMMER 3	0,05	5	900	800	0,13	13
	FS²	5 925				

Figure 7-3 Workflow of the Network Studies during Common Planning Studies

The reinforcement projects:

- were selected considering the severity and frequency of the bottlenecks
- considered first the border concerned by market increased target capacities

Map representation

Maps to illustrate physical flows:

Following types of map can were used:

- bulk power flow maps (e.g. percentile 95% or 80% and 5% or 20% of the cross-border yearly distribution from PTDF flows)
- map of link loadings using AC load flow calculation

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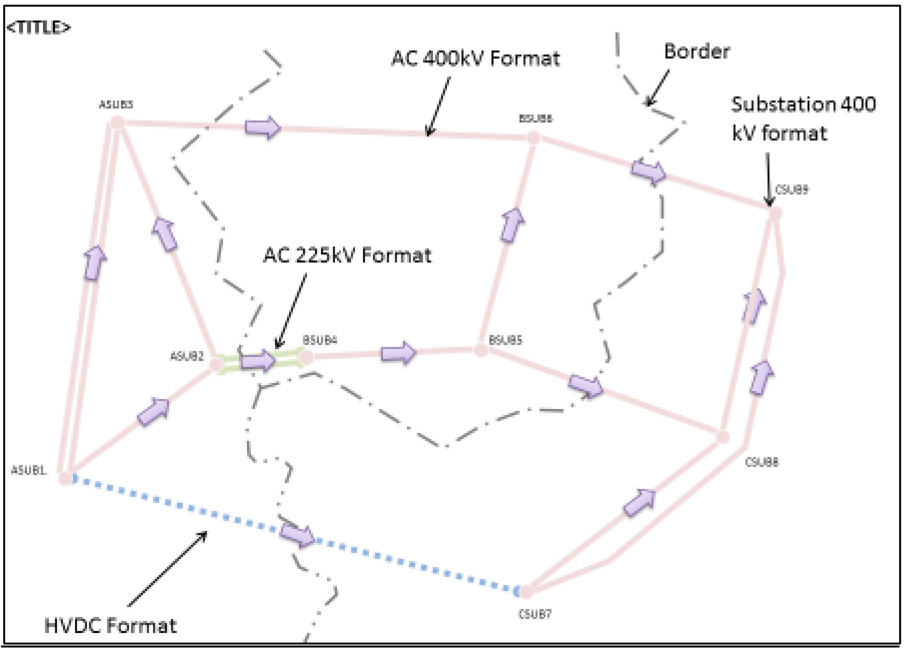

Maps to illustrate bottlenecks:

- Map illustrating bottlenecks in N and N-1 condition, using a qualitative approach with colors, based on the results of the FS² criteria:
  - Color green = no bottleneck
  - Color yellow = occasional bottleneck in N-1
  - Color red = structural bottleneck in N-1
  - Color highlighted red = bottleneck in N

7.2 Detailed regional walkthrough of process

Detailed description of the Market Modelling

The purpose of the market studies is to investigate the impact of the new interconnection projects by comparing two different grid situations in terms of economic efficiency, variable generation costs as well as the overall amount of CO2 emissions and volumes of spilled energy. An economic optimisation is conducted for every hour of the year taking into account several constraints, such as the flexibility and availability of thermal units, wind and solar profiles, load profile and uncertainties, and transmission capacities between countries.

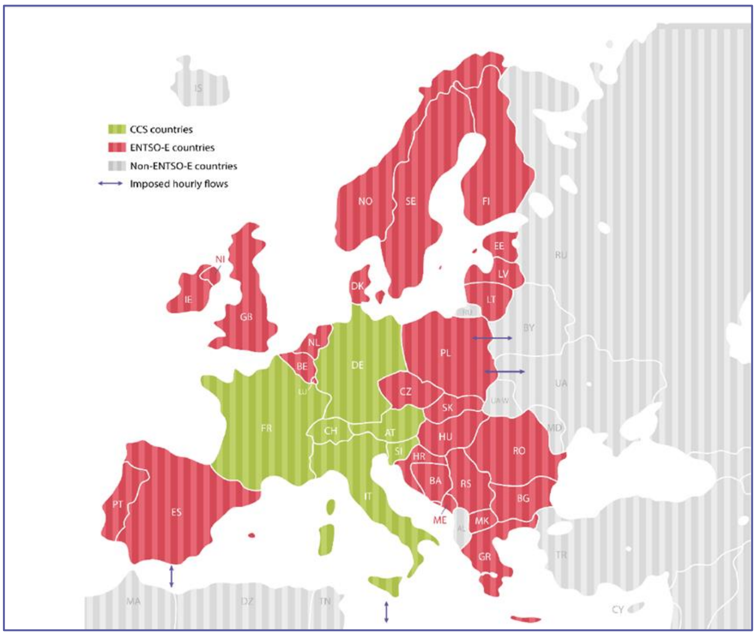

Figure 7-4 Overview map system modelling

The main elements of the electric system were modelled as described hereafter:

- Load: hourly time series out of the PEMMDB were used. Those time series were derived based on the assumptions of common ENTSO-E Visions.
- Thermal generation: modelled by their main relevant characteristics: installed capacity, fuel type (incl. fuel and CO2 price), start-up costs, efficiency, must-run obligations, minimum up and down times, availabilities, etc..
- Hydro generation: was subdivided into three kinds of power plants: run of river, storage and pump storage. The behaviour of hydro pump storages (pumping, turbining) was internally implemented using the simulation tool.
- Non dispatchable generation (wind, solar, etc.) are being considered by scaled per unit time-series based on common ENTSO-E climate database.

The modelling takes also into account multiple interlinked restrictions that are driven by the structure of the grid. Total import or export possibilities for a country may be lower than the total capacity on all borders as exchanges capacities may not be simultaneously achievable.

The expected exchange capacity between two price zones models the interconnection capacity available to market players.

Generally the study process made it unavoidable to encounter a number of limitations that need to be clearly stated and which are:

- The underlying assumption hour by hour, is that of a perfectly competitive market (which implies, among other assumptions, that information is not only complete but also perfect)

- Regarding economy, the fuel and operating costs taken into account for each cluster of thermal plants were realistic enough (in particular regarding the general merit-order to which they lead) but should not in any way be considered as accurate. Whenever energy figures are converted into monetary figures, it should be remembered that the confidence interval of the estimation may be very wide.

- Even if NTCs are assumed to integrate the effect of domestic constraints, the use of an extremely simplified modelling for the network (all the plants of each country having the same "ability" to access the cross-border capacities) tends to over-estimate the overall economic performance of the interconnected system. The assumption of a NTC approach is an approximation of the reality of physical and commercial exchanges; the resulting bias may be either an over or an under-estimation of the real flows.

- The assumption of a perfect forecast for the renewables reduces the need for the balancing.

The Market tool used in the study is ANTARES (A New Tool for generation Adequacy Reporting of Electric Systems) is a sequential Monte-Carlo multi-area adequacy and market simulator.

Standard costs estimation

The goal of standard cost is to provide very preliminary figures about the cost of implementing the border transmission capacities increases founded in the market studies iterations.

In the other hand, if there is no predefined project on a border, the goal is to provide quite good figures based on:

- the TYNDP2014 costs;
- estimated cost of an HVDC/HVAC of 1000 MW between the two countries (according to the number of kilometres and the proposed unit cost / km);
- specificities identified by means of bilateral studies.

On the base of the standard cost assumptions and the results of market studies iterations, several Regional borders have been discarded. See table below for further details.

Region	Border	Standard cost (first step) (Meuros)	standard cost assumptions	what drives the standard cost provided
CCS	AT-ITN	1200 (1000 MW)	estimated based on the average cost per km of a HVDC link of 1000 MW	significant length to connect the link crossing the Alps to highly meshed network nodes on both sides of the border and use of HVDC solutions
CCS	CH-ITN	1000 (1000 MW)	estimated based on the average cost per km of a HVDC link of 1000 MW and internal reinforcements	significant length to connect the link crossing the Alps to highly meshed network nodes and use of HVDC solutions (converter stations) and additional internal reinforcements
CCS	FR-ITN	1750 (1000 MW)	estimated based on the average cost per km of a 500 km HVDC marine link of 1000 MW and internal reinforcements	lenght of marine route and seabed depth/slope
CCS	ITN-SI	800 (1000 MW)	estimated based on the average cost per km of a 400 kV double circuit OHL and internal reinforcements	significant length to connect the link crossing the Alps to highly meshed network nodes on both sides of the border and additional internal reinforcements
CCS	ITS-ME	1150 (1000 MW)	estimated based on the average cost per km of a 450 km HVDC marine link of 1000 MW	lenght of marine route and seabed depth (additional costs should be considered for 400 kV internal grid reinforcements)
CSW	ES-ITN	3550 (1000 MW)	estimated based on the average cost per km of a 1200 km HVDC link of at least 1000 MW.	Feasibility obstacles due to the length of the marine cables, the depth and slope of the seabed, the lack of strength and stability of the internal networks
CSE/CCS	ITS-GR	2400 (1000 MW)	estimated based on the average cost per km of a 700 km 1000 MW HVDC link	lenght of the HVDC marine link to connect to highly meshed network portion and additional costs for 400 kV internal grid reinforcements on Italian side

7.3 Guidelines for project promoters

In line with Regulation (EU) 347/2013, the EC provides a set of guidelines[15] for ENTSO-E to apply when handling all applications by project promoters for TYNDP inclusion. These guidelines ensure the same procedure, timeline and qualification criteria are used for all project promoters, and enshrine the rights and responsibilities of promoters, ACER, EC and ENTSO-E. It addresses Promoters of transmission infrastructure projects within a regulated environment, Promoters of transmission infrastructure projects within a non-regulated environment (i.e. exempted in accordance with Article 17 of Regulation (EC) No 714/2009, referred to as "merchant lines"), and Promoters of storage projects. All who aspire inclusion of their project in the PCI list in year X, need to be included in the latest available TYNDP of year X-1.
Based on the EC's draft guidelines, and building on the experience of past TYNDPs, all promoters of electricity transmission and storage projects were invited by ENTSO-E to submit between 1 April and 30 April 2015 their application for inclusion in the Ten-Year Network Development Plan 2016.
During May 2015 ENTSO-E reviewed the data submitted in order to verify its completeness and compliance with the guidelines. Throughout May any promoter had the opportunity to complete or update its project details, and ENTSO-E was in regular contact with all promoters to ensure a smooth process. All

15 https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/20150217_Guidelines_Update_ENER_TC_24.02.2015_1st%20draft.pdf

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promoters were invited to provide information via a dedicated Sharepoint platform. Ultimately it is the applicant's responsibility to ensure the application was completed by end of May.
This procedure allowed ENTSO-E to compile a list of TYNDP project candidates which completes the picture of planning studies, regional context and investment needs sketched in the Regional Investment Plans[16]. This timely compilation of a list of TYNDP projects allows ENTSO-E to have a baseline reference architecture for CBA assessments starting in summer 2015. Any late request for TYNDP inclusion can be handled evidently in future TYNDP editions. Any request for significant change to TYNDP projects during the 2016 process will be assessed in line with ENTSO-E's governance rules, with oversight from EC and ACER, and taking on board the role of ENTSO-E's neutral Network Development Stakeholder Group.
The main drivers in this approach is to keep transparency over the development and updates of the TYNDP project list, and ensure clarity over the CBA assessment 'ingredients' (methodology, list of projects, scenarios, data).

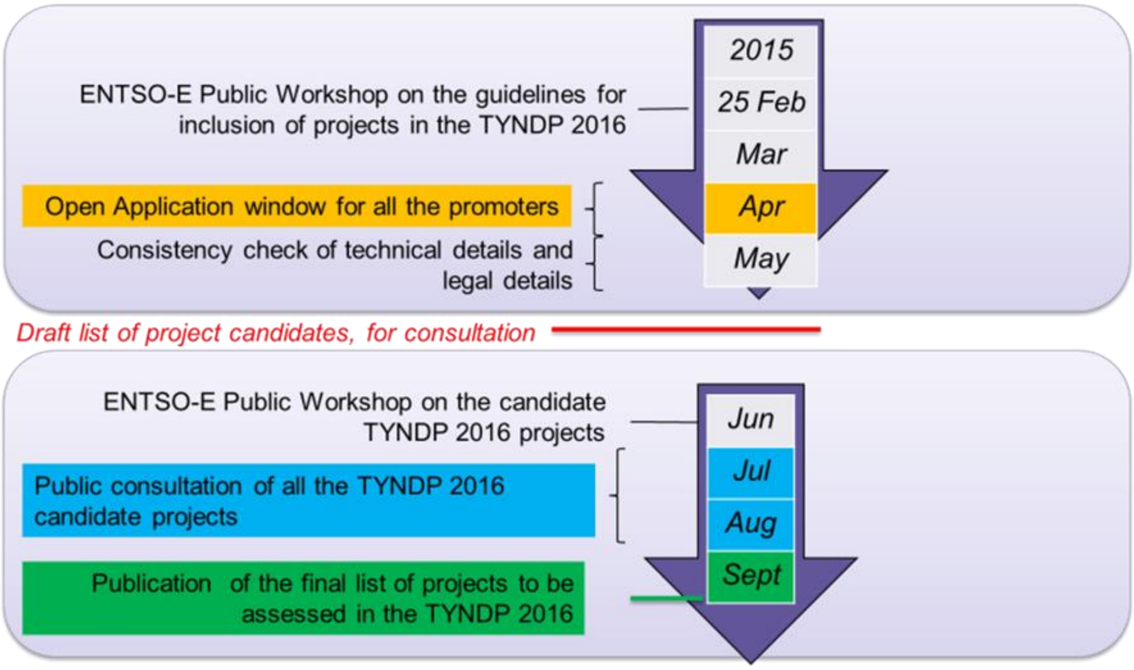

Figure 7-5 Workplan for project promotors

7.4 Abbreviations

The following list shows abbreviations used in the Regional Investment Plans 2015.

AC Alternating Current

ACER Agency for the Cooperation of Energy Regulators

CCS Carbon Capture and Storage

CBA Cost-Benefit-Analysis

CHP Combined Heat and Power Generation

DC Direct Current

16 https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/150331_TYNDP_2016_FAQs_application_for_projects.pdf

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EH2050 e-Highway2050

EIP Energy Infrastructure Package

ENTSO-E European Network of Transmission System Operators for Electricity

ENTSOG European Network of Transmission System Operators for Gas

EU European Union

GTC Grid Transfer Capability

HV High Voltage

HVAC High Voltage AC

HVDC High Voltage DC

IEA International Energy Agency

KPI Key Performance Indicator

IEM Internal Energy Market

LCC Line Commutated Converter

LOLE Loss of Load Expectation

MS Member State

MWh Megawatt hour

NGC Net Generation Capacity

NRA National Regulatory Authority

NREAP National Renewable Energy Action Plan

NTC Net Transfer Capacity

OHL Overhead Line

PCI Projects of Common Interest

PINT Put IN one at the Time

PST Phase Shifting Transformer

RegIP Regional investment plan

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 Socio-Economic Welfare

SOAF Scenario Outlook & Adequacy Forecast

SoS Security of Supply

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TEN-E Trans-European Energy Networks

TOOT Take Out One at the Time

TSO Transmission System Operator

TWh Terawatt hour

TYNDP Ten-Year Network Development Plan

VOLL Value of Lost Load

VSC Voltage Source Converter

7.5 Terminology

The following list describes a number of terms used in this Regional Investment Plan.

Congestion revenue/ congestion rent – The revenue derived by interconnector owners from sale of the interconnector capacity through auctions. In general, the value of the congestion rent is equal to the price differential between the two connected markets, multiplied by the capacity of the interconnector.

Congestion - means a situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from international trade requested by market participants, because of a lack of capacity of the interconnectors and/or the national transmission systems concerned.]

Cost-Benefit-Analysis (CBA) – Analysis carried out to define to what extent a project is worthwhile from a social perspective.

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

Cluster – several investment items, matching the CBA clustering rules. Essentially, a project clusters all investment items that have to be realised in total to achieve a desired effect.

Grid transfer capacity (GTC) – represents the aggregated capacity of the physical infrastructure connecting nodes in reality; it is not only set by the transmission capacities of cross-border lines but also by the ratings of so-called “critical” domestic components. The GTC value is thus generally not equal to the sum of the capacities of the physical lines that are represented by this branch; it is represented by a typical value across the year.

Investment – individual equipment or facility, such as a transmission line, a cable or a substation.

Net Transfer Capacity (NTC) – the maximum total exchange program between two adjacent control areas compatible with security standards applicable in all control areas of the synchronous area, and taking into account the technical uncertainties on future network conditions.

N-1 Criterion – The rule according to which elements remaining in operation within TSO’s Responsibility Area after a Contingency from the Contingency List must be capable of accommodating the new operational situation without violating Operational Security Limits.

Project – either a single investment or a set of investments, clustered together to form a project, in order to achieve a common goal.

Project candidate– investment(s) considered for inclusion in the TYNDP.

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Project of Common Interest – A project which meets the general and at least one of the specific criteria defined in Art. 4 of the TEN-E Regulation and which has been granted the label of PCI Project according to the provisions of the TEN-E Regulation.

Put IN one at the Time (PINT) – methodology, that considers each new network investment/project (line, substation, PST or other transmission network device) on the given network structure one-by-one and evaluates the load flows over the lines with and without the examined network reinforcement.

Reference network – the existing network plus all mature TYNDP developments, allowing the application of the TOOT approach.

Reference capacity – cross-border capacity of the reference grid, used for applying the TOOT/PINT methodology in the assessment according to the CBA.

Scenario – A set of assumptions for modelling purposes related to a specific future situation in which certain conditions regarding gas demand and gas supply, gas infrastructures, fuel prices and global context occur.

Transmission capacity (also called Total Transfer Capacity) – the maximum transmission of active power in accordance with the system security criteria which is permitted in transmission cross-sections between the subsystems/areas or individual installations.

Take Out One at the Time (TOOT) – methodology, that consists of excluding investment items (line, substation, PST or other transmission network device) or complete projects from the forecasted network structure on a one-by-one basis and to evaluate the load flows over the lines with and without the examined network reinforcement.

Ten-Year Network Development Plan – The Union-wide report carried out by ENTSO-E every other year as (TYNDP) part of its regulatory obligation as defined under Article 8 para 10 of Regulation (EC) 714 / 2009

Total transfer capacity (TTC) – See Transmission capacity above.

Vision – plausible future states selected as wide-ranging possible alternatives.

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