entsoe

European Network of
Transmission System Operators
for Electricity

TEN-YEAR NETWORK DEVELOPMENT PLAN 2010-2020

28.06.2010

NON-BINDING COMMUNITY-WIDE TEN-YEAR NETWORK
DEVELOPMENT PLAN – PILOT PROJECT
FINAL

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[0] EXECUTIVE SUMMARY

0.1 INTRODUCTION

The development of the transmission network has undergone fundamental changes since the Electricity Directive 96/92/EC in 1999 for the liberalisation of the national electricity markets in Europe. Transmission System Operators (TSOs) had to develop their networks to accommodate European policy objectives without relying on a formal integrated planning of generation and network assets.

Ten years after the Directive, the 3rd Legislative Package for the Internal Market in electricity (hereinafter the 3rd Package) was adopted and will come into force in early 2011. The 3rd Package provides for institutions and tools that promote the strong coordination of the operation and development of the national transmission networks, as well as the harmonisation of the European regulatory frameworks. Regulation (EC) 714/2009 of the 3rd Package calls for the creation of the European Network of Transmission System Operators for Electricity (ENTSO-E) and according to Art. 8.3 (b) of the Regulation (EC) 714/2009, "*ENTSO-E shall adopt a non-binding Community-wide ten-year network development plan*" (TYNDP) with the objective to ensure greater transparency regarding the entire electricity transmission network in the Community and to support the decision making process at regional and European level.

According to Art. 8.10 of the Regulation, *"The Community-wide network development plan shall include the modelling of the integrated network, scenario development, a European generation adequacy outlook and an assessment of the resilience of the system"*. Furthermore, the TYNDP must *"build upon national investment plans"* (the consistency with which is monitored by the Agency for the Cooperation of Energy Regulators, ACER), *"and if appropriate the guidelines for trans-European energy networks"*. Also, it must *"build on the reasonable needs of different system users"*. Finally, the TYNDP must *"identify investment gaps, notably with respect to cross-border capacities"*.

The European TSOs, already familiar with the advantages of international collaboration through their experiences within long-standing associations[1], established ENTSO-E in anticipation of the 3rd Package in December 2008 as a fusion of the above mentioned organisations. The mission of ENTSO-E is to promote important aspects of energy policy in the face of significant challenges concerning the *security* of the operation of the network, the *adequacy* of the power system, the *market* integration and transparency, and the *sustainability* of development through the integration of renewable energy sources.

ENTSO-E, having recognised that:

- the overwhelming response of European society to the climate change issue translates into massive investments in renewable energy sources whose efficient integration into the grid is a challenge that has to be urgently and adequately addressed;

[1] **ATSOI** (Association of the Transmission System Operators of Ireland); **BALTSO** (Baltic Transmission System Operators); **ETSO** (European Transmission System Operators); **NORDEL** (Association of TSOs from Norway, Finland, Denmark, Sweden and Iceland); **UCTE** (Union for the Coordination of the Transmission of Electricity); **UKTSOA** (UK Transmission System Operators Association).

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- the wide scope and ambitious objectives of the TYNDP require a large number of dedicated resources, as well as the conception and implementation of processes and methodologies that have not been applied in a pan-European level before;
- the TSOs should continue to contribute towards the Internal Energy Market by ensuring the maximum transparency concerning the operation and development of their transmission grids;

decided to proactively release this report as the first TYNDP before the coming into force of the 3rd Package in the form of a pilot project.

This early release has four main objectives:

- to gain the feedback of the stakeholders regarding the content and the collaboration they expect for the next releases of the report,
- to illustrate existing trends for attaining European energy policy objectives,
- to test the necessary processes and Europe-wide methodologies,
- to feed the political debate with an in depth review of existing trends.

ENTSO-E has also the ambition with this report to deliver a valuable input for the National Renewable Energy Action Plans (NREAPs) that Member States are committed to submit in June. The TYNDP also underlines the benefits power grid planning can derive from the Proposal of the EU-Council of a new Regulation concerning the notification to the Commission of investment projects in energy infrastructure within the European Community, repealing Regulation (EC) 736/96, and presently under discussion.

To achieve the above, the first release of the TYNDP:

- provides the most up-to-date and accurate information (to the TSOs' knowledge) of the planned or envisaged transmission investment projects of European importance.
- provides an outlook of the future condition of the electricity power system in Europe.
- discusses the development and evaluation of generation-demand scenarios, based on which analyses (such as the System Adequacy Forecast) will be performed.
- describes the challenges related to the development of the transmission network.
- initiates a "learning-by-doing" process to build TYNDP reports in an open and transparent manner, with the strong involvement of stakeholders, the European Regulators and the EC.

For this TYNDP pilot project, ENTSO-E has initiated at a very early stage a series of open discussions with major stakeholders and with the European Energy Regulators' Group for Electricity and Gas (ERGEG) aiming at receiving suggestions to its proposed content. These interviews were not held in the context of a formal consultation and ENTSO-E welcomes the stakeholders' feedback during the public consultation in Spring 2010 in written and during the workshop on March 2010, 19th, in which more than 100 participants could express their views.

In this report, *network development* means *any investment in high voltage assets* – either expansion or refurbishment – *of European significance*, i.e. addressing at least one of the three pillars of the EU energy policy: Security of Supply (SoS); tackling climate change and integration of Renewable Energy Sources (RES); economic efficiency and realisation of the Internal Energy Market (IEM). Although of key importance to monitor and operate the network, investments in IT, smart devices and appliances are not reported in the TYNDP so as to focus on transmission issues.

0.2 CHALLENGES FOR GRID DEVELOPMENT

Over the past hundred years, ever larger power systems developed taking advantage of scaling effects and mutual support of generation and transmission components in case of failure. The outcome nowadays is the high reliability standard the grid offers in Europe to end-users, coping with defaulting system components (the so-called “N-1 criterion”), and, more generally, anticipating relevant risk and proposing mitigation measures.

Despite the ever changing context, drivers for grid development are primarily the same as they used to be for the last several decades, accommodating load and generation development. Changes in the legal and regulatory framework have induced major challenges for TSOs, such as:

- respond to the EU energy policy, especially market integration and connection large amounts of RES generation often in remote locations, while maintaining a high level of Security of Supply;
- deal with an increased number of uncertainties and a globally complex legal and regulatory context, especially for permitting procedures, stemming from a multitude of different authorities;
- secure the financial means to achieve the expected network developments in due time.

Still, the main concern is the lack of social acceptance that severely delays or jeopardises the realisation of transmission projects.

Although TSOs play a key-role, both as operators and as privileged observers of the system, they are not the only party with a major role in this respect. Meeting EU energy policy targets by 2020 and 2050 and also fulfilling the Article 194[2] of recently ratified Lisbon treaty[3] will demand coordinated efforts from all concerned stakeholders in order to mitigate uncertainties, harmonise the legal and regulatory framework, and enhance social acceptance of transmission assets.

Uncertainty is also a challenge which transmission system planner must address, with the following concerns:

- the inherent uncertainty in predicting the future location of generation and consumption and the limited availability and quality of this information available to TSOs;
- the changes over time in the way electricity is generated (from embedded generation to large off-shore wind-power clusters, etc.), transported, and consumed (new high-speed trains, heat pumps, electric vehicles, etc.);

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[2] Setting the objectives of European Policy on energy; ensure the functioning of the energy market; ensure security of energy supply in the Union; promote energy efficiency and energy saving and the development of new and renewable forms of energy; and promote the interconnection of energy networks.

[3] Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December 2007 and entered into force on 1 December 2009

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- the medium and long term impact of separate policies (and also different policy implementation options) such as energy demand reduction and efficiency, renewable energy sources integration, CO_2 emissions reduction, decommissioning of polluting units, etc.

0.3 BACKGROUND SCENARIOS, INVESTMENT NEEDS, AND PROJECTS

The construction of multiple generation-demand scenarios for evaluating new transmission assets is an indispensable tool for dealing with uncertainties. The scenarios lay down technical and economic assumptions and identify possible solutions.

As expected from the Regulation, the core of the report focuses on the coming 5-15 years, divided into mid-term (until 2014 for the present release) and long-term issues. Within this timeframe, background scenarios are extensively described together with the contemplated investment in high voltage facilities, and the corresponding projects proposed by TSOs.

0.3.1 BACKGROUND SCENARIOS

Scenario analysis intends to deliver a set of multiple diversified and plausible future environments for power systems. Scenario analysis gives decision-makers an overview of future perspectives and facilitates decision-making in complex, unpredictable situations. Stakeholders' involvement is required to sketch shared long-run perspectives accounting for different energy policies and national contexts.

As Member States are to submit their National Renewable Energy Action Plans (NREAPs) in June 2010, this report focuses on bottom-up scenarios, highlighting mainly mid-term *trends*, which are reliably proposed by TSOs, and suggests procedures to develop longer-run top-down background scenarios for further releases.

The two scenarios outlined in the present report are a *conservative* scenario and a *best estimate* scenario[4]. Generation adequacy and their overall consistency regarding the EU 2020 targets have been checked.

In summary, both Net Generating Capacity and Load are expected to moderately increase throughout the study period (2010-2025). Generation adequacy (i.e. the balance between generation and demand) in the best estimate scenario should be maintained during the entire monitored period; in the conservative scenario generation adequacy is maintained until 2020. After this period new generation capacity could be needed to achieve at least the same level of adequacy as exists in 2010.

Although data on how Member States plan to achieve their EU 2020 targets is not currently available, ENTSO-E sketched some overview:

- power consumption is expected to grow, but rather moderately – at about 1.5% per year in the coming decade.

[4] More information is available in the ENTSO-E *System Adequacy Forecast 2010-2025* report released January 2010 and available at www.entsoe.eu.

- With about 933 TWh of RES generation[5] in 2020, compared to 3657 TWh of consumption, about 25.5% of the power demand in the EU will be supplied by RES.
- Depending on macro-economic conditions, favouring coal-fired or gas-fired power plants, CO_2 emissions may vary between less than 800 to more than 1400 Mt CO_2/year, falling within or short of the EU target[6].

The moderate increase in power consumption takes into account increasing standards of living (and all the new electric devices involved) and end-use switch from oil and gas to electricity (for example in public and automotive transportation, heating, etc.), if electrical energy is seen as easier to decarbonise. This apparent paradox is explained by efficient enforcements of energy savings policies at national and EU level[7]. This increase is probably compatible with the overall decrease of energy consumption (and not only electricity) by 20% compared to the business-as-usual scenario.

Also, according to some experts, the relative ease with which RES may be integrated in the power sector compared with others (transport or heating), means that this figure may need to be higher than 20% (perhaps 30-35%) in order to achieve EU 2020 targets.

Finally, the economic crisis may slow down consumption and investment in generation, and may sometimes result in reduced subsidies for RES. If the present economic downturn is quickly overcome, the EU targets would probably be within reach.

In any case, large grid investments must be undertaken at a quicker pace than during the last years so as to achieve the contemplated EU 2020 targets.

0.3.2 COMING INVESTMENT NEEDS ON THE TRANSMISSION GRID

The report describes extensively, at the pan-European level, all *investment needs* with importance to the Security of Supply, the development of the European energy market and the integration of RES, i.e. every concern likely to trigger investments in high voltage assets, for the time periods under consideration.

ENTSO-E System Development Committee regional groups' perimeters were defined (as in Fig. 1) so as to address most efficiently the challenges for grid development and integration in the coming years. The overview derives from common TSOs analyses at a regional level, accounting for up to date information regarding background evolution scenarios depicted above.

[5] Pure hydro: 118 GW; wind: 194 GW; solar: 38 GW; others: 23 GW.

[6] which can be assessed in the range 800-900 Mt CO2/year for an overall 20% reduction compared to 1990.

[7] Especially, the Directive EC 2005/32 "Eco-design requirements for Energy-using Products.

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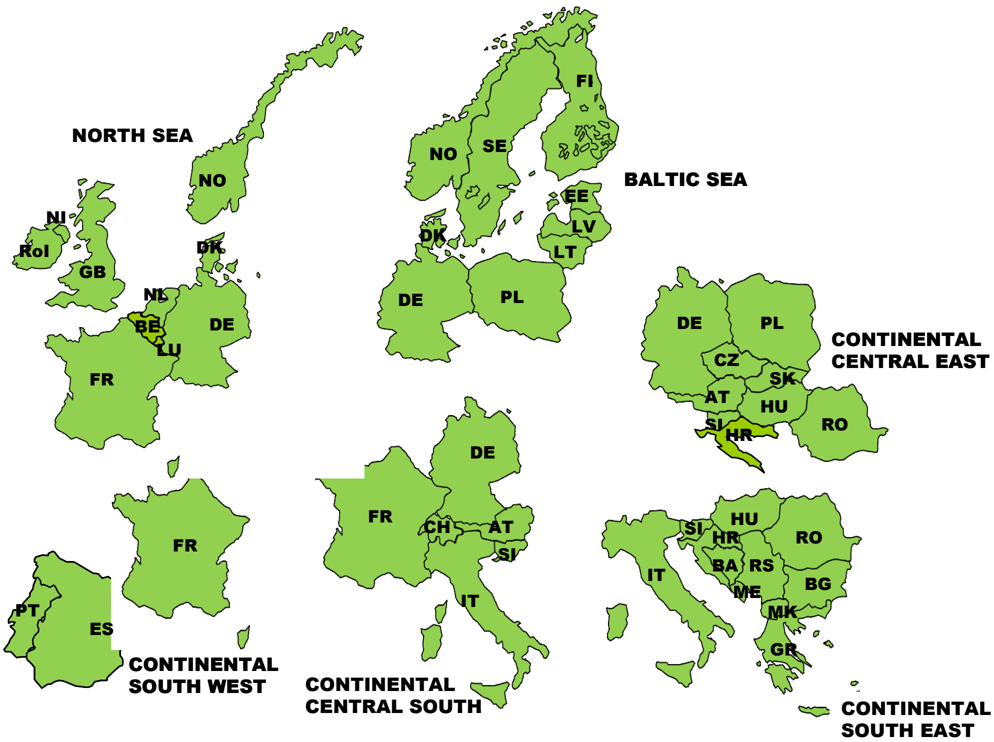

FIG. 1 ENTSO-E REGIONS (SYSTEM DEVELOPMENT COMMITTEE)

Cross-border congestion and market integration are important yet not the sole drivers for grid investment "of pan-European significance". ENTSO-E identified seven mains investment clusters:

- *Massive renewable integration in the North part of Europe*: the connection of renewable sources, mainly wind, is one of the most important drivers of this plan as these plants are often located in remote areas of low load requirements inducing changing flow patterns within the concerned areas as well as the surrounding ones. Investment needs are threefold: connection to the network, increased on-shore transmission capacity and efficient balancing of the system. For the latter, both offshore interconnections and optimised usage of available hydroelectric facilities will also trigger new investment requirements.
- *Massive renewable integration in the South part of Europe*: the connection and transmission of renewable sources, mainly wind, hydro and solar in the Iberian Peninsula, are major investments in the South-West and Central-South regions of Europe. For the same reasons as for the Northern part of Europe, internal reinforcements and increased interconnection capacity with the rest of the continent and especially with France are required.
- *Important East-West and North-South flows in the South-East and Central South Regions*: these investment needs are dictated by the power balances and market prices of the member countries. The area including Greece, FYR of Macedonia, Albania and Italy is usually importing electricity. Strengthening of the Regional network in the predominant power flow directions, in order to assist market integration, is a main driver for transmission investments. North–South flow will rise in importance as new generation in Bulgaria, Hungary and Croatia will be connected to the network. A similar trend will be observed for the East–West flows but for different

reasons, namely the interconnections of new systems with the continental synchronous system (possibly Turkey's system in the short term and possibly Moldova's and Ukraine's system later on). Also, the strong increase of generation and pumping capacity (new hydro pump storage power plants of several thousand MW) especially in the Austrian and Swiss Alps will have a strong influence on the power exchange in the region. A strong correlation with the wind power generation especially in North Germany is expected which will increase the need of transmission capacity between those two regions. A future increase of the wind generation in France and Italy will in a similar way lead to a need for investments to increase the exchange capacity between those regions.

- *Baltic States integration*: Two initiatives, namely the Baltic Sea Energy strategy from the Baltic Council of Ministers' Energy Committee in 1999 (which supports the results from the Multiregional plan) and the EU Commission Energy Market Interconnection Plan (BEMIP) launched in 2008 aim at the full integration of the three Baltic States into the European energy market, through the strengthening of interconnections with their EU neighbouring countries. The new connections to Finland, Sweden and Poland will create a need for internal investments in the Baltic countries.
- Complementary to RES integration, *connection of new conventional power plants* totalling more than 100 GW is foreseen all over Europe in the next decade either to replace old, decommissioned plant or to cope with load growth and system balancing.
- *The power supply of some European cities and regions* will need reinforcements and could become an issue in Europe (Spain, France, Hungary, Slovakia, Poland, Czech Republic, etc.) as they could interact with other investments needs in the area, or limit the available cross-border capacity.
- With new locations and clustering of generation units, and greater variations of the generated power, an efficient *market integration* is key to ensure that wherever power is available, it can be efficiently brought to consumption areas. Grid development and adaptation of grid access rules complement each other so as to propose the most appropriate market framework.

0.3.3 GRID DEVELOPMENT PROJECTS

All planned or envisaged transmission *investment projects* of European importance proposed by TSOs to address the above-mentioned investment needs are presented in this TYNDP pilot project. Almost all the reported projects are the result of regional, multilateral or bilateral cooperation between TSOs in order to address the requirements derived from users or European policies.

TABLE 1 LENGTH OF NEW AND REFURBISHED POWER LINES UNTIL 2020 (PROJECTS OF EUROPEAN SIGNIFICANCE)

Project tehcnology	Total Length Km	Length of new connections Km	Length of upgraded connections Km
AC	32500	25700	6900
of which >300kV	*29600*	*23200*	*6400*
DC (mainly subsea)	9600	9600	0
TOTAL	**42100**	**35300**	**6900**
of which in mid-term	*18700*		

Only projects “of European significance”, as defined above, are reported. They consist both of tie-lines and national projects, as all contribute to achieving European goals. These projects represent roughly 42100 km of new or refurbished network routes, of which 18700 km are expected in the mid-term. The economic crisis may delay some projects but is not expected to trigger significant changes in the above figures.

With about 23200 km, new 400kV AC overhead lines (OHL) account for slightly more than half of the total reported. On the other hand, about 25% of this total concerns new DC links (almost all sub-sea or underground cables). The refurbishment of 6900 km of AC existing lines is also planned, i.e. more than 15% of the total. New 400 kV AC OHL projects are in technical, economic, and ecological terms the most efficient solution for long distance electricity transmission. Indeed, such reinforcements integrate straightforwardly into the existing grid since this technology has been the standard for a long time.

Given that the ENTSO-E transmission network consists of about 300 000 km of lines, it can be deducted from Table 1 that TSO investments correspond to more than 14% of the existing network in either new (12%) or refurbished (2%) power lines for the next ten years.

In Fig. 2, the new or refurbished transmission lines are classified according to their contribution to the EU Energy Policy objectives. It must be noted that the total number of kilometres of lines reported in Fig. 2 is about 170% of the number of kilometres physically constructed (as in Table 1) as a single project may respond to several needs at once. This is an illustration of the network effect (the value of the network is greater than the sum of the values of its components).

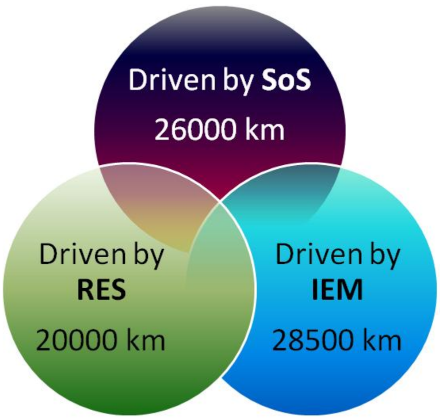

FIG. 2 MAIN DRIVERS FOR INVESTMENT IN NEW OR REFURBISHED POWER LINES (PROJECTS OF EUROPEAN SIGNIFICANCE)

The assets due to be completed within the next five years represent investment costs ranging from 23 to 28 billion €, spread all over Europe, as depicted in Table 2. Although this range represents just a fraction of the total investment efforts of TSOs (i.e. it does not include all national or local investments on new/refurbished infrastructure, etc.) it demonstrates the magnitude of challenges ahead.

TABLE 2 INVESTMENT COSTS OF TRANSMISSION PROJECTS OF EUROPEAN SIGNIFICANCE TO BE COMPLETED WITHIN THE PERIOD 2010-2014

Perimeter	Investments (billion €)
RG North Sea	12 to 14
RG Baltic Sea	11 to 13
RG CCS	11 to 12
RG CCE	8 to 9
RG CSW	6 to 7
RG CSE	4 to 5
Total ENTSO-E	**23 to 28**

For the longer run, several projects are under study and costs are not fully known, or several options (route, technology, etc.) are still open. It is worthwhile noticing that with increasing lengths of DC, underground cables, and more demanding projects, the unitary cost of new power routes tends to increase significantly.

Moreover, unitary costs of individual projects depend largely on technical choices which are strongly influenced by public/local requirements. For instance, when it was proposed to implement the new France-Spain interconnection in Eastern Pyrenees via DC underground cable instead of double-circuit 400 kV OHL, an increase of the cost of the project by a factor 5.5 to 8 was observed[8]. Grid investment costs can thus sometimes compare to generation investment costs, when in the past they always showed a smaller order of magnitude.

In Fig. 4 and Fig. 5, all investment projects of European significance for the mid-term and long-term horizons respectively are depicted.

0.4 ASSESSMENT OF RESILIENCE

High voltage investments are expensive infrastructure projects, with a long lifetime, setting precedence of standards for coming projects, and require years to be carried out. To this aim, TSOs evaluate the resilience of their investment projects in order to avoid stranded costs, and to meet grid user's expectations over time with appropriate solutions.

The resilience of this set of projects has been addressed in the report, according to four main concerns:

- New grid components must at least maintain, and possibly improve, the high standards to which European end-users are accustomed. When planning, TSOs perform network and engineering studies to this aim taking into account new types of generating units and transmission equipment (with specific behaviour and possibly design constraints).
- Investments should positively address social welfare. To this aim, cost-benefit analyses are undertaken by TSOs according to market indicators where consistent

[8] European Coordinator Mario Monti Report – available at http://ec.europa.eu/energy/infrastructure/tent_e/doc/high_voltage/2008_06_high_voltage_report_fr.pdf.

and mature market frameworks have been implemented. Harmonisation concerns are also addressed for the coming years, accommodating structural differences between countries when justified.

- New technological advances are taken into account with consideration to the overall consistency of the interconnected system. TSOs strive to make the best use of existing assets implementing technologies such as FACTS, PST, HTLS[9] in order to optimise grid development or as an interim measure where grid extension cannot be realised in a timely manner; when grid extension is needed, novel and unconventional technologies can also be applied (DC connections, underground cables, etc.) to overcome barriers; TSOs also anticipate future challenges with live-testing of promising new technologies through pilot projects.
- Grid planning should anticipate long run perspectives beyond the coming ten years. Although shared and precisely defined scenarios are required to perform a more quantitative analysis, EU targets for Security of Supply, RES integration, and implementation of an Integrated Electricity Market set a clear blueprint. The future European power grid will probably be connected to neighbouring systems at its Southern and Eastern borders, extending in particular from north of the polar circle to the Sahara with a close network both onshore as today, but also offshore. Such a change of scale, with large amounts of climate-dependent RES will induce new operational limitations to mitigate disturbances over a wide perimeter and require reinforcements of existing high voltage networks onshore.

The set of projects proposed in the present report appear resilient in all these four respects. All these projects complement themselves to develop the overall transfer capability of the grid in all locations. Besides, with further RES development to expect in order to reach the EU 2020 targets, this set of transmission projects is only likely to be complemented. In such a context, project prioritisation is not an issue.

Achieving the integration of large amount of offshore resources will require a significant amount of investment. Appropriate shared technical standards (voltage level, operation principles if not procedures) and a consistent harmonised regulatory framework for investors must be developed in order to anticipate the likely interconnection of initially separately developed assets.

ENTSO-E intends to play a key-role in paving the way for the coming decades, be it through large systems interconnection studies or its roadmap toward a North Sea off-shore grid released in November 2009.

0.5 CONCLUSIONS

0.5.1 DELIVERABLES OF THE FIRST TYNDP

This TYNDP pilot project marks progress in fulfil the objectives set forth by the Regulation in the following ways:

- Bottom-up scenarios have been developed by TSOs describing mid-term trends.

[9] Flexible AC Transmission System (FACTs) ; Phase Shifting Transformers (PSTs) ; High Temperature Low Sag conductors (HTLS)

- Investment needs and projects derive from coordinated modelling of integrated networks between TSOs, from numerous market and network studies, such as the EWIS study, the PLEF Regional Adequacy Forecast etc.
- A comprehensive assessment of resilience is presented synthetically. Principles are proposed as bases for future, refined and shared procedures for such assessments.
- A consultation of stakeholders has been performed to get feedback about the present report.
- This first release TYNDP will be the basis for seeking consistency with national and regional plans when the 3rd Package is enforced in early 2011.
- The detailed description of projects in Appendix 1 provides the necessary data to enable monitoring of the implementation of the plan as from the second edition.

ENTSO-E is also presently setting up common procedures so that TSOs share the same methodological standards, enabling future TYNDPs to be based on consistent Regional studies. A consultation regarding scenarios will be launched to prepare the next issue of the TYNDP as soon as the implementation of the EU 2020 targets for the power sector is available.

The new context in Europe, with the extensive development of carbon-free generation facilities and their integration in the IEM, the amplification of free electricity trade, the connection of neighbouring systems, and the difficulties in grid development will certainly present significant challenges to operating reliably and efficiently the grid. TSOs' individual and combined expertise and experience safeguards the Security of Supply, and, through this report, demonstrates, not only the magnitude of the required collegial effort, but also their readiness to respond to these challenges.

0.5.2 TOWARDS THE FUTURE RELEASES OF THE TYNDP

By its nature as a pilot project, this first release of the TYNDP allows ENTSO-e to identify the main improvement areas and the best means for organising future releases. Fig. 3 depicts a possible way this could be accomplished, starting an iterative process, involving stakeholders, that is based on this first TYNDP.

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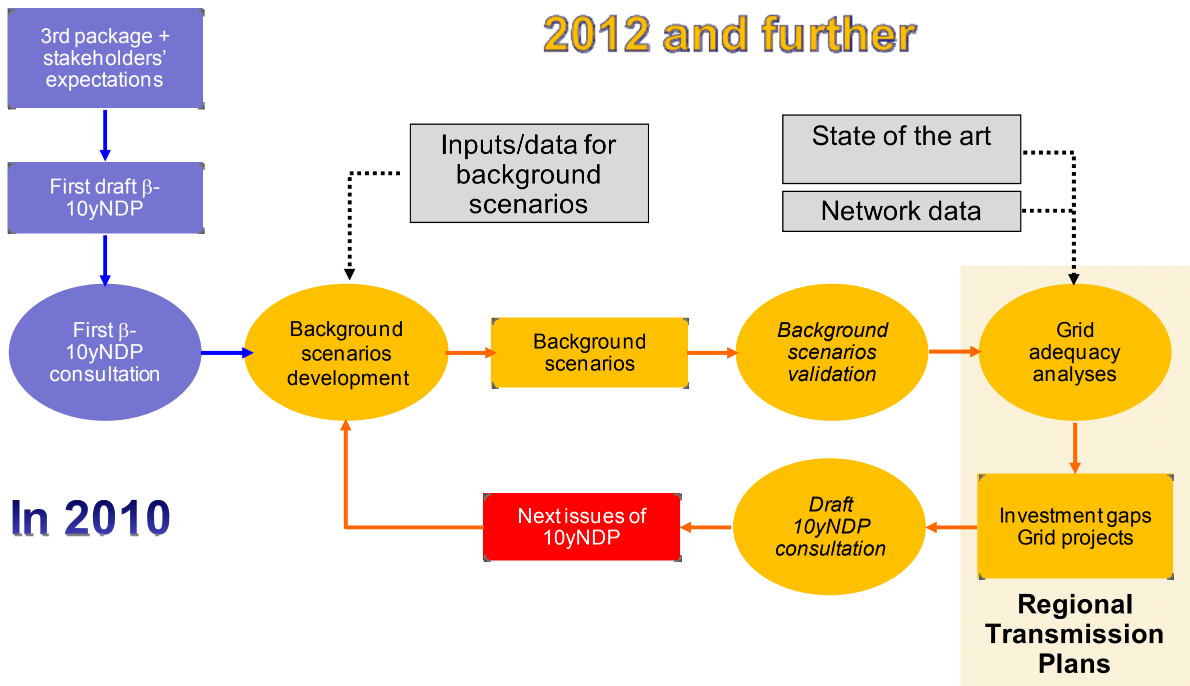

FIG. 3 BUILDING UP PROCESS OF THE TYNDP

With two consultations planned, one on scenarios, the second on the final deliverable, and common studies to perform meanwhile, the loop is an extensive two-year process.

In order to meet a future release in June 2012, works for the next issue of the TYNDP must start immediately after the first report is published, in July 2010. Efforts presently concentrate on the three main concerns:

- to update present bottom-up scenarios, as well as developing shared, long-run, top-down, scenarios, involving ACER, stakeholders, policy and decision-makers. It will require the commitment and consensus of concerned parties, to define at least the 2020 horizon[10] and the completion of the EU 2020 targets based on the NREAPs finalised by June 2010.
- to develop common ENTSO-E pan-European market modelling, reflecting as close as possible the forces which drive the commercial flow of electricity and its translation into physical power flows.
- to further develop an ENTSO-E wide common framework for the regional network studies, based on pan-European scenarios and integrated network model for mid and long term.

Stakeholders supported strongly these proposed priorities during the consultation process.

Works about other pending issues, especially shared resilience criteria, in whatever respect are also being prepared. These are however long-lasting concerns and the scope of coordinated works must first be carefully defined with stakeholders, ACER and National Regulatory Authorities, before completion deadlines can be proposed. Progress in this respect will enrich the next releases of the TYNDP.

[10] If released in June 2012, the next release of TYNDP will look beyond 2020.

Critical to the above is the availability of data, especially concerning generation investment locations, to ENTSO-E in order to better forecast future needs. A clear framework on how reliable information reaches ENTSO-E needs to be set up and activated well before the second release of the TYNDP.

ENTSO-E intends to enrich the interaction with all stakeholders during the building up of the next releases of the TYNDP (in constructing scenarios, obtaining/providing data, sharing methodologies), or through meetings and workshops. Each release of the TYNDP will be subject of a public consultation. All these layers of exchange between ENTSO-E and stakeholders are meant to lead to the production of consistent, useful, and complete TYNDP reports.

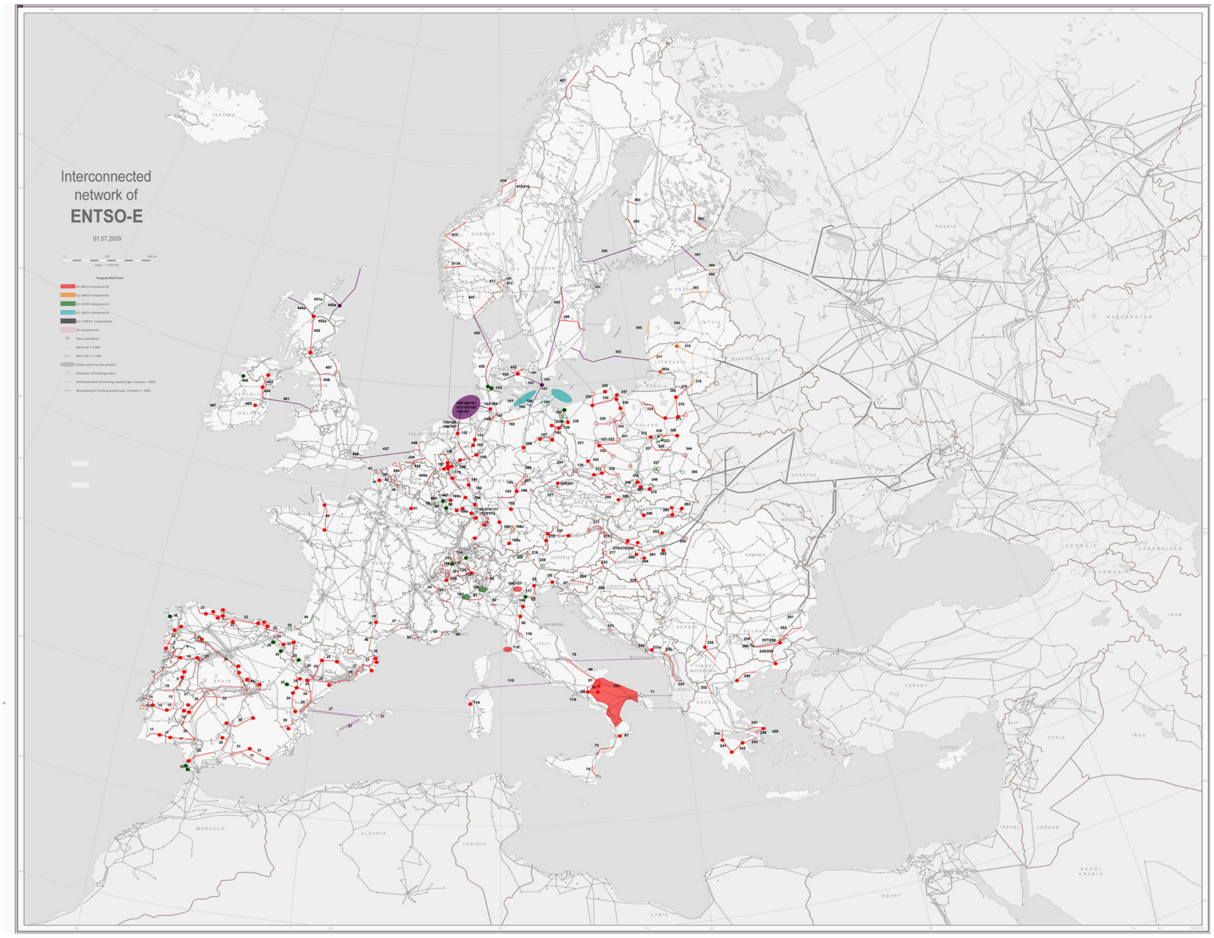

FIG. 4 PROJECTS OF EUROPEAN SIGNIFICANCE (2010-2014)

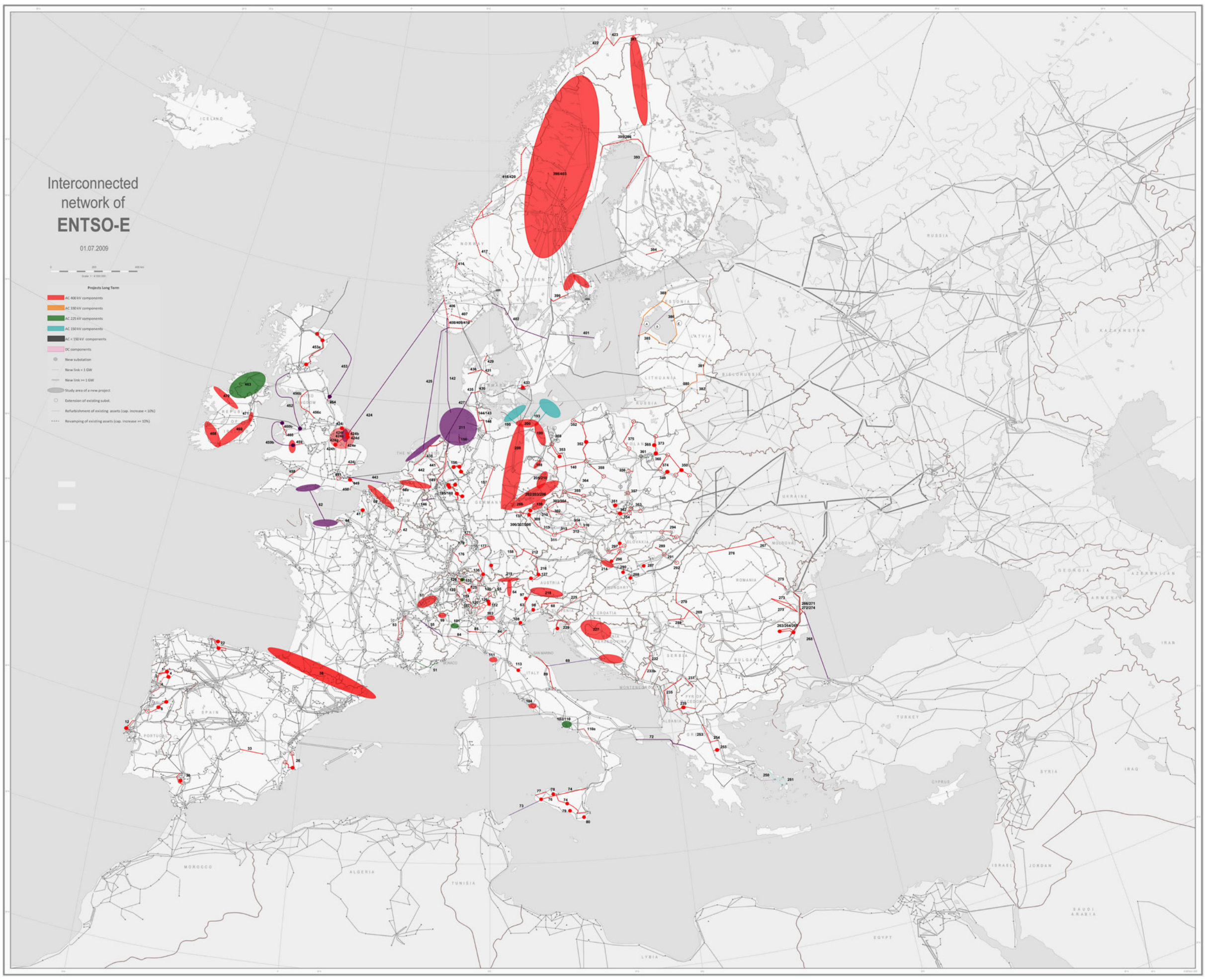

FIG. 5 PROJECTS OF EUROPEAN SIGNIFICANCE (2015 - 2020)

[1] INTRODUCTION

1.1 ENTSO-E

The European Network of Transmission System Operators for Electricity (ENTSO-E), established on a voluntary basis in December 2008 in anticipation of the entry into force of the EU 3rd Legislative Package for the Internal Energy Market in early 2011, replaced all the former electricity Transmission System Operator (TSO) associations, namely the ATSOI (Association of the Transmission System Operators of Ireland); the BALTSO (Baltic Transmission System Operators); the ETSO (European Transmission System Operators); the NORDEL (Association of TSOs from Norway, Finland, Denmark, Sweden and Iceland); the UCTE (Union for the Coordination of the Transmission of Electricity); and the UKTSOA (UK Transmission System Operators Association). Its *mission* is to promote important aspects of energy policy in the face of significant challenges:

- Security - it pursues coordinated, reliable and secure operations of the electricity transmission network;
- Adequacy - it promotes the development of the interconnected European grid and investments for a sustainable power system;
- Market - it offers a platform for the market by proposing and implementing standardized market integration and transparency frameworks that facilitate competitive and truly integrated continental-scale wholesale and retail markets;
- Sustainability - it facilitates secure integration of new generation sources, particularly growing amounts of renewable energy, and thus the achievement of the EU's greenhouse gases reduction goals.

Today, 42 TSOs from 34 European countries are members of ENTSO-E (see Fig. 6). The working structure of the association consists of Working and Regional Groups, coordinated by three Committees (System Development, System Operations, Markets), supervised by a management Board and the Assembly of ENTSO-E, and supported by the Secretariat, the Legal and Regulatory Group, and Expert Groups (see Fig. 7).

The main *purposes* of ENTSO-E are:

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

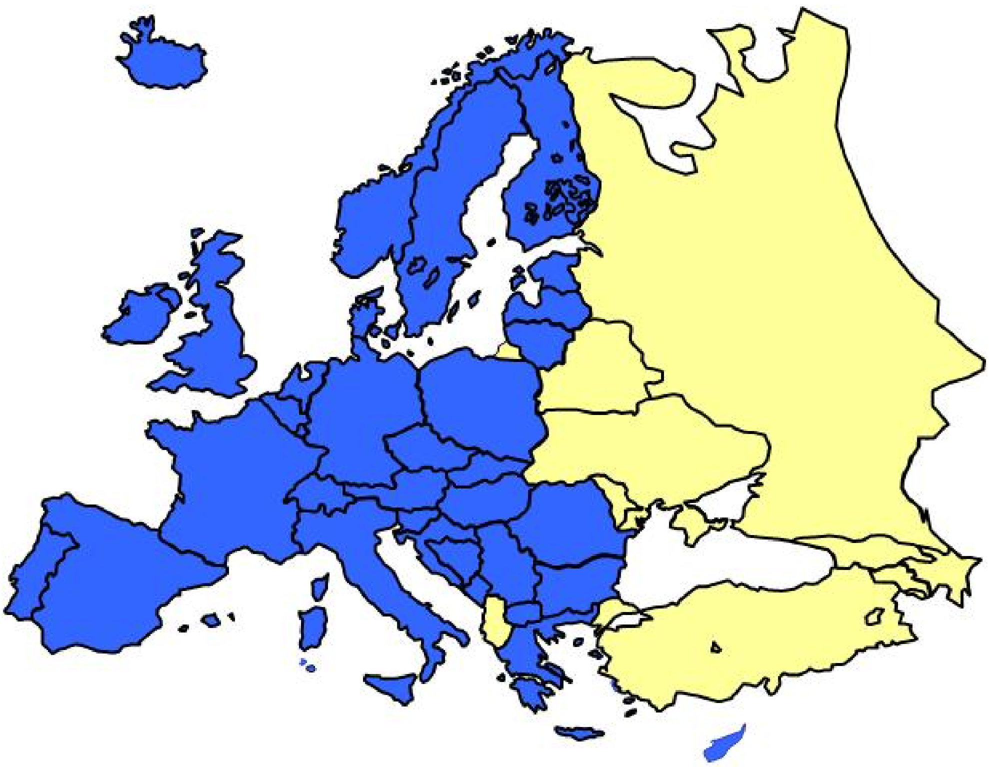

FIG. 6 ENTSO-E MAP

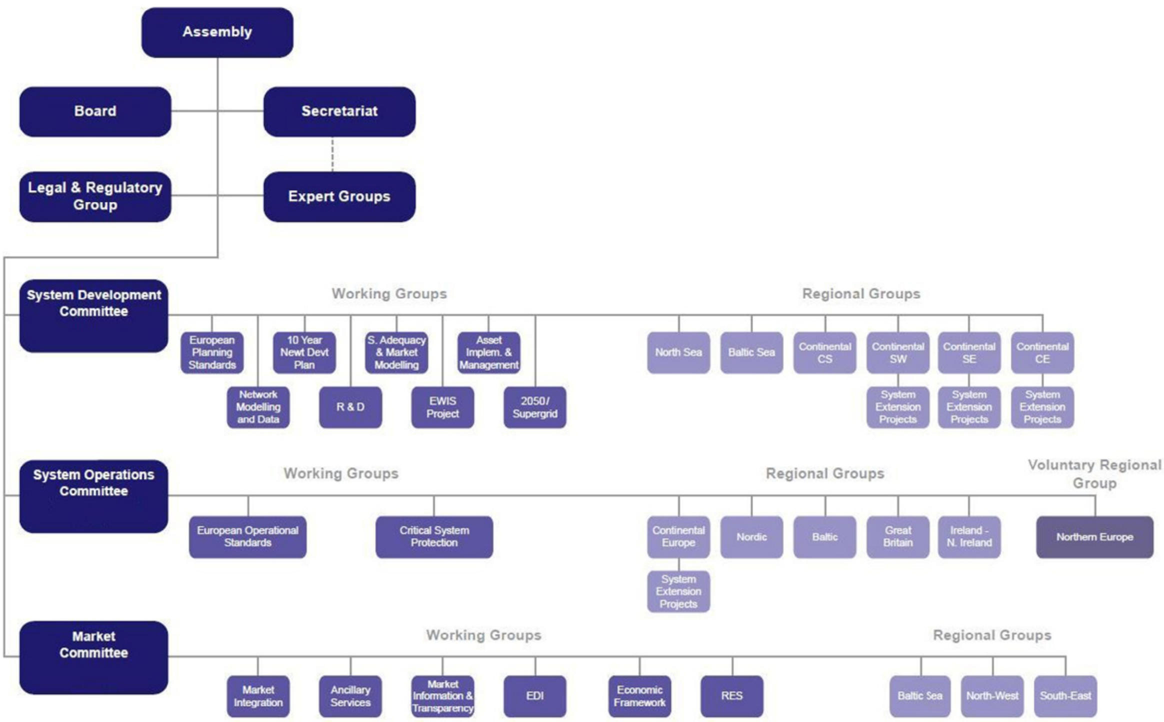

FIG. 7 ENTSO-E ORGANISATIONAL STRUCTURE

ENTSO-E *activities* include among others:

- Coordination of development of an economic, secure and environmentally sustainable transmission system. The emphasis lies in the coordination of cross border investments and meeting the European security and quality of supply requirements, while the implementation of investments lies with the TSOs.
- Development of technical codes for the interoperability and coordination of system operation in order to maintain the reliability of the power system and to use the existing resources efficiently.
- Development of network related market codes in order to ensure non-discriminatory access to the grid and to facilitate consistent European electricity market integration.
- Monitoring and, where applicable, enforcing the compliance of the implementation of the codes.
- Monitoring network development, promotion of R&D activities relevant for the TSO industry and promotion of public acceptability of transmission infrastructure.
- Taking positions on issues that can have an impact on the development and operation of the transmission system or market facilitation.
- Enhancing communication and consultation with stakeholders and transparency of TSO operations.

The 3rd Package assigns to ENTSO-E the task of elaborating a Ten-Year Network Development Plan (hereinafter the TYNDP) every two years.

1.2 OBJECTIVES OF THE FIRST RELEASE OF THE TYNDP

According to Art. 8.3 (b) of the Regulation (EC) 714/2009, "*ENTSO-E shall adopt a non-binding Community-wide 10 year network development plan (« network development plan »), including a European generation adequacy outlook, every two years*"; and according to Art. 8.10, *"The Community-wide network development plan shall include the modelling of the integrated network, scenario development, a European generation adequacy outlook and an assessment of the resilience of the system"*. Furthermore, the TYNDP must *"build upon national investment plans"* (the consistency to which is monitored by the Agency for the Cooperation of Energy Regulators, ACER), *"and if appropriate the guidelines for trans-European energy networks"*. Also, it must *"build on the reasonable needs of different system users"*. Finally, the TYNDP must *"identify investment gaps, notably with respect to cross-border capacities"*.

ENTSO-E, having recognised that:

- The overwhelming response of European society to the climate change issue translates into massive investments in renewable energy sources whose efficient integration into the grid is a challenge that has to be urgently and adequately addressed;

- The wide scope and ambitious objectives of the TYNDP require a large number of dedicated resources, as well as the conception and implementation of processes and methodologies that have not been applied in a pan-European level before;
- The TSOs should continue to contribute towards the Internal Energy Market by ensuring the maximum transparency concerning the operation and development of their transmission grids;

decided to proactively release this report as the first TYNDP before the coming into force of the 3rd Package in the form of a *pilot project*. This early release has four main objectives:

- to gain the feedback of the stakeholders regarding the content and the collaboration they expect for the next releases of the report,
- to illustrate existing trends for attaining European energy policy objectives,
- to test the necessary processes and Europe-wide methodologies,
- to feed the political debate with an in depth review of existing trends.

The TYNDP illustrates existing trends for attaining European energy policy objectives and at the same time allows ENTSO-E to gain the feedback of the stakeholders regarding the content and the collaboration they expect for the next releases of the report.

To achieve the above, the first release of the TYNDP:

- provides the most up-to-date and accurate information (to the TSOs' knowledge) of the planned or envisaged transmission investment projects of European importance.
- provides an outlook of the future condition of the electricity power system in Europe.
- discusses the development and evaluation of generation-demand scenarios, based on which analyses (such as the System Adequacy Forecast) will be performed.
- describes the challenges related to the development of the transmission network.
- initiates a "learning-by-doing" process to build TYNDP reports in an open and transparent manner, with the strong involvement of stakeholders, the European Regulators and the EC.

Investment needs and projects in this report derive from coordinated modelling of integrated network between TSOs, from numerous market and network studies, such as the EWIS study, the PLEF (Pentalateral Energy Forum) Regional Adequacy Forecast etc. All these multilateral studies can be seen as an input for further development of ENTSO-E-wide methodologies.

A new release published every two years means that the report can be improved every two years. This pilot project is therefore the basis upon which improvements are to be accomplished using the experience gained and stakeholders' feedback, ultimately meeting all expectations and requirements, in a "learning by doing" process[11].

Despite the non-binding nature of the TYNDP, it is intended that the information within, representing the best knowledge of the TSOs, should be a reference for all stakeholders, either in planning their own asset investments or, in the case of Regulating Authorities or the EC, evaluating the results of regulations and policies. The fact that the TYNDP will be published and adapted every two years will help the alignment of generation and

[11] ERGEG promotes such process also for the TYNDP for gas infrastructure.

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transmission infrastructure development in an efficient manner optimising investments and addressing the problem of bringing new assets into the system in a timely manner.

In this report, *network development* means *any investment in high voltage assets of European significance, either expansion or refurbishment*. Therefore, this definition

- Excludes all the smart devices and appliances, which TSOs resort widely to, but the implementation of which is not usually challenged;
- Does not encompass high voltage projects undertaken by TSOs, but which only address local, national concerns.

1.3 BUILDING UP THE FIRST RELEASE OF THE TYNDP

ENTSO-E elaborated the report in an open and transparent manner, initiating at a very early stage a series of open discussions with selected stakeholders and in close collaboration with the European Energy Regulators' Group for Electricity and Gas (ERGEG). The goal was to present ENTSO-E proposals for a fast-paced pilot project for TYNDP and possibly amend its proposed content, and the initiative was welcome. The selection of stakeholders was made such that they would represent not just the electric industry in a broad sense, but also the sensitivity of the European public with regard to energy issues and policies. Obviously, these interviews could not be exhaustive for practical reasons, and were not held in the context of a formal consultation. In this respect, ENTSO-E welcomes the stakeholders' feedback during the public consultation in Spring 2010, in written and during the workshop on March 2010, 19th, in which more than hundred participants could express their views. Although their feedback regarded mostly next releases of the report, the present report has been completed and clarified (see especially §2.3, §6.8.2 and §6.8.3).

As discussed in section 1.1, the System Development Committee is organised in working groups, of which the TYNDP group leads the task of producing the TYNDP report with the strong involvement of all other groups. Additionally, the regional groups of the Committee representing the regions shown in Fig. 8 are the main vehicles for information exchange between the TSOs and the leading working group. In the report, the information presented is therefore along the organisational lines of the regional groups, while preserving the details necessary to be of use. When relevant, information regarding isolated systems is provided.

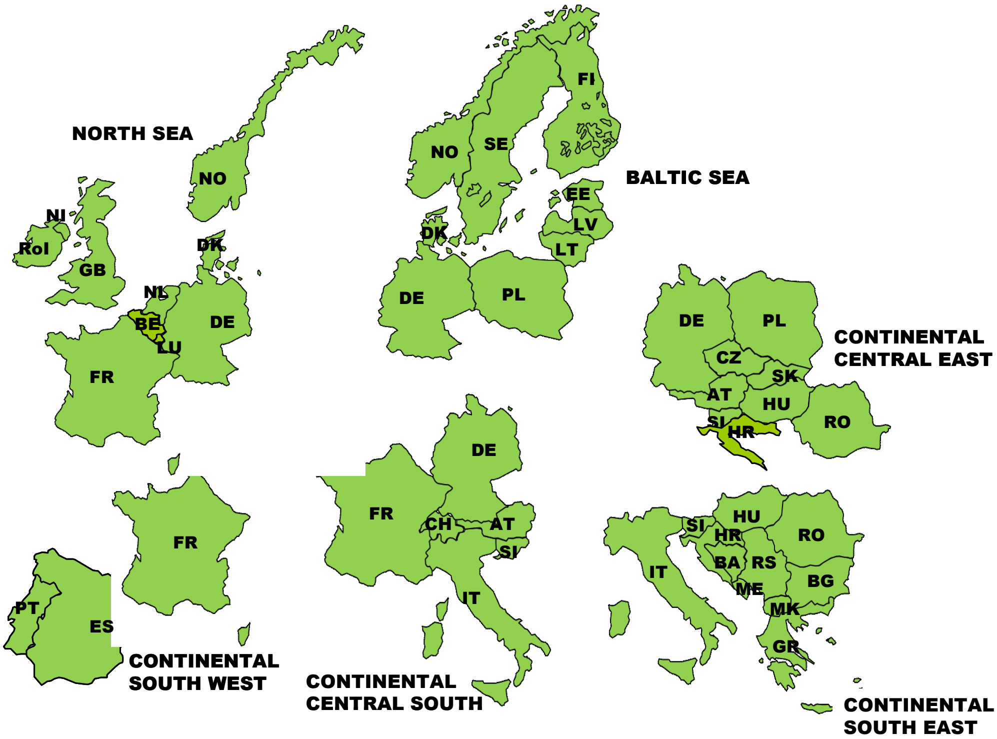

FIG. 8 ENTSO-E REGIONS (SYSTEM DEVELOPMENT COMMITTEE)

1.4 HOW TO READ THE DOCUMENT

The document is structured in the following way:

Chapter 2 presents a brief description of the history of the transmission system development in Europe, so as to point out the main features of power transmission today.

Chapter 3 discusses the challenges of grid development, from the uncertainties dominating forecasts for load and generation evolution, to the complex regulatory and legal frameworks and the lack of social acceptance for transmission projects.

Chapters 4-6 focus on the coming 5-15 years:

Chapter 4 describes pan-European background scenarios for grid development and pending issues, allowing the system users to form an appreciation of the underlying assumptions used by the TSOs in developing their systems and the expected level of generation adequacy. Bottom-up scenarios, highlighting mainly mid-term trends are efficiently and reliably developed by TSOs. A top-down defined EU 20.20.20 scenario must be developed as soon as the NREAPs are made public.

Chapter 5 describes investments needs at the pan-European level, i.e. every concern likely to trigger investments in high voltage assets. The overview derives from common TSO analyses at regional level, accounting for the most up to date information regarding background evolution scenarios described above. Cross-border congestion and market integration are important but not the sole drivers for grid investment “of pan-European significance”: connection applications from larger amounts of new generation, especially RES and gas power plants often in a large distances from consumption areas, to supply a growing demand and replace obsolete units can cause major changes in power flow patterns in the coming years. All these investment needs must be addressed together in the grid planning process.

Chapter 6, the foremost accomplishment of this pilot project is the presentation in a collated and comprehensible manner of all the planned or envisaged transmission *investment projects* of European importance proposed by TSOs to address the above-mentioned investment needs.

Chapters 7-10 introduce principles for the assessment of resilience, divided into four main concerns:

Chapter 7 presents the technical criteria and grid development studies which TSOs perform in order to ensure a high level of quality of service and reliability standards for the grid in the future;

Chapter 8 deals with the criteria and methodologies which TSOs consider to assess the economic soundness of transmission projects;

Chapter 9 summarises the TSO perspective on the new technologies that are now evaluated or tested to develop the transmission network;

Chapter 10 attempts the projection of a longer-term horizon by considering the plans for development of the offshore grid in North Sea, the Mediterranean ring, the "supergrid", and the expansion of the European system.

Finally, the Conclusion presents a self-assessment of the present report, possible methodology improvements and sketches an outlook for next releases.

HIGHLIGHTS:

- ENTSO-E delivers the first release for the TYNDP as a result of a pilot project, to initiate a constructive dialog with stakeholders, in a "learning by doing" process.
- In this report, network development refers to investment in high voltage assets of European significance, either expansion or refurbishment.

[2] THE EUROPEAN POWER SYSTEM TODAY

This chapter aims at recalling key features about grid design and operation, recalling a bit of history to explain why the grid was build and its benefits for the European society.

2.1 HISTORY OF THE EUROPEAN POWER SYSTEM

Transmission grid aims at connecting end consumers to generation centres, since the dawn of the power industry at the end of the 19th century. However, very early and very quickly, larger and larger networks and power system developed.

The paramount reason is that the power sector is capital intensive. Compared to generation assets, relatively cheap transmission assets to build power systems enable significant savings with respect to generation costs:

- Recourse to cheaper energy resources, accessing them where they are also in remote location compared to consumption centres (especially hydropower and nowadays also other RES);
- Lower synchronous peak loads than the sum of individual ones, hence requiring less generation equipment;
- Mutual supports, to accommodate disturbances of the generation and load balance, and reduce costs of mitigation measures (damping of faults over a larger, stronger system, sharing power reserves, etc.)
- The ability for all generators to access all consumers and vice-versa, enabling increased size of generation equipment to benefit from scaling effect; specialised and more efficient design of every power unit addressing an aggregated demand (few flexible ones to accomodate the aggreagated variations, enabling to design less flexible, cheaper ones to serve baseload) and setting a framework for competition.

Therefore, direct connection between power plants and their immediate outlet were rapidly completed by their interconnection and integration into power systems, more economical and more resilient to every single fault and component failure. These power systems themselves then merged into larger ones.

The integration of the single European power system we presently know resulted from this process, abiding by economical, societal and geopolitical evolutions. Higher interdependency, via exchanges and collaboration between the countries has been seen as a means to achieve stability in Europe for several decades now. As from the fifty's, vertically integrated companies built tie-lines and organise mutual support via dedicated associations to accelerate the recovery after World War 2 and enable generation capacity to cope with a booming demand. In 1999, the coming into force of the Electricity Directive 96/92/EC, paved the way for the Internal Energy Market in electricity to benefit from increased trade.

FIG. 9 UCPTE 1956

The present European electric power system comprises seven main synchronously interconnected sub-systems. The backbone of every synchronous system is an AC, more or less dense and meshed network. Five of these synchronous systems are interconnected and can exchange power via one or several DC interconnectors. The other two (Iceland and Cyprus) are isolated.

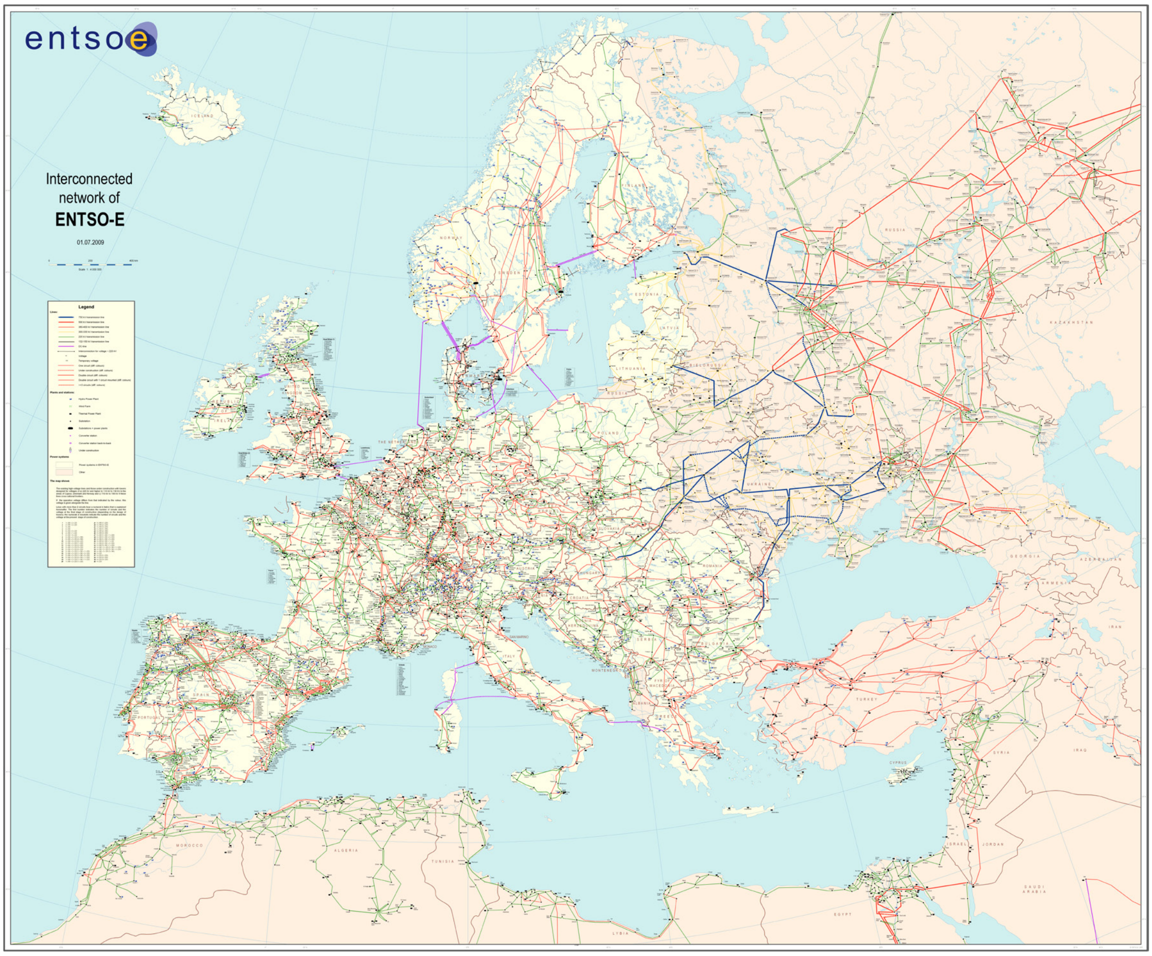

FIG. 10 ENTSO-E NETWORK MAP

2.2 MAIN FEATURES OF GRID OPERATION

2.2.1 ROLE OF TSOs

As definition a TSO is responsible for the bulk transmission of electric power on the main high voltage electric networks. It provides grid access to the electricity market players (i.e. generating companies, traders, suppliers, distributors and directly connected customers) according to non-discriminatory and transparent rules. In order to ensure the security of supply and reliable operation, it constantly monitors the system, and implements the appropriate correction measure to avoid any violation of operating rules. Characteristic of the TSO is its responsibility to ensure load and generation are balanced at every moment (via the *frequency* control in their respective control zone). In many countries, it is also the same company in charge of the maintenance and development of the grid infrastructure.

2.2.2 GRID OPERATION AND DESIGN

The present design of today's European power system reflects the technical choices made over time, since the dawn of the electricity era, in the late 19th century: generalised AC technology to enable higher voltage transmission and hence mitigate transmission losses; generation/load balance procedures in a synchronous area (shared by TSOs but also involving generating facilities providing ancillary services); standardisation of voltage levels which users are connected to, etc.

These technical choices quickly became standards: they are shared by a lot of users and thus difficult to change once implemented. Moreover transmission facilities are rather expensive with adequate performance over a very long life span (of several decades), and are not due to be dismantled and renewed regularly. Hence, grid planning takes advantage of network effects (the value of the network is higher than the sum of its components) and more economically resorts to incremental adaptations of the existing infrastructure rather than introduce new standards, with associated transition costs (for instance, a new 400 kV AC link would prove cheaper to reinforce the existing 400 kV grid than a DC link of the same capacity and in the same corridor, as no converter station or any transformer would be needed).

The design and operation of power transmission systems also depend on the following structural technical features:

- Power flows primarily obey Kirchhoff's laws: i.e. in a meshed network, electricity transferred from one point to another follows practically all branches of the network with inverse proportionality to their apparent impedance (depending on the technical consistency of the line).
- In the rather dense European network, the actual capacity of a grid component (line, transformer) is often[12] its thermal rating, i.e. the maximum current beyond which heat would accumulate in the component, putting at risk either the surroundings (overhead line sag) or the integrity of the equipment itself. As a consequence, thermal limits are no physical limits for power flows by themselves and monitoring and control measures must be implemented by TSOs to ensure thermal limits are not violated.
- In order to avoid any cascading effect, the system is designed and operated with the principle that the failure of a single network element (such as transmission line, transformer, generating unit, etc.) will not result in any disturbance of grid user or violate any system and equipment limitation (frequency, voltage, current). On an AC system, power flows will be adjusted immediately after the failure because of Kirchhoff's laws. This is the so called "N-1 security criterion". More sophisticated security criteria can also be implemented (see Chapter 7).

The combination of these three features results in a complex assessment of the transfer capability of the network, which simply cannot be the sum of the capacities of the individual single components.

With this background, TSOs organised efficient and reliable grid operation of large systems in the past decades although no powerful IT was available for monitoring. Control largely resorted to strictly organised decision making at all levels, from easy local swift fault isolation

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[12] Dynamic stability becomes nowadays more and more an issue, possibly limiting the transfer capability of the network as well.

by automatic devices, to complex – but slower – decisions of human operators. This organisation largely built on the technical opportunities of AC technology: generation/load balance based on frequency control; circuit breakers to isolate faults; automatic redistribution of power flows after faults according to Kirchhoff's laws. The outcome nowadays is the high reliability standard the grid offers to end-users, coping with any possible defaulting system component (the so-called "N-1 criterion"), and, more generally, anticipating every other relevant risk to readily propose mitigation measures.

2.3 Transmission network and the Internal Energy Market

A common transmission grid with non-discriminatory third party access is the key to the organisation of the Internal Electricity Market: all consumers can access all generators and vice-versa, and competition can be organised. In this respect, the network is expected to adapt to choices of market players (output of generators, free location of new units, etc.).

Hence, since the introduction of the Electricity Directive 96/92/EC in 1999, TSOs undertook an additional important role, that of market facilitators.

The European market is presently organised in price areas, often corresponding to countries. Within every price area, the network can normally accommodate market players' decisions, and no limitation to trade is set to them. (Whenever power flows resulting from trade exceed grid limitations then TSOs implement the appropriate mitigation measures, possibly re-dispatching of generation). Price areas limitations correspond to lower transfer capability of the system: in order to ensure a reliable and safe operation, trade is limited to the Net Transfer Capacity (NTC)[13].

NTC is the maximum exchange programme between two areas compatible with security standards applicable in both areas and taking into account the technical uncertainties on future network conditions. The assessment of transfer capacities in highly meshed interconnected transmission networks like that in Europe is a very complex task and includes extensive load flow calculations done by the TSOs.

However, NTC is an important indicator for market participants to anticipate and plan their cross–border power transactions and for TSOs to manage these international exchanges and ENTSO-E strives to supply all useful information on its websites, which enable an accurate characterization of congestion in every corner of Europe and in all possible respects (NTCs, capacity auction results, etc.). The following interactive map is available on the main ENTSO-E web-site: http://www.entsoe.eu/index.php?id=70.

[13] For more information on these definitions see ETSO publication "Definitions of Transfer Capacities in liberalized Electricity Markets" available at http://www.entsoe.eu/fileadmin/user_upload/_library/publications/etso/Congestion_Management/Transfer%20Capacity%20Definitions%20-%20Final.pdf

FIG. 11 ENTSO-E NTC MAP

ENTSO-e publishes also on a dedicated website www.entsoe.net all statistical data and maps of daily, monthly and yearly cross–border NTC, in order to provide the interested parties a clearer and user-friendlier vision of the energy trading possibilities throughout the European grid.

HIGHLIGHTS:

- Enlarging power system allows for more reliable and economical power supply.
- Grid technical standards such as voltage levels are shared by a multitude of end-users' connected facilities, and thus difficult to change.
- Historically, grid operation built on opportunities of AC technology to provide high reliability standards to end-users.
- NTC is an important indicator for market participants to anticipate and plan their cross–border power transactions and for TSOs to manage these international exchanges.

[3] CHALLENGES FOR GRID DEVELOPMENT

This chapter presents the main challenges encountered in developing new transmission corridors or in improving the existing infrastructure.

3.1 AMBITIOUS EUROPEAN ENERGY POLICY GOALS

As explained in Chapter 2, the reasons for developing the grid have adapted over time, according to economic and social needs and aims. In this respect the EU, as well as individual Member States, sets specific standards with respect to the pillars of European energy policy, namely:

- Security of Supply (SoS);
- Renewable integration;
- Economic efficiency, targeting free access to the grid and fostering the Internal Energy Market.

In this concern TSOs play a key role, as operators, privileged observers and experts of the European electrical systems.

3.1.1 SECURITY OF SUPPLY

The term Security of Supply can be seen from two perspectives:

- Access to *primary resources*: appropriate raw materials for electricity generation should be available at a reasonable price. The examples of the oil crises in the 70's and of the more recent gas crises illustrate the necessity of forward looking EU Energy Policies in ensuring access to a diversified mix energy resources and hence in shaping an appropriate European power grid to connect and share them.
- Electricity *transportation*: uninterrupted electricity supply, respecting predefined high reliability and quality standards. In this respect, according to the EC Directive 2005/89 concerning measures to safeguard Security of electricity Supply and infrastructure investments, the TSOs are asked to maintain an appropriate level of technical reserve capacity for operational network security including also all the aspects of blackout prevention.

3.1.2 RENEWABLE INTEGRATION

The EU climate and energy policy sets ambitious targets concerning climate change threats that have an impact on the development of the electricity network. To measure this impact, one may consider the need to increase the share of total energy consumption coming from RES (wind, solar, biomass, etc.) up to 20%, from 8.5% in September 2009. As RES may be easier to integrate in the power sector than in others (transport or heating), it has prompted an overwhelming interest in RES investment, especially wind. Compared with other generation sources, RES have been initially connecting to the distribution level, and hence operating in a less visible manner to the TSOs. This has changed recently, as monitoring and sharing tools have been developed and with large wind production facilities requiring extra high voltage equipment for their connection, often where the infrastructure is not extended for the new challenges yet. As further increasing RES production and by this further needs for power transmission are foreseen it is necessary to extend the transmission networks adequately.

The way the RES will develop depends largely on the national political, legal, and regulatory measures to encourage such investments in their areas. The current experience is that significant progress has been made in many countries, but in an uncoordinated manner resulting in disparities in investment planning and hence a reduced visibility for the TSOs to ensure that the network follows efficiently and on-time these investments, as well as to accommodate bulk power flows from areas with high RES penetration.

Given the above, the recent development of the network is clearly adapting to this challenge; nevertheless the task that remains is no less daunting given the projections for even more massive investment in RES. The European Wind Energy Association (EWEA) for instance foresees 230 GW of wind power in 2020 (including 40 GW offshore, and even 265 GW in their optimistic scenario)[14]. Two aspects will be at the centre of the discussions in the next years: the balanced RES mix and the coordinated incentives mechanisms to both reach the targets at a reasonable cost and to be able to balance the system efficiently.

3.1.3 INTERNAL ELECTRICITY MARKET

The starting point has been a network designed to ensure security of supply and reliability within Member States via well-dimensioned national grids and strategically chosen interconnections. Directive 96/92/EC concerning common rules for the internal market in electricity initiated the path to the liberalisation of European electricity markets in 1996. It has been repealed by Directive 2003/54/EC establishing common rules for the generation, transmission and distribution of electricity. Aiming at intensifying electricity trade, the Regulation (EC) 1228/03 regulates the access to the network for cross-border exchanges and lays out the principles of cross-border congestion management. Finally, the 3rd Package that will enter into force in early 2011 provides for institutions and tools that promote the strong coordination of the operation and development of the transmission network, as well as the harmonisation of the European regulatory frameworks.

The above short history of legislative initiatives towards the Internal Market in electricity shows the constant evolution of the industry towards the objective of enabling free trade between EU Member States. The challenge for TSOs is therefore to contribute, as network developers, to the Internal Market in electricity in the most cost effective manner, always ensuring the reliability of the system. They have been focusing on the development of cross-border capacity in the network to transport electricity for more than a decade now. Significant progress has been achieved so far.

To continue the (r)evolution of the transmission grids, reinforcement and extension measures could be complemented by large-scale storages, FACTS, or other novel technologies.

[14] "Pure Power" report, available at http://www.ewea.org/fileadmin/ewea_documents/documents/publications/reports/Pure_Power_Full_Report.pdf

Research and development programmes are of the utmost importance to ensure the capacity of the network to respond to the new requirements (see Chapter 9).

3.2 UNCERTAIN DEMAND AND GENERATION

In order to appreciate whether the transmission network will be able to accommodate the users' needs in the future, TSOs must anticipate the evolution of demand for and generation of electricity. The multiplication of market participants however makes the context more complex, resulting in a growing amount of uncertainties in the recent years.

Scenarios analyses at national, regional and pan-European levels are key elements in order to decide on grid extensions and to adequately assist political reasoning (see Chapter 4). For TSOs it is of importance to reach the policy targets at reasonable costs and by maintaining the service quality at its present level. TSOs must resort to modelling in their scenarios very fundamental elements into their forecasts. For example, fuel prices, economic and monetary conditions, geopolitical developments, meteorological conditions, technological breakthroughs, market mechanisms, regulatory and legal frameworks are some of the sources of uncertainty for future conditions.

In the long-run, considerations such as population growth, economic conditions, energy efficiency, and technological innovations are notable uncertainties in load forecasts. Although still an issue, demand evolution can be forecasted with reasonable accuracy, as statistical methodologies can usually apply at the transmission grid scale and have been used by TSOs for decades.

For the last decade, generation development has been becoming the main issue for grid development. Fig. 12 below shows that until 2002, the development of the generation capacity (then mostly conventional thermal units) is parallel to the load growth[15]. As from 2002, the faster growth corresponds to the development of RES units, with a high installed capacity – the sizing parameter for grid development in order not to shed RES power –; but a relatively low load factor[16] compared to conventional units

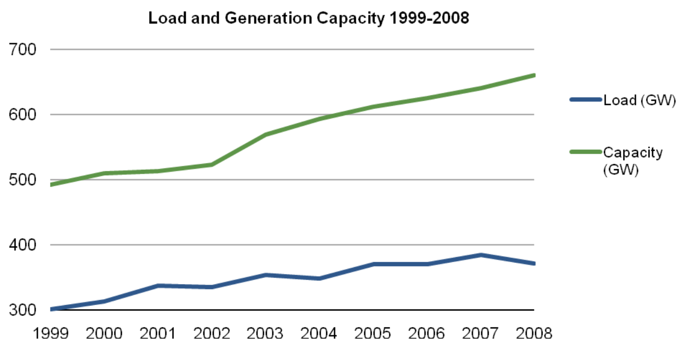

FIG. 12 LOAD AND GENERATION EVOLUTION IN EUROPE (1999-2008)

[15] The discrepancy between the two curves correspond to the non usable generation capacity: the overall installed generation capacity cannot be accessed fully at every time, as the power output depends on the actual availability of the power units (e.g. maintenance), water and wind inflows for hydro power plants and wind farms, etc.

[16] The load factor is the ratio between average generated power and installed capacity.

As a matter of fact, the most important source of uncertainty came as the consequence of the more complex coordination between generation and transmission planning due to the unbundling of the industry enacted in 1999.

- First, the overall capacity of the generation fleet in the coming years, and thus the mix and generation adequacy, is uncertain: no body or market mechanism – beyond TSOs generation adequacy reports and warnings which enhance market transparency – ensures an appropriate generation capacity to cover demand harmoniously. Decommissioning is a particular concern, as a power plant can be closed with no prior notice to the TSO.
- Second, from a legal point of view, TSOs are required to respond to all requests for connection to the grid in a non discriminatory manner; however, a large number of these requests do not materialise into concrete projects and there is no requirement for developers regarding the transparency of their portfolio evolution. This portfolio often encompasses projects in very different locations. Beyond the uncertainly about the overall generation capacity which is a concern for the demand/supply balance, the actual siting of new generation units is also uncertain and a concern to prioritise grid development. This is aggravated by the fact that building transmission assets requires almost double the time as for building production assets, increasing substantially the risk of stranded costs for TSOs, or over/under investment.

Another uncertainty with respect to generation that does not stem from the unbundling structure is related to the appraisal of the stochastic behaviour of RES. TSOs are implementing new monitoring and control tools in this respect – see for example section 3.6.

Generation is subject to competition considerations and to market forces of increased unpredictability. However, greater transparency and hence efficiency in the planning process can be achieved: the System Adequacy Forecast (SAF) and TYNDP reports can merge information from individual market players into appropriate statistics and analyses preserving the confidentiality of commercially sensitive information and thus provide in a non-discriminatory manner to all market players and stakeholders sound conclusions regarding coming trends for generation and grid development, which all stakeholders can share and use as inputs to their own business plan.

In this respect, ENTSO-E supports the proposal of the EU-Council of a new Regulation concerning the notification to the Commission of investment projects in energy infrastructure within the European Community, repealing Regulation (EC) No 736/96, presently under discussion.

3.3 SOCIAL ACCEPTANCE OF TRANSMISSION PROJECTS

The implementation of the required grid reinforcements turns out to be more and more difficult due to an increasing lack of social acceptance by affected local communities and their representatives, or environmental organisations. This social opposition usually comes on top of already long and complex permitting procedures. Consequently, delays in implementation processes may be significant or even end up in projects being cancelled. For example, the total duration for line projects which at best can be around 5 years, frequently require more than 10, and sometimes up to 20 years when major obstacles are encountered. The authorisation phase for a project accounts on its own for the bulk part of this prolongation. This endangers the timely completion of infrastructure projects and the achievement of European policy targets.

The problems encountered are in principle observed on both domestic and cross-border lines construction. However, cross-border lines are frequently perceived by the public as mere “transit lines” or “commercial lines” of limited or nil benefit for the local community and therefore, opposition against these lines is often stronger. Moreover, the process must be coordinated between more than one country often with incongruous permitting procedures.

The main difficulties in permitting procedures are:

1. Variety of legal procedures and diluted legal responsibilities for the planning application process;
2. Lack of reasonable and mandatory time limits for duration of permitting procedures;
3. Unwillingness from stakeholders to support TSOs in the argumentation for the social acceptance of projects;
4. Difficult balancing between environmental impacts and other public interests in evaluation of importance of a grid project by third parties.

The solution does not lie within the abolition of the checks and balances in place which guarantees the respect of the quality of life of European constituencies. TSOs seek to be sufficiently informed about and must take into account local sensitivities with respect to the environment. At the same time, TSOs must effectively communicate the motivations behind projects and demonstrate their competence in identifying the most appropriate solution in a case by case basis as a compromise between the economic and environmental aspects. In order therefore to reduce the duration of the permitting procedures, the following improvement points are proposed:

A. Adapt the legal frameworks to propose a harmonised, efficient, and clear permitting procedure with compulsory time limits, e.g. about 3 years;
B. Ensure the so-called « infrastructure corridors » for high priority infrastructure projects, reserving some land in advance;
C. Formal recognition of the importance of priority electricity infrastructure projects by the respective national laws according to EU requirements. Knowing these lines are only a means to implement policies, support from appropriate decision makers should be granted;
D. Address the cultural and political issues relating to electricity infrastructure.

Another important element within the permitting process is the public acceptance of the new transmission line due to the electro-magnetic field concerns. Compliance with the EMF exposure limits, as contained in the EU Recommendation derived from internationally recognised independent scientific bodies[17] must be ensured. Therefore all the transmission projects in Europe are endorsed to fulfil these limits and to take these concerns into account when selecting the optimal route for transmission infrastructure.

[17] ELF EMF basic restrictions of the Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines (“Guidelines for limiting exposure to time varying electric and magnetic fields (1Hz to 100kHz) published in July 2009” as used in the EU Recommendation are from the ENTSOE point of view adequate and suitable in general in respect of exposure of the general population to electric and magnetic fields generated by high voltage electricity circuits.

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A key element in smoothing, from this perspective, the permitting process is the accurate and correct information of the general public by all the concerned bodies (EU, national government authorities and agencies, TSOs, local government, medical and scientific bodies etc.)

A more detailed description of the permitting barriers encountered by TSOs is presented in Appendix 5.

3.4 EUROPEAN MARKET DESIGN

Besides consistent regulation and contractual frameworks, removing congestion on the grid (i.e. physical limitation to power exchanges) is key to enable free trade between countries and promote the integration of electricity markets. However, congestion, as seen by market participants in the form of day-ahead price differences, does not correspond exclusively to physical constraints on the grid, as it may occur even when real time power flows are below the transfer capability of the network.

Grid expansion often appears as the panacea to resolving market integration problems and TSOs are encouraged to do so. Indeed, infrastructure development is a long lasting solution to alleviate congestion. However, it sometimes may not prove a desirable approach, when for example the projected costs overcome the anticipated benefits with respect to European social welfare (see Chapter 8), or when other, more efficient solutions exist.

In this respect, enhanced market rules or mechanisms can prove, up to a certain point, more sufficient, cheaper and quicker solutions to remove the congestion than grid development. This is true in day-ahead and intraday horizons, as well as for balancing/reserves markets. Therefore, TSOs promote enhanced market mechanisms and grid access rules (taking advantage of netting of schedules, trading close to real-time, implicit auctioning of transmission capacity via market splitting and coupling, etc.), as long as the reliability of the system can be ensured. Only well developed, liquid, and technically sound markets can produce trustworthy signals to assist the network developer in finding the most optimal solutions.

3.5 CHALLENGES REGARDING LEGAL AND REGULATORY FRAMEWORK

The regulations applied to transmission grid development and operation stem from many different bodies, with different focuses: National Regulatory Agencies (NRAs) have been created by the EC 1992/96 Directive and enforce the EU legislation applicable to the unbundled power sector; however, safety and environmental regulation applicable to high voltage facilities usually depend on other dedicated authorities. The framework is all the more complex that different administrative levels exist (European, Member States, local authorities), and differ from one Member State to another. Competing priorities are one of the major sources of slow development processes, requiring guidelines with a strong influence on national and also local governments in a way that all involved stakeholders are able to unambiguously prioritise projects.

Sharing costs and benefits of grid development projects is also an issue. Nationwide regulations provide answers with respect to connection costs supported by TSOs and new users. They may differ from one Member State to another with no real consequences to date, except when common international challenges are at stake. For instance different rules for exempted “Merchant lines” may end up with legal stalemates. Furthermore, the swift and efficient development of a new offshore grid, shared by several Member states, demands a harmonised framework, prior to the adoption of any technical standard. The risk is that every Member State implements its own specific set of technical solutions, suiting the techno-economic optimum the local regulation would imply, and thus particular to this Member State, later preventing – or at least making more costly – any further development to connect farther situated RES and to interconnect all the clusters and countries.

Also, the financing scheme for investments of European interest must be addressed (equal handling of capital base assessment, depreciation, revenue cap, procedural regulation, application of investment budgets, adequate return for debt finance, etc.), both to ensure fairness and assess priorities. Given the new context in the European markets, the higher risk of stranded costs must also be internalised.

Acknowledging the major progress that has been achieved so far, but also the long way ahead, ENTSO-E welcomes the call of the 3rd Package for the establishment of ACER “to fill the regulatory gap at Community level and to contribute towards the effective functioning of the internal markets in electricity and gas”[18], and will fully support EU, ACER, governments and NRAs to overcome the present difficulties.

3.6 INCREASING COMPLEXITY OF GRID OPERATION, AND THUS OF GRID DEVELOPMENT STUDIES

The European transmission grid connects more than 500 million European customers, factories, offices, generators, and gives them power access with the ability to adapt their power demand or in-feed without prior notice and with a high standard or reliability. This is made possible by common operating procedures organising consistent decentralised decision making, from coordinated frequency control areas, to every single automatic fault protection automatic device. The bases of this organisation were set fifty years ago, when the electric industry included mostly centralised large generating units, limited in number and thus easily monitored; and the network consisted almost exclusively of HV AC equipment where power flows directly derive from and adapt to instant generation dispatch, load distribution and network topology according to Kirchhoff laws (see also Chapter 2).

The landscape however has been changing for the last few years. The swift development of large number of semi-centralised RES units set new monitoring and control requirements to ensure still high level reliability standards. HV equipment enabling an active control of power flow (PSTs, FACTS, DC technology as explained in Chapter 9) are likely to be implemented in ever larger numbers in the grid. In general their operation is decentralised and coordinated between TSOs. However, to ensure coordinated operation in a more complex future grid, operation procedures, especially in emergency conditions, are a major focus of TSOs (e.g. the Spanish Renewable Control Centre – CECRE –, RTE’s IPES monitoring tool, etc.).

Consequently, grid development projects necessitate ever more complex technical studies: market studies to assess likely power flow patterns, accounting for the uncertainties explained in Section 3.2; load flow studies to assess the ability of the grid to accommodate these power flows; dynamic studies to analyse transient phenomena, the reliable behaviour

[18] Regulation (EC) No 713/2009

of new sophisticated devices, and the safe interaction of all system components in all situations; and all the more detailed engineering analyses that projects become more specific and adapted to their local context. Such increasingly complex studies are described in Chapter 7 while Appendix 4 presents some illustrations.

3.7 CONCLUSION

Even though the main concerns of TSOs for grid development, namely security of supply and reliability, have remained practically unchanged over the past decades, the context has evolved with the introduction of new energy policies concerning climate change and the integration of European electricity markets. This evolution has accentuated or created new challenges in grid development that the industry has to face:

- Undertake their main duties to respond to the long run EU energy policy: maintain a high level of Security of Supply; connecting large amounts of RES amongst others, often concentrated and in remote locations; facilitate market integration.
- Deal with an increased number of uncertainties and a globally complex legal and regulatory context. In particular, a whole range of permitting procedures, stemming from a multitude of different authorities, result in slower planning and development processes. Still, the main concern is the lack of social acceptance that severely delays or jeopardises the realisation of transmission projects.
- Secure the financial means to achieve their ends in the absence of an adequate regulatory framework. In particular, the economic regulation of the TSOs should be developed to effectively support the needed investments in new grid infrastructure.

TSOs play a key-role in this respect, both as operators and as privileged observers of the system. They adapt their internal procedures, but have not got all the means, especially with respect to regulatory issues. The uncertainties concern both the assumptions considered in the scenarios and the effective realisation of the selected infrastructure projects. Meeting EU energy policy targets by 2020 and 2050 will demand coordinated efforts from all stakeholders in order to mitigate uncertainties, harmonise the legal and regulatory framework and enhance social acceptance of transmission assets.

HIGHLIGHTS:

- TSOs have to manage the connection of large amounts of generation, especially RES, improve market integration and still ensure reliable supply while complying with increased legal and regulatory obligations.
- Though TSOs play a key role, coordinated efforts from all stakeholders are required to accelerate realisation processes.

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[4] BACKGROUND SCENARIOS

4.1 INTRODUCTION

Transmission assets, usually of multi million euro value, that require a long process of implementation and frequently have some environmental consequences, are to be carefully designed in order to ensure the security of electricity supply, optimise the efficiency of the system, and contribute to the European energy policies whilst ensuring that environmental and social issues are respected. Furthermore, the strong interdependence between national networks from operational and market points of view suggests that the network planning exercise should be a coordinated one between TSOs. The objective of this section is to describe the underlying assumptions adopted by the TSOs in pursuing the above objectives.

This report sums up and expands on material mostly taken from the ENTSO-E System Adequacy Forecast[19] (SAF).

4.1.1 GRID PLANNERS MUST ANTICIPATE SEVERAL POSSIBLE FUTURES

The foremost of the transmission network development planning challenges is the ability of the system planner to look into the future, near and far, in order to assess the necessity, the feasibility and the economic soundness of an investment. The two major considerations in this forward-looking exercise are the evolution of the generation and the demand for electricity. These two parameters are to be modelled in sufficient detail and forecasted for several future instances in what are termed hereinafter as *background scenarios*.

Before dwelling upon the background scenarios in this report, it is important to briefly explain the reasons that motivate the construction of multiple scenarios within the system planning context as opposed to a single blueprint for the evolution of the electricity market. First and foremost, is the inherent uncertainty in predicting the future location of electricity generation and consumption as motivated by market forces, technology advances, geopolitical developments, meteorological changes and so on. Second, the sources of this information tend to be less and less transparent as reporting on future generation investment for example must take into account competition considerations. Even when this information is available, the long time needed to build generating units is an additional source of uncertainty. Third, it is important to examine the effect of separate policies (and also different policy implementation options) such as energy demand reduction and efficiency, renewable energy sources (RES) integration, CO_2 emissions reduction, decommissioning of polluting units, etc. Finally, changes in the way electricity is generated, transported, and consumed (for example decentralised generation) are not easily quantifiable a long time in advance. Given the above, each scenario is not deemed to represent a given reality but rather to depict some parameters of the possible future system realisations upon which a transmission investment is to be evaluated.

[19] ENTSO-E System Adequacy Forecast 2010-2025 available at www.entsoe.eu

4.1.2 DIFFERENT UNDERSTANDINGS OF THE WORD "SCENARIOS"

A scenario is a consistent description of the future to organize concepts about alternative future environments. The essence of scenario analysis is to come to multiple diversified and plausible pictures of the future. Scenario analysis gives decision-makers an overview of future perspectives and facilitates decision-making in complex unpredictable situations.

Scenarios help to clarify uncertainties and the interaction between uncertainties. If a scenario also describes the events where one can identify early changes in trends and developments it helps to prepare for the future that becomes reality. In energy infrastructure, a considerable time period is needed to adapt the system, so it is important to identify those "early warnings" which indicate that reality is moving towards certain future views.

On the other hand, planning studies require more or less detailed set of assumptions as inputs: basically, for running a load-flow, the power consumed and generated at every node of the network in the studied area is needed at a given point in time and the network must be fully represented.

Thus, network planning makes use of two different levels of details to describe the hypotheses, both of which are often referred to as "scenarios" (and thus become sources of confusion):

- A *scenario*: general economic conditions (economic growth, prices of primary fuels and CO_2); general level of load (with underlying uses of electricity, resulting for example in typical shape of load curve and sensitivity to temperature); generation fleet (number of units of every type, and respective size), network consistency;
- A *case*: i.e. a particular situation that may occur within the framework of a scenario, featuring:
  - one specific point-in-time (e.g. winter / summer, peak hours / low load conditions),
  - a particular realisation of random phenomena, generally linked to climatic conditions (such as wind conditions, hydro inflows, temperature, etc.) or availability of plants (forced and planned);
  - the corresponding merit-order dispatch of all generating units resulting from all above assumptions.

A scenario can thus be described quite synthetically, and debated. Cases correspond however to the relevant situations that network planers study to assess likely investments needs and the efficiency of any measure to solve them.

4.1.2.1 EXAMPLE: EWIS[20] STUDY

The EWIS study considers two scenarios in order to study the integration of wind generation into the European network up to 2015. These are:

- The Best Estimate Scenario features the expected development of load and conventional generation up to 2015, with wind generation fixed at that established in 2008 (*circa* 140 GW across Europe)

[20] European Wind Integration Study (EWIS) (funded by EC as TREN/07/FP6EN/S07.70123/038509) available at www.wind-integration.eu

- The Optimistic Wind Scenario differs from the Best Estimate scenario in its forecast for wind generation development (*circa* 185 GW across Europe in 2015).

Two typical cases are considered in grid analyses:

- Low load, high wind north;
- Low load, high wind south.

These cases are the representative ones to identify and assess investments needs (see Chapter 7). The grid calculations resulted in proposals for risk mitigation measures to reduce the load of some most congested parts of the grid.

4.1.3 TOP-DOWN AND BOTTOM-UP SCENARIOS

There are two prevailing approaches for considering scenarios, “top-down” and “bottom-up”:

4.1.3.1 TOP-DOWN SCENARIOS

In a “top-down” approach, a *target* is set (usually as a policy objective) for a future date and then applied to assess the trajectory for achieving this target. TSOs are hardly able to build such a scenario alone, even if they know the target, as they need some additional information about the roadmap of stakeholders to reach the goal. For example, the EU 20.20.20 scenario is a top-down scenario; some considerations are further in Section 4.2 below.

Alternatively, it is not really a target that is set, but some high level assumptions regarding the general economic framework, stakeholders’ behaviour or public opinion. An illustration of this process is given in Fig. 13 extracted from the Nordic Master Plan 2008[21]. A more detailed description is available in section 1 of Appendix 3.

The purpose of the Nordic Grid Master Plan 2008 was to identify Nordic grid reinforcements with positive cost-benefit value, according to prerequisites for 2015 and 2025.

The prospective demand and generation of electricity were set up in scenarios for 2015 and 2025. The scenarios were developed by Nordel to illustrate different possible pathways for power infrastructure requirements. The scenarios made were a business-as-usual reference for 2015 (BAU 2015) and alternative scenarios for 2025. The alternatives were a business-as-usual scenario with two levels of production, a scenario with focus on climate and international cooperation (Climate & Integration) and a scenario with focus on national solutions (National Focus).

[21] Available at www.entsoe.eu

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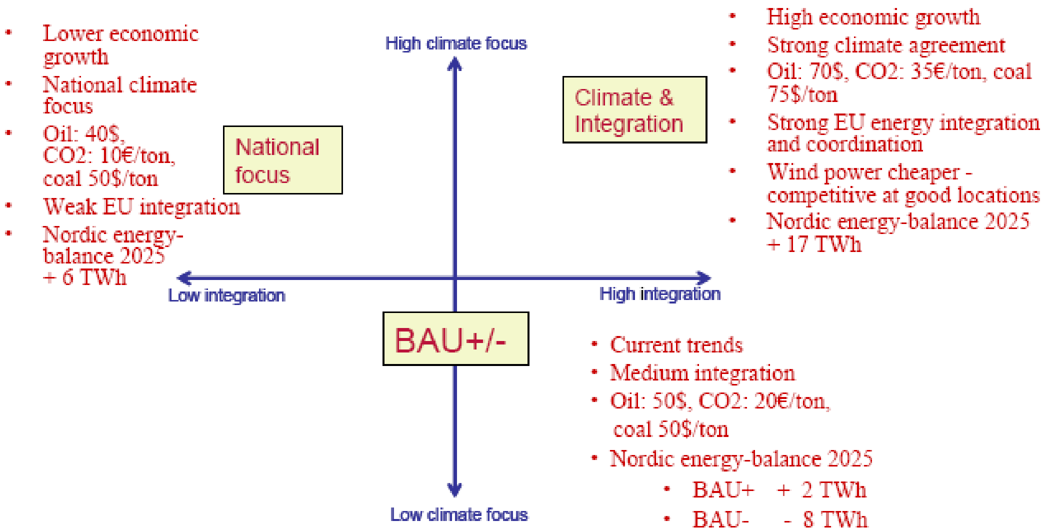

FIG. 13 THE THREE SCENARIOS ILLUSTRATED IN THE DIMENSIONS "INTEGRATION" AND "CLIMATE FOCUS"

4.1.3.2 BOTTOM-UP APPROACH

The so-called “bottom-up” approach describes and builds on present *trends* in which the TSOs predict the evolution of the generation and demand based on the current observations and their appreciation of the future needs according to numerous considerations. The European system features are then the result of merging the contribution of each TSO (or country). This is the most common practice among TSOs. An example is the System Adequacy Forecast, described in Section 4.3 below.

4.1.4 CONSISTENCY CHECKS

Once a scenario has been built, its performance can be assessed with reference to three main issues:

- Adequacy forecast: meaning the ability of the generation system to meet the demand with a suitable security of supply (if not, additional generation should be needed);
- Economic consistency: addressing whether or not the generation units are expected under economic sound conditions (if some generators are hardly used, it seems that generation installed capacity has been somehow overestimated, not all the units will be built and/or some existing ones may be mothballed or even decommissioned; conversely, half-base units being „overused“ would lead to the conclusion that probably some base load units would be needed);
- Ability of the power system to meet the EU energy policy targets: aiming at estimating how the European power system as a whole follows its roadmap towards the EU targets.

These three items will be developed below.

4.1.4.1 ADEQUACY FORECAST

Here the ability of the generation to meet the demand with sufficient margins (therefore adequate level of security of supply) is addressed. Probabilistic assessment may be made whenever needed, but it is worth mentioning that some deterministic indicators, easy to compute, are also available, e.g.

- ***Remaining Capacity (RC)***: Difference between the Reliably Available Capacity (i.e. the average available power from installed generation capacity) and Load. RC is the part of Net Generating Capacity (NGC) left on the system to cover any unexpected load variation and unplanned outages at a reference point.
  - When Remaining Capacity is positive, it means that some spare generating capacity is likely to be available on the power system under normal conditions.
  - When Remaining Capacity is negative, it means that the power system is likely to be short of generating capacity under normal conditions.
  - When Remaining Capacity is over or equal to Adequacy Reference Margin[22], it means that some generating capacity is likely to be available for export on the power system.
  - When Remaining Capacity is lower than Adequacy Reference Margin, it means that the power system is likely to have to rely on import flows when facing severe conditions.

This concept is illustrated in Fig. 14 and covered in section 4.4.

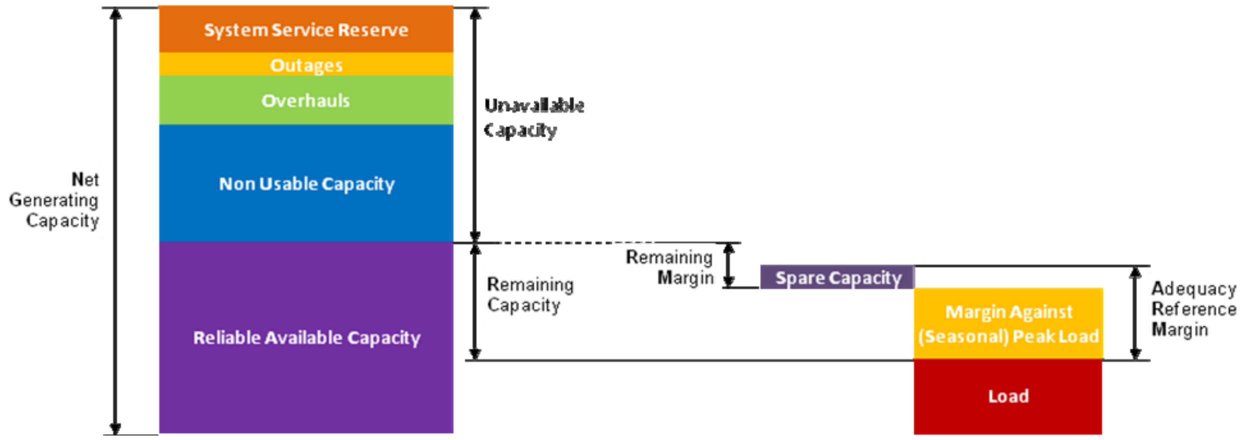

FIG. 14 GENERATION ADEQUACY ANALYSIS

4.1.4.2 ECONOMIC CONSISTENCY

The aim is to assess whether the expected operating conditions of the generating units considered in the scenario would make them economically viable. The principle relies on an assessment of the use of the generating unit, based on some merit order criterion. The idea behind this is that the units coming out with very short expected running time or very low load factors would most likely not be built by investors; existing ones may be mothballed or even decommissioned.

Here again, the national aspect is not sufficient and a pan-European assessment is needed, since market players operate at the European scale. Therefore probabilistic market

[22] Adequacy Reference Margin: part of NGC that should be kept available at all times to ensure the security of supply over the whole period for which each reference point is representative. ARM is calculated in order to cover the increase of load from the reference time point to the peak load and demand variations or longer term generation outages not covered by operational reserves. ARM accounts for unexpected events affecting load and generation.

ARM in an individual country is equal to Spare Capacity plus the related MaPL.

Margin against Peak Load: MaPL is the difference between load at the reference point and the peak load over the period represented by the reference point.

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simulations are the most suitable. Nevertheless, it should be pointed out that some simplified approaches are still possible, either by conducting the studies at regional level (instead of pan-European) or by a simplified assessment (considering only some situations instead of probabilistic approach).

4.1.4.3 COMPATIBILITY OF BOTTOM UP SCENARIOS WITH THE EU 2020 TARGETS

The last set of checks address the ability of the system to meet the decided goals of European energy policy, namely the "EU 2020 targets". Here, some assessment has to be made on the amount of CO_2 emissions for the power system and the share of RES supply in covering the electricity consumption. The assessment of savings in energy demand due to improved energy efficiency is more complex as it concerns the whole system and not only the electricity demand.

The targets are more accurately addressed in the following Section 4.2, the indicators in Section 4.6 below.

4.2 SCENARIO 20.20.20

4.2.1 EU 2020 TARGETS

The EU's climate and energy policy sets the following ambitious targets for 2020:

- Cutting greenhouse gases by at least 20% of 1990 levels (30% if other developed countries commit to comparable cuts);
- Increasing use of RES (wind, solar, biomass, etc) to 20% of total energy consumption (currently around 8.5%);
- Cutting energy consumption by 20% in 2020 compared to business-as-usual perspectives - by improving energy efficiency.

The EU's climate and energy package approved in December 2008 implements these targets. Within the package itself, there are five areas of legislation:

- Promotion of Renewable Energy: RES will produce 20% of all the EU's energy by 2020. This will be realised through binding national targets (from 10% for Malta to 49% for Sweden). Table 3 gives the binding national renewable energy targets in gross final consumption of energy in 2020;
- Revision of the current EU emission trading system (ETS): For power plants and energy intensive industries emissions to be cut to 21% below 2005 levels by 2020. This will be done by granting fewer emission allowances under the EU Emissions Trading System (ETS) (covering some 40% of total EU emissions). For sectors not covered by the ETS as for example transport (except aviation, which will join ETS in 2012), farming, waste and households, emissions are to be cut to 10% below 2005 levels by 2020.This will be implemented through binding national targets;
- Provision of the legal framework for the new carbon dioxide capture and storage technology (CCS);
- CO_2 emissions from cars;

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- Implement fuel quality standards: At least 10% of transport fuel in each country must be renewable (biofuels, hydrogen, “green” electricity, etc.). Biofuels must meet agreed sustainability criteria.

Member States are required to transpose these directives into national law within 18 months of publication in the EU’s Official Journal

TABLE 3 NATIONAL RENEWABLE ENERGY TARGETS

Country	Share of energy from renew able sources in gross final consumption of energy, **2005**	Target for share of energy from renew able sources in gross final consumption of energy, **2020**
Austria	23.3%	34%
Belgium	2.2%	13%
Bulgaria	9.4%	16%
Cyprus	2.9%	13%
Denmark	17.0%	30%
Estonia	18.0%	25%
Finland	28.5%	38%
France	10.3%	23%
Germany	5.8%	18%
Greece	6.9%	18%
Hungary	4.3%	13%
Ireland	3.1%	16%
Iceland	76.6%	not decided
Italy	5.2%	17%
Latvia	32.6%	40%
Lithuania	15.0%	23%
Luxembourg	0.9%	11%
Malta	0.0%	10%
Norw ay	57.9%	not decided
Poland	7.2%	15%
Portugal	20.5%	31%
Romania	17.8%	24%
Slovakia	6.7%	14%
Slovenia	16.0%	25%
Spain	8.7%	20%
Sw eden	39.8%	49%
Sw itzerland	16.2%	not decided
The Czech Republic	6.1%	13%
The Netherlands	2.4%	14%
United Kingdom	1.3%	15%

4.2.2 2020 EU TARGETS FOR THE POWER SECTOR

Several comments can be made on the 2020 targets at this stage:

- First, they are targets, not a scenario: in theory, several scenarios (i.e. individual sectors performance) may meet the same targets;
- Therefore, the three targets are somehow linked to each other;
- Moreover, they address the whole energy sector and not only electricity: figures for the power sector only are not currently available;

- In addition, the objectives for the power sector cannot be derived from the global objectives by only a simple adaptation ("copy/paste");
- Last, national scenarios are not yet available: following an ENTSO-E internal survey carried out in September 2009, the governments of only 7 out of the 34 countries (42 TSOs) represented in ENTSO-E have released their official targets of how to achieve the 2020 goals and how this is reflected for the power sector.

For example, the global objective of cutting down the energy consumption by 20% may result in much lower reduction or even increase of power demand, as a consequence of transfer to electricity of certain types of use (e.g. electric vehicles, heat pumps replacing conventional gas or oil heating which may increase electricity demand, especially at low temperatures).

In addition, a global target of producing at least 20% of the total amount energy consumed from RES could lead to an increase in the part of RES in electricity generation to more than 20% as it is much easier to generate electricity from RES (wind for example) than to increase the part of RES in other sectors, like transport. An order of magnitude of 30-35% for the share of RES in the power sector may be envisaged.

Last, the amount of CO_2 emissions from the power sector is somehow linked to the share of RES generation and expected demand for power sector: Combined Cycle Gas Turbines (CCGT) have some impact on CO_2 emissions but they may be needed for suitable adequacy of the power system.

4.2.3 NECESSARY CONSULTATION OF STAKEHOLDERS IN THE PROCESS OF BUILDING A 20.20.20 SCENARIO

The section just above has shown the difficulty in translating the EU targets into national roadmaps for the power sector. The following issues in particular have to be highlighted:

- The individual target of each Member State for the use of Renewable energy in the gross final consumption of energy (electricity, heat and transport) and specifically for the power sector; some information should be available in the National Renewable Energy Action Plans (NREAP) that should be delivered by all the Member States in June 2010. Even when the national targets are available, it is worth remembering they are only targets and trajectories, but not commitments.
- Conversely, with a more bottom-up approach, the present draft update of EU Regulation 736/96 is a chance for the EU to gather information from developers of energy infrastructure via Member States, including power plants. Guidelines must be devised to make this information as reliable and consistent as possible. Member States could delegate the gathering of this information to TSOs for electrical infrastructures, and ENTSO-E is ready to contribute.
- Demand-related issues; a number of factors may affect TSOs' ability to forecast demand accurately:
  - Climate change may affect demand patterns (e.g. warmer summers in the South, warmer winters in the North);
  - The duration of the current economic conditions that have resulted in reduced demand and the pattern of demand increase after the recession;

- Many wind farms (and more and more other RES plants) are connected to distribution networks and appear as “negative demand” to TSOs, increasing the complexity of gross demand forecasting;
- Many Member States have introduced end-user energy efficiency programmes to reduce demand – their effectiveness is difficult to predict and politically sensitive;
- Many Member States are phasing out regulated end-user electricity tariffs which may reduce demand and might also be postponed as an aftermath of the economic recession;
- Increasing use of industrial Combined Heat and Power units (CHP), domestic CHP, domestic solar power and domestic wind turbines may increase the complexity of gross demand forecasting.

- Supply-related issues: as well as the issues already mentioned regarding renewable generation, CHP etc., there are a number of other supply-related issues which need to be taken into consideration:
    - LCPD (Large Combustion Plant Directive) plant closures by the end of 2015;
    - IED (Industrial Emissions Directive) plant closures;
    - Many Member States are reviewing their policy on nuclear generation, which may have a significant effect on future generation mix.
- Many of the provisions of the 3rd Package, the Climate Change Package, IED, etc. will require significant changes in government and regulatory policies e.g. incentives for infrastructure development, incentives for energy efficiency, system access regimes to connect renewable generation, streamlining of planning/approvals/licensing processes. The consistency of those measures between Member States is not guaranteed and the large number of variables will make it difficult to anticipate their impacts.

The considerations above clearly demonstrate that building a 20.20.20 scenario cannot be the task of TSOs alone but deserves a shared approach involving stakeholders. In addition, grid reinforcements being highly sensitive to the assumptions on generation and load amount and location, the value of the information included in the TYNDP and more generally the adequacy of grid development is highly dependent on the reliability of information provided by stakeholders about their future plans (e.g. generation project developments, merchant interconnector development).

The following section provides some information based on ENTSO-E SAF report.

4.3 TRENDS FOR THE COMING 5-15 YEARS

The ENTSO-E SAF report covers the period 2010-2015, building on information provided by each TSO (based on national policies), therefore this is clearly a bottom-up process. Input data are collected for the years 2010, 2015, 2016, 2020 and 2025 (at given three reference time points of each year: 3rd Wednesday in January at 11:00 a.m. and at 19:00 p.m., 3rd Wednesday in July at 11:00 a.m.); other years and time horizons are calculated by linear interpolation.

Two scenarios are considered, namely:

- Conservative Scenario or Scenario A

This scenario takes into account the most probable demand evolution and the commissioning of new power plants considered as certain and the shutdown of power plants, for whichever it can be expected during the study period.

It shows the evolution of the potential imbalances if no new investment decision were to be taken in the future and allows the identifications of the investments necessary to maintain the expected security of supply over the forecast period.

- Best Estimate Scenario or Scenario B

This scenario takes into account the most probable demand evolution and the generation capacity evolution described in scenario A as well as future power plants whose commissioning can be considered as reasonably credible according to the information available to the TSOs.

It gives an estimation of potential future developments, provided that market signals give adequate incentives for investments, and may include extensions to operating lifetimes of existing generation plants.

4.3.1 DEMAND FORECAST

Most of TSOs consider the influence of the economic crisis in their load and consumption[23] forecasts by linking the provided forecasted load values to the evolution of the Gross National Product and hence subject to change according to the future economic recovery/development. Average annual peak load growth corresponds withTable 4:

TABLE 4 AVERAGE ANNUAL PEAK LOAD GROWTH

ENTSO-E Annual average peak load growth	2010 to 2015	2015 to 2020	2020 to 2025
January 7 p.m.	1.32%	1.45%	1.21%
July 11 a.m.	1.49%	1.66%	1.32%

The ENTSO-E annual average load growth in period between 2010 and 2020 is shown in Fig. 15

[23] In this section, *load* refers to power values in GW; *consumption* refers to energy values in TWh.

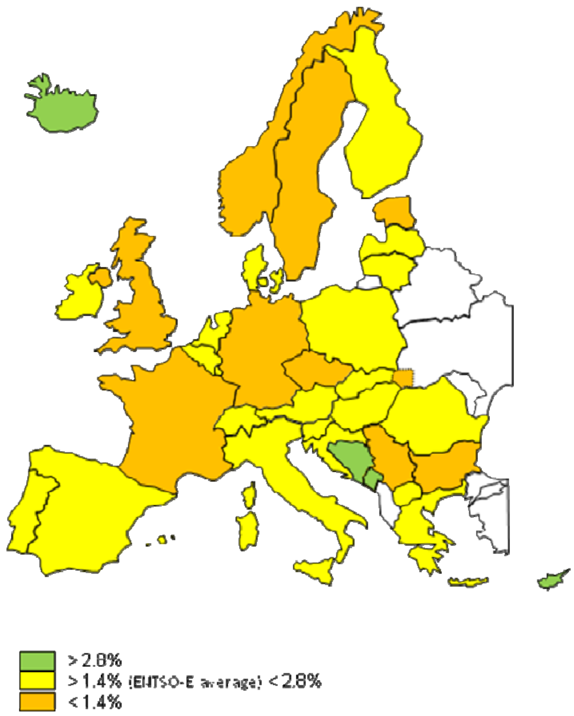


FIG. 15 ENTSO-E ANNUAL AVERAGE LOAD GROWTH; FROM 2010 TILL 2020; JANUARY, 7 P.M.

Consumption forecast is based on the national growth rates of consumption delivered for the period 2010-2025 by each TSO. ENTSO-E energy consumption forecast is shown on Fig. 16 and the annual average energy consumption growth for ENTSO-E is stated in Table 5.

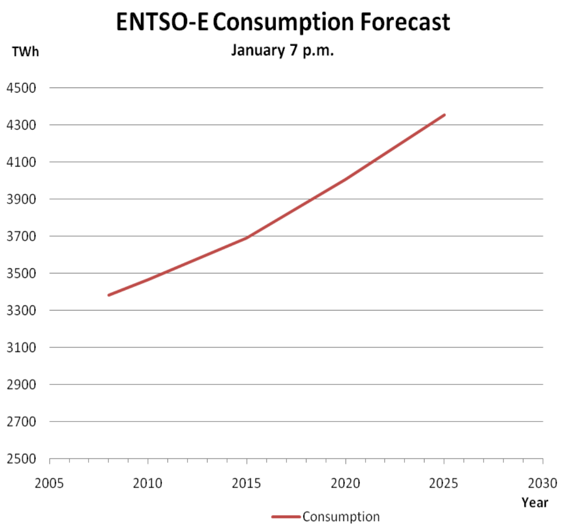


FIG. 16 ENTSO-E ENERGY CONSUMPTION FORECAST

TABLE 5 ENTSO-E ANNUAL AVERAGE CONSUMPTION GROWTH

	2010-2015	2015-2016	2016-2020	2020-2025
Annual Average Consumption Growth	1.26%	1.44%	1.70%	1.68%

The biggest annual average consumption growth is expected in Cyprus, Slovenia, Bosnia-Herzegovina, and Bulgaria in all monitored time periods. This growth for each individual country for the period between 2010 and 2015 is depicted in Fig. 17.

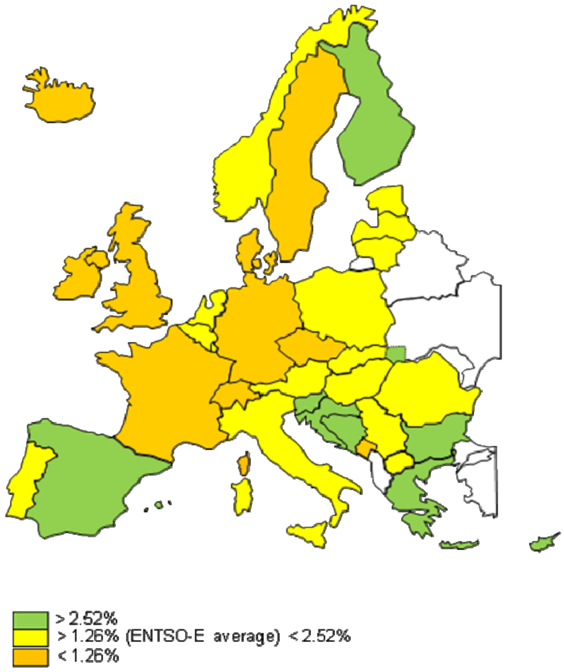


FIG. 17 ENTSO-E ENERGY CONSUMPTION GROWTH BETWEEN 2010 AND 2015

4.3.2 GENERATING CAPACITY FORECAST

The full impact of the economic and financial crisis on generating capacity development may not be yet fully known. It may lead to additional delayed and frozen generation projects.

Until 2015, the Net Generating Capacity is increasing in both of scenarios (Fig. 18). After this term in conservative Scenario A there is a small decrease of NGC about 3 GW (from 984 GW in 2015 to 981 GW in 2016). Then the NGC starts to increase very slowly again (1007 GW in 2020 and 1010 GW in 2025). It can be linked to the fact that classical thermal units typically have a lead-time of around 5 years (the lead time for nuclear unit is around 10 years). Therefore, TSOs are probably not able to take into account “certain” projects for classical thermal units after 2015 when preparing scenario A. Meanwhile TSOs will try to forecast the decommissioning dates of some older units using reference technical lifetimes. Hence, in Scenario A, the NGC development after 2015 is influenced by the decommissioning of older units with commissioning of a small amount of new units (just a few nuclear ones up to 2020).

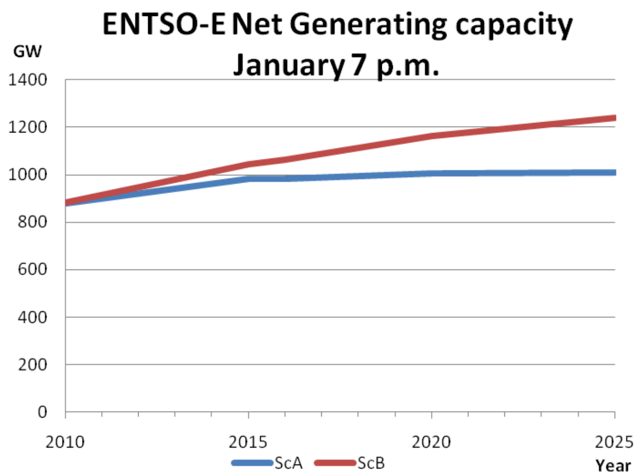


FIG. 18 ENTSO-E NET GENERATING CAPACITY

Scenario B, on the contrary, shows continuous increase of NGC. The highest increase is reported for the period from 2010 to 2015. After 2020, the lowest growth rate is identified. Further to the adding of existing projects up to 2015 or 2020 for nuclear units, TSOs tend to take into account longer-term forecasts based on existing and likely future policies (e.g. climate change) and investment signals (e.g. related to the forecasted load increase). Therefore national forecasts for scenario B do not necessarily reflect a business as usual scenario prolonging the existing trends but can also be a best estimate of the likely investments.

It is also important to bear in mind that the time period after 2020 is based on data with a higher level of uncertainty than the data given for the near future. It is caused by data availability/unavailability to the respective TSO along with the fact that a lot of the different national policies, which are used by the TSOs´ for their long term forecast, do not cover such a long-term period, etc.

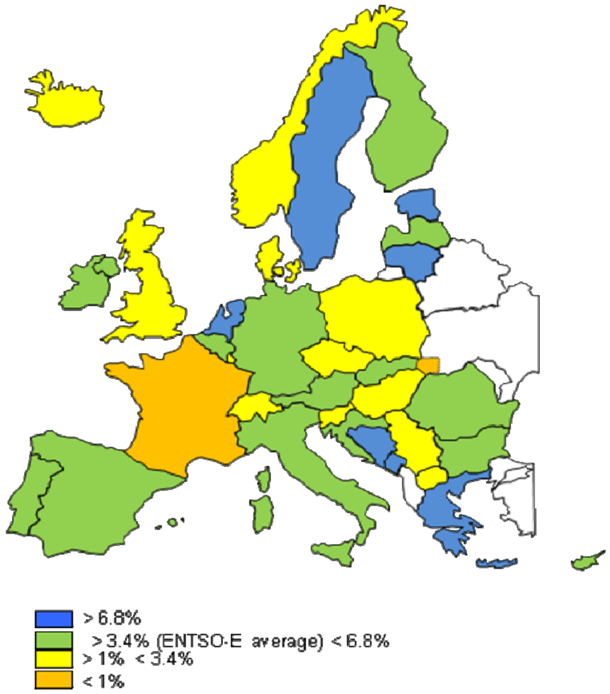


FIG. 19 NET GENERATING CAPACITY ANNUAL AVERAGE GROWTH PER COUNTRY IN JANUARY 7 P.M. FROM 2010 TO 2015; SCENARIO B

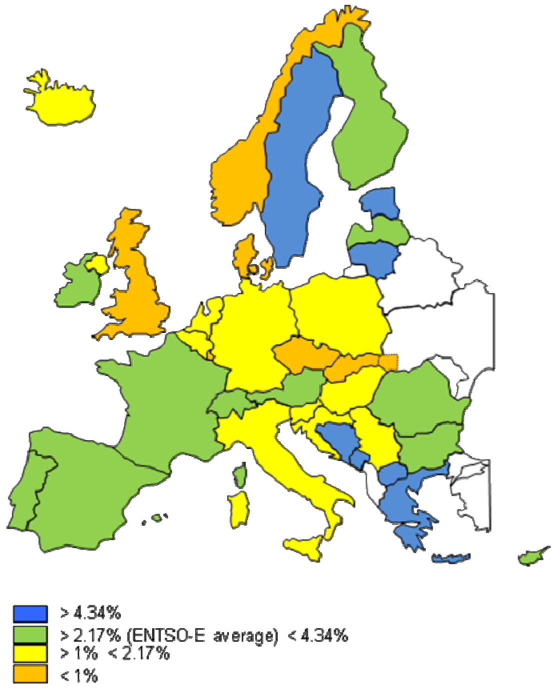


FIG. 20 NET GENERATING CAPACITY ANNUAL AVERAGE GROWTH PER COUNTRY IN JANUARY 7 P.M. FROM 2015 TO 2020; SCENARIO B

Fig. 19 and Fig. 20 show NGC increase rate per country from 2010 to 2015 and from 2015 to 2020 for Scenario B.

The biggest annual average increase of NGC is visible in Bosnia – Herzegovina, Estonia, Greece, Lithuania, Montenegro, and Sweden. For the first 5 years, the Netherlands belongs to this list, however, for the subsequent 5-years period, its growth rate will decrease. NGC growth rate in the FYR of Macedonia will increase significantly for the time period 2015-2020. All mentioned countries show a two times higher increase of NGC than the ENTSO-E average (for the period 2010-2015 the ENTSO-E average value is 3.4% and for the period 2015-2020 it is 2.17%). These national increases in NGC cannot solely be explained by an increase of national load. National policies for security of supply and international trade may also be strong incentives. Furthermore these increases in installed capacity are somewhat tempered when considering the available capacity.

Although the financial and economic crisis will influence investments in generating units in the short run, the impact on the long-term forecast of investments in generation will be less sensitive to a temporary economic downturn. Yet, some might be questioned by an enduring credit crunch and permanent load reduction due to the closure of electro intensive industrial sites. Both could lead to some projects being postponed or even cancelled. Therefore, TSOs will have to closely monitor the development of the economic situation.

Fig. 21 below shows the ENTSO-E generation mix evolution over the period:

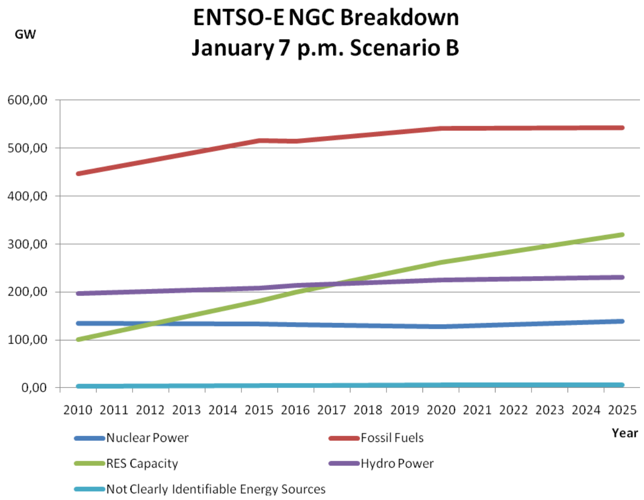


FIG. 21 ENTSO-E NET GENERATING CAPACITY BREAKDOWN

According to the methodology already described in section 4.1.4, these bottom-up scenarios are to be submitted to further investigations in order to check the system's ability to provide an adequate security of supply (generation adequacy forecast), economic use of the generation mix and meet the EU goals of the European energy policy, such as the EU 2020 targets. The following sections will mainly focus on Scenario B of the ENTSO-E SAF.

4.4 GENERATION ADEQUACY FORECAST

4.4.1 ADEQUACY LEVEL IN AVERAGE SITUATIONS

Remaining capacity in ENTSO-E is positive in each reference point and in both scenarios with quite similar evolutions. Only in scenario A in January 2025 at 7 p.m. are some negative values of RC expected (-3.2 GW). This time horizon is some way off in the future and is therefore influenced by high uncertainty concerning assumptions made by each TSO. Fig. 22 shows the course of the RC.

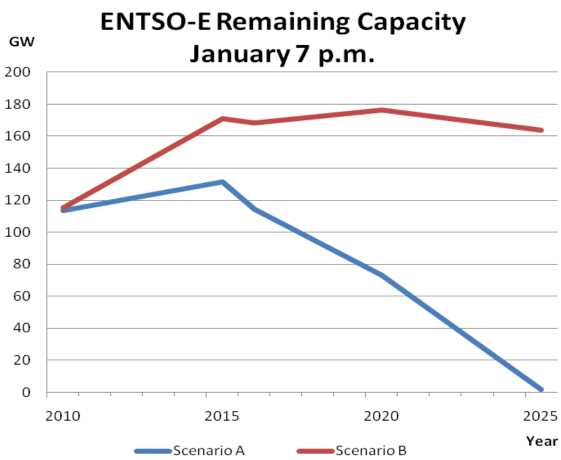


FIG. 22 ENTSO-E REMAINING CAPACITY FORECAST

Differences between Scenario A and Scenario B are given by their nature. In Scenario A much lower commissioning of new units is expected (scenario A only contains commissioning which is certain) with higher level of decommissioning of older units. On the contrary in Scenario B there is higher development of RES capacity (excluding hydro) and some kinds of fossil fuels expected, which influences the amount of RC. Countries with positive/negative Remaining Capacity in 2015 and 2020 are shown on Fig. 23 and Fig. 24. In 2015 Finland and Latvia seem to be dependent on imports whereas, in the same year, Germany, Italy, Netherlands and Austria have sufficient available capacity (40.40 GW; 22.30 GW; 14 GW and 13.60 GW respectively). In 2020 only Denmark seems to be importing for security of supply reasons at the reference points, and among countries with enough capacity France (with 19.1GW) stands out.

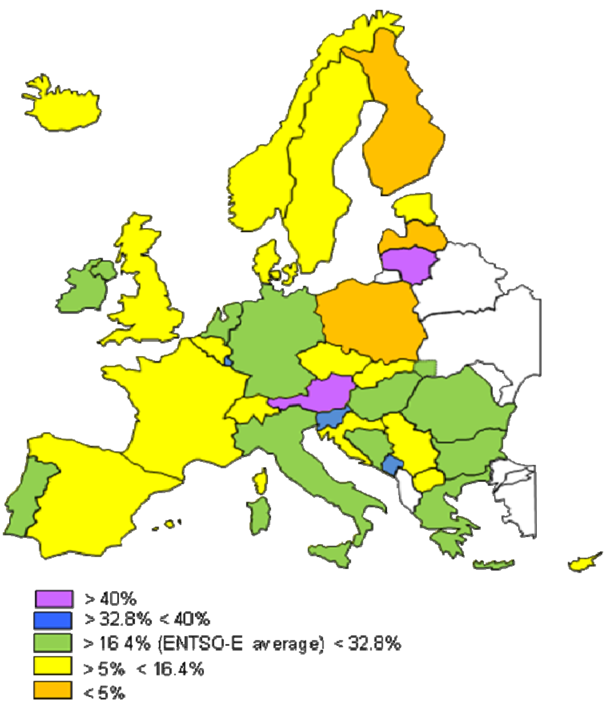


FIG. 23 ENTSO-E REMAINING CAPACITY AS A PART OF NET GENERATING CAPACITY; JANUARY 2015; 7 P.M. SCENARIO B

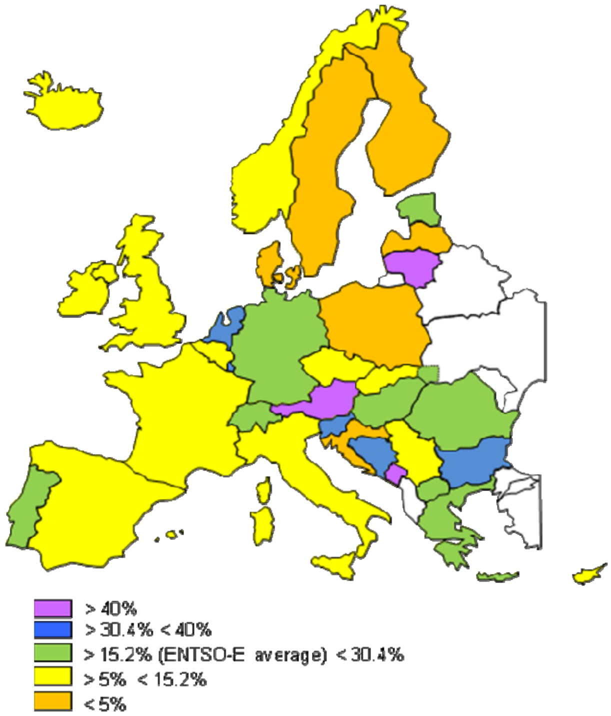


FIG. 24 ENTSO-E REMAINING CAPACITY AS A PART OF NET GENERATING CAPACITY; JANUARY 2020; 7 P.M. SCENARIO B

Although wind installed capacity will increase significantly, most of the RC will result from Fossil Fuels capacity. It is worth reiterating that after 2015 TSOs have less and less information on new projects coming in, which results in a probable underestimation of the RC for the longer-run horizons.

4.4.2 ADEQUACY LEVEL IN 99% OF SITUATIONS

As already mentioned in Section 4.1.4 above, the criteria of generation adequacy assessment:

“*When Remaining Capacity is over or equal to Adequacy Reference Margin, it means that some spare generating capacity is likely to be available for export on the power system*”

"*When Remaining Capacity is lower than Adequacy Reference Margin, it means that the power system is likely to have to rely on import flows when facing severe conditions*";

The generation adequacy within the whole ENTSO-E system in Scenario B should be maintained during all monitored periods for each reference point-in-time (not taking into account possible transport capacity limitations between countries and/or regions).

In Scenario A, generation adequacy should be maintained until 2020. After this year, new generation capacity could be needed in January over both reference points to achieve at least today's levels of adequacy (not taking into account possible transport capacity limitations between countries and/or regions). For July, this situation occurs after 2020 (around 2022).

As the lowest level of ARM occurs in January at 7 p.m., focusing only on this reference point, there will be a need for about 124 GW of additional RC in 2025 in Scenario A in order to achieve at least today´s level of adequacy. It means thus 124 GW in RAC. However, when considering that only 64% of NGC will result in Reliably Available Capacity there will be a need for about 193 GW of additional new generation capacity that is not yet decided today.

In Scenario B, generation adequacy is maintained at all the times for any reference point. For 2025, January, 7 p.m., the difference between RC and ARM is for 24 GW higher than the same difference for the current situation. Thus it means 24 GW in RAC, i.e. there is surplus of generation capacity about 37.4 GW (see also the previous paragraph).

The described situation is illustrated in Fig. 25, Fig. 26, and Fig. 27.

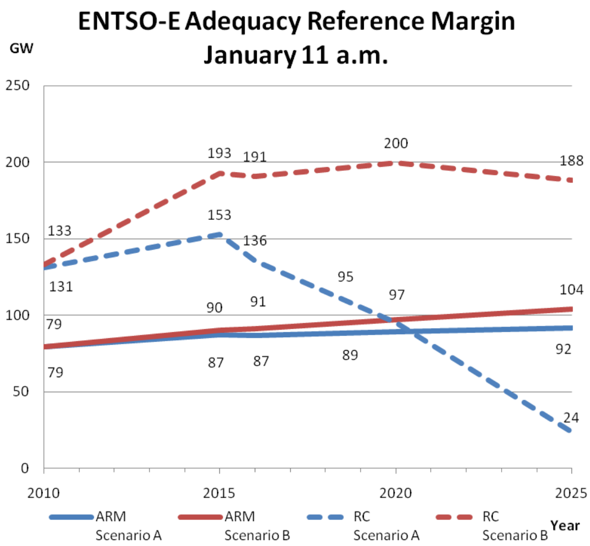


FIG. 25 ENTSO-E GENERATION ADEQUACY FORECAST

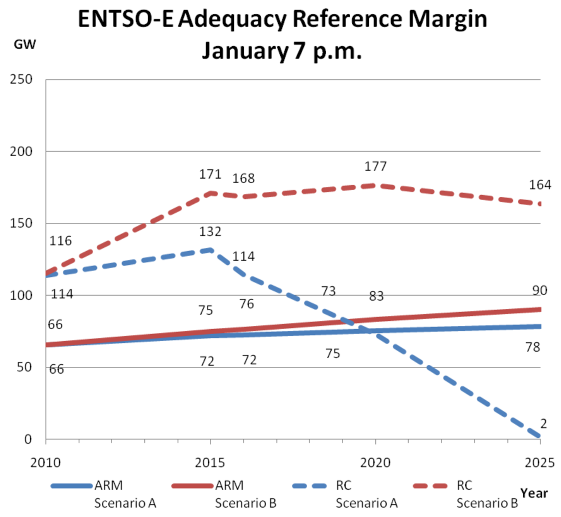


FIG. 26 ENTSO-E GENERATION ADEQUACY FORECAST

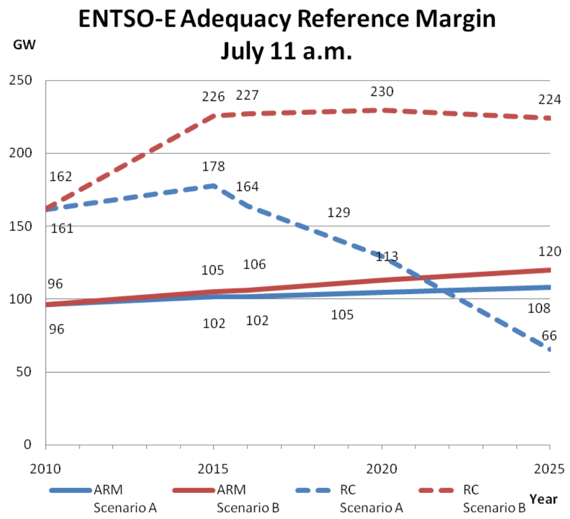


FIG. 27 ENTSO-E GENERATION ADEQUACY FORECAST

The situation in each ENTSO-E member state is illustrated in Fig. 28 and in Fig. 29. In 2015 countries with remaining capacity below ARM are Cyprus (-17%), Finland (-7%), Croatia (-5%), Latvia (-8%), FYR of Macedonia (-11%), Poland (-7%) and Republic of Serbia (-1%). In 2020 the situation will improve (i.e. RC will be above ARM) in Finland (+1%), Latvia (+6%), FYR of Macedonia (+10%) and Republic of Serbia (+1%), however in Belgium (-1%), Denmark (-21%) and Iceland (-3%) the situation is worse compared to 2015.

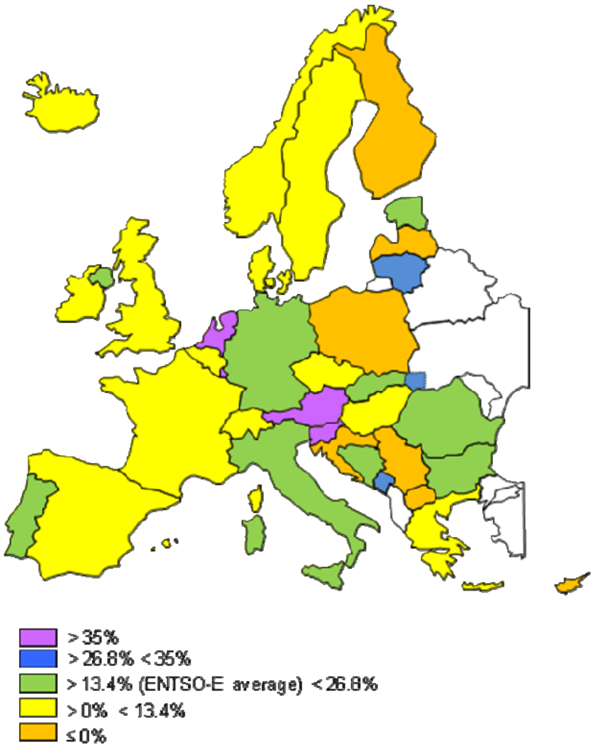


FIG. 28 REMAINING CAPACITY MINUS ADEQUACY REFERENCE MARGIN AS A PART OF RELIABLY AVAILABLE CAPACITY PER COUNTRY; JANUARY 2015; 7 P.M. SCENARIO B

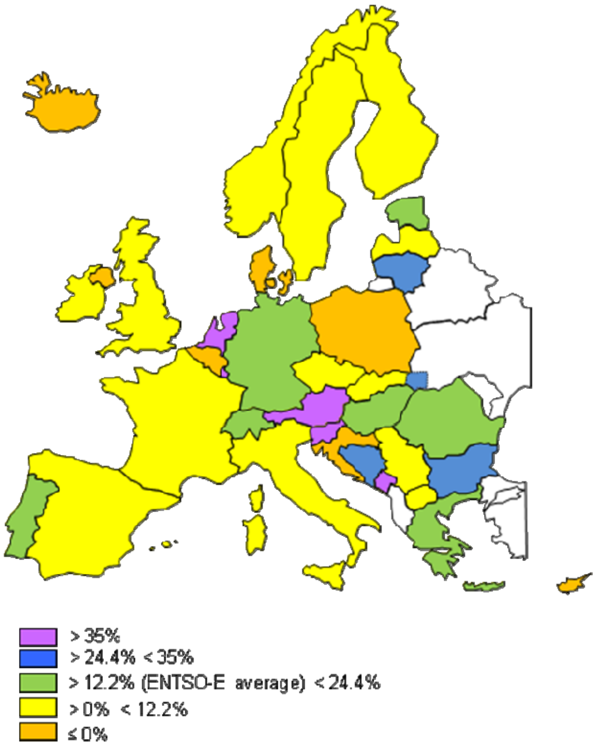


FIG. 29 REMAINING CAPACITY MINUS ADEQUACY REFERENCE MARGIN AS A PART OF RELIABLY AVAILABLE CAPACITY PER COUNTRY; JANUARY 2020; 7 P.M. SCENARIO B

4.5 ECONOMIC CONSISTENCY

The principle basis on estimating the expected running times (or load factor) of each type of generating units is to assess whether they are around the typical values expected for sound economic operation. Therefore, the process consists of assessing the expected energy generated by each type of generation (hydro, wind, other RES, nuclear, conventional thermal (coal, lignite, oil, gas fired units), peak-units.

If yearly probabilistic simulations are available, then they provide directly the necessary indicators. If such simulations are not available, the following simplified process may be conducted:

The energy produced by RES is assessed using the installed power and the equivalent running times estimated from statistics over the recent period (more detailed explanations are given in Section 4.6.2 below, dealing with RES).

The same kind of assessment is made for base-load nuclear units (with an equivalent running time of 6900h/year[24]).

Based on the same reports, typical yearly running times of base and half-base conventional thermal units are quite constant from one year to another, as follows:

- 5900 h for lignite;

[24] Based on System Adequacy Retrospect reports available within former UCTE

- 4900 h for coal;
- 4500h for gas;
- 4800 h for non-attributable sources.

Conversely, running times of thermal peak and back-up units are highly variable as these units are used to meet the general balance of generation and load; however, whatever the year and the country, it is always lower than 2000 h.

In theory, it could be possible to assess the equivalent running times of each category of base and half-base fossil fired plant, and then to compute that of peak and back-up units as a difference between the load and the energy generated by all other sources. Nevertheless, it should be remembered that this assessment is based on the reliability of statistics regarding the type of generating units and the assumption that economic conditions (such as the relative prices of different primary fuels) will remain the same in the future, which could be questioned for 10 or 15 year-ahead forecast.

It is then concluded that it may be sufficient to consider the conventional thermal units as a whole, compute the global amount of energy it generates as the difference between the yearly consumption and the energy generated by the other sources (RES and nuclear). It is then possible to compute and discuss its equivalent running time.

4.6 20.20.20 INDICATORS

4.6.1 CONSUMPTION INDICATOR

The expected electricity consumption under normal climatic conditions shown in the ENTSO-E SAF is 4004 TWh in 2020 (3657 TWh for EU without Malta), which means an increase of about 18 % with respect to the present values (electricity demand for ENTSO-E system was about 3400 TWh in 2008).

As has been previously mentioned, this does not mean that the EU is off the tracks towards the 2020 targets, as electricity demand alone is not the relevant parameter: for example, if electricity replaces other energy sources for some purpose (e.g. increased of use of RES energy, reduction of CO_2 emissions or higher energy efficiency), the result will be an increase of the electricity demand, still possibly consistent with a global decrease of total energy consumption.

Therefore, the whole energy demand should be considered. Alternatively, the evolution of the electricity demand should be compared with the expected evolution compatible with the global energy target.

4.6.2 RES INDICATOR

In order to construct the RES indicator, the following data is needed:

- the electricity yearly consumption in 2020
- the RES production in 2020

4.6.2.1 Expected electricity yearly consumption in 2020

As already mentioned, the ENTSO-E and EU (without Malta) expected electricity consumption for 2020 are estimated to 4004 TWh and 3657 TWh respectively.

4.6.2.2 Expected RES generation in 2020

In order to calculate the RES production in 2020, the information related to Net Generating Capacity in the framework of the SAF 2010-2025 report needs to be combined with equivalent running duration per type of generation.

Although hydro generation is a major part of the foreseen RES production, it poses a special challenge since the pure pump storage part is not recognized as RES. In addition, some hydro power units combine the possibility of pump storage with natural inflow. Hence TSOs are not always able to identify if the hydro unit that can be classified as a RES unit. For the calculation of the RES indicator the installed capacity of hydro units was reduced by the installed capacity of those units identified as pure pumped storage as well as not clearly identifiable. Table 6 gives the installed generation capacity reported for 2020.

Table 6 Installed generation capacity of RES in 2020 in ENTSO-E and the EU (without Malta)

	NGC (in GW)
Wind (ENTSO-E)	198
Wind (EU without Malta)	194
Solar (ENTSO-E)	38
Solar (EU without Malta)	38
Other RES (ENTSO-E)	26
Other RES (EU without Malta)	23
Hydro (without pure pumping and not clear hydro) ENTSO-E	172
Hydro (without pure pumping and not clear hydro) EU without Malta	118
Total RES (excluding pure pumping and not clear hydro) ENTSO-E	**434**
Total RES (excluding pure pumping and not clear hydro) EU without Malta	**374**

By definition, the yearly output of renewable units may vary from one year to another because of climatic conditions, with possible variations from one country to another complying with different primary source of energy potentials. However, for a given country, or set of countries, the equivalent running time for every RES category (wind, hydro, solar) remains quite stable on a few years average.

The equivalent running hours of the different type of RES units were determined based on System Adequacy Retrospect materials that were collected in the framework of former UCTE with exception of the equivalent running hours for hydro for Norway and Sweden that are based on national correspondent's insights:

- All hydro (except for Norway and Sweden): 2700 h/year (but pumped storage);
- All hydro for Norway and Sweden: 4200 h/year (but pumped storage);
- On-shore wind: 1800 h/year;
- Off-shore wind: 3500 h/year;
- Solar: 620 h/year;
- Other RES (biomass, waste…): 5200 h/year.

An additional hypothesis was made concerning the division between onshore and offshore windmills. No specific information regarding this division is collected for the SAF report. However, the equivalent running hours for onshore and offshore windmills are quite different. It was assumed that the EWEA suggested target of 40 GW for 2020 is reached. Hence 21% of the wind capacity was considered as offshore wind with 3500 equivalent running hours and 79% of the wind capacity was considered as onshore wind with 1800 equivalent running hours.

4.6.2.3 Assessment of the achievement of the 2020 objective regarding the share of RES

Based on the above assessments, the share of RES production in the electricity consumption of ENTSO-E (respectively EU without Malta) is foreseen to be around 29.8% (respectively 25.5%) in 2020.

These figures should be compared to the expected share of RES in electricity consumption for meeting the 2020 targets, which is probably significantly higher than 20% (for instance 30-35%) as RES may be easier to integrate in the power sector than in others (transport or heating).

4.6.3 CO_2 INDICATOR

The idea here is to estimate the amount of Green House Gases (GHG) emissions from the power system and to compare it to the expected value according to the EU 2020 targets.

For the power sector, CO_2 is supposed to be the only GHG to be taken into account.

4.6.3.1 Expected CO_2 emissions from the power sector in 2020

The proposed CO_2 emission indicator is a simplified approach that assumes that a representative average CO_2 content per MWh can be relied upon. The amount of CO_2 emission from electricity production is derived by multiplying the amount of electricity consumption not compensated by RES or nuclear production and a representative average CO_2 content per MWh. The proposed indicator only reflects the CO_2 emissions resulting from the generation of electricity and does not include the other greenhouse gases that can be expressed as a CO_2 equivalent. Furthermore the indicator is a very rough estimation.

In order to construct the CO_2 emission indicator, the following data is needed:

- the electricity yearly consumption in 2020;
- the CO_2 free production in 2020 (RES production + nuclear production);
- a representative average CO_2 content per MWh.

With the exemption of the nuclear production and the representative average CO_2 content per MWh, the needed data is already calculated in order to estimate the RES generation indicator.

The Nuclear production is estimated by multiplying the installed capacity of nuclear units in ENTSO-E and the EU (without Malta), respectively 128 GW and 125 GW, by the equivalent running hours for nuclear units.

Nuclear power plants are typical base-load units, with relatively high fixed, mainly investment costs, but relatively cheap variable operating costs, and requiring rather high equivalent running time to be profitable. The equivalent running hours is estimated at 6900 h/yr for nuclear power units based on former UCTE System Adequacy Retrospect material.

The representative average CO_2 content per MWh is based on assessments of the primary fuels' typical energy and the CO_2 content as well as the typical efficiencies of power plants. In order to avoid assumptions on which type of fossil fuel that will be used for the electricity consumption not compensated by RES or nuclear production, an indicative range can be used. Therefore an average internal content for thermal generation production of 0.4 t CO_2/MWh (which would correspond to 100% gas, or equivalent fossil fuel mix), as well as 0.8 tCO_2/MWh (which would correspond to 1/3rd gas and 2/3rd lignite and hard coal, or equivalent) were used.

4.6.3.2 TARGET VALUE OF CO_2 EMISSIONS FROM THE POWER SECTOR IN 2020

Here again, it must be highlighted that the objective value for the power sector may be different from a 20% decrease (30% if other developed countries commit to comparable values).

Beyond the computation of the indicator itself, there is a real issue with respect to the target figure to reach for the CO_2 indicator: no explicit reference figure exists for the electrical sector at EU level (and even less so at ENTSO-E perimeter)

- A 2020 reference exists for the ETS sector as a whole: 1720 MtCO_2. This figure accounts for sectors, which are today not under the ETS, all 27 EU countries.
- In 2005, the verified CO_2 emissions for the ETS sector (excluding Bulgaria, Romania, and Malta) were 2012 MtCO_2[25]. The average yearly allowance for 2005-2007 was about 2152 MtCO_2, the power sector being allocated about 50% of the quotas.
- Price Waterhouse Coopers releases a yearly survey with respect to CO_2 emissions of the largest electricity producers in the EU27. In 2008, the 22 largest generating companies emitted 800 MtCO_2, representing 59% of the total emissions of the electricity + heat sectors of the EU27 (about 1400 MtCO_2).

Hence, although no specific official figure can be encountered, an accurate-enough target range can be assessed for the EU power sector in 2020, based on the previous material:

[25] Source: EU press release IP/08/787.

- 20% cut in GHG emissions in 2020 compared to 1990 ⇔ 800 to 900 MtCO_2 from electricity generation;
- 30% cut in GHG emissions in 2020 compared to 1990 ⇔ 650 to 750 MtCO2 from electricity generation.

4.6.3.3 ASSESSMENT OF THE ACHIEVEMENT OF THE 2020 OBJECTIVE REGARDING CO_2 EMISSION

Combining the parameters of section 4.6.3.1, the CO2 emissions from electricity production are estimated between 770 and 1540 Mt CO2 emissions for ENTSO-E and between 744 and 1488 MtCO2 emissions for the EU (without Malta) depending on whether the thermal production is assumed to come 100% from gas or only 1/3 from gas and 2/3 from coal or lignite.

The EU target can be assessed in the range 800-900 MtCO_2/year for an overall 20% reduction compared to 2005 for the power sector. Depending on macro-economic conditions, favouring coal-fired or gas-fired power plants, CO_2 emissions may vary between less than 800 to more than 1000 MtCO_2/year, falling close to the EU target. However, further investigations should be needed for assessing whether this objective is met.

4.7 CONCLUSIONS

When planning the future investments many elements are considered, from unpredicted future location of electricity generation and consumption to energy policies. Based on these diverse parameters a series of scenarios are build.

This report focuses on bottom-up scenarios, highlighting mainly mid-term *trends*, which are easily and reliably developed by TSOs, but suggests procedures to develop longer-run top-down background scenarios for further releases, focusing also on the comparison between the bottom up approach and the targets set.

The two scenarios outlined in the present report are a *conservative* scenario and a *best estimate* scenario[26]. Generation adequacy and their overall consistency regarding the EU 2020 targets have been checked.

Despite the unavailability of data concerning how Member States plan to achieve the EU 2020 targets is still possible to sketch some overview:

- Power demand is expected to grow, but rather moderately – at about 1.5% in the coming decade - despite on the one hand increasing standards of living (and all the new electric devices involved) and on the other hand end-use switch from oil and gas to electricity (for example in public and automotive transportation, heating, etc.), if electrical energy is seen as easier to decarbonise. This apparent paradox is explained by efficient enforcements of energy savings policies at national and EU level[27]. This increase is probably compatible with the overall decrease of energy consumption (and not only electricity) by 20% compared to the business-as-usual scenario.

[26] More information is available in the ENTSO-E *System Adequacy Forecast 2010-2025* report released January 2010 and available at www.entsoe.eu.

[27] Especially, the Directive EC 2005/32 “Eco-design requirements for Energy-using Products.

- With about 933 TWh of RES generation[28] in 2020, compared to 3657 TWh of consumption, about 25.5% of the power demand in the EU is supplied by RES. According to some experts, the relative ease with which RES may be integrated in the power sector compared with others (transport or heating), means that this figure may need to be higher than 20% (perhaps 30-35%) in order to achieve EU 2020 targets.
- Depending on macro-economic conditions, favouring coal-fired or gas-fired power plants, CO_2 emissions may vary between less than 800 to more than 1400 $MtCO_2$/year, falling within or short of the EU target (which can be assessed in the range 800-900 $MtCO_2$/year for an overall 20% reduction compared to 1990).

HIGHLIGHTS:

- Two Generation/Load bottom-up scenario highlighting trends for the coming 5-15 years, with assessment of Generation Adequacy and compared to EU 2020 targets.
- The interest of top-down scenarios has been demonstrated, highlighting the need for stakeholders' support and cooperation.
- Member States must submit their NREAPs in June 2010 and in this respect it appeared premature to devise and present a 20.20.20 scenario in the present report.

[28] Pure hydro: 118 GW; wind: 194 GW; solar: 38 GW; others: 23 GW.

[5] INVESTMENT NEEDS ON THE EUROPEAN POWER GRID

5.1 INTRODUCTION

The transmission grid must satisfy a whole range of users needs. It should provide everyone the ability to connect their facilities, take advantage of a reliable signal (frequency, voltage), and access to the entire European market.

Grid planning consists thus basically of checking in which extent the present infrastructure would be able to fulfil its duties in the mid and long term future; and proposing whenever needed grid reinforcements to address any identified failure. Because all system elements (grid components, any facilities connected to the grid) continuously interact, identified concerns ahead cannot be addressed one after the other; they must be considered all at once, so as to propose the most efficient solutions: when aptly devised, a single investment can solve several concerns at once. Vice versa, a generic concern might trigger investments in several locations, possibly far apart one from another.

In order to give the reader a better and more transparent understanding of this complex matter, the TYNDP report depicts separately:

- On the one hand, in the present Chapter, the "**Investment needs**", this word being given the broad meaning of *every concern ahead on the regional grid and of European significance, and which are likely to trigger HV grid investment in order to restore the HV grid ability to fulfil the duties and services expected from this infrastructure*.
- On the other hand, in the following Chapter 6 the **"Development projects**", which TSOs promote to face and eventually solve the abovementioned investment needs. Please remember that *development* is also to be understood in a quite broad extent of substantial HV assets' evolution (e.g. major refurbishment or revamping of existing assets are hence also to be accounted for).

The investments needs are thus the basic drivers or triggers of projects. "**Of European significance**" means basically addressing at least one of the three pillars of the EU energy policy: Security of Supply; integration of RES and fight against climate change; economic efficiency and realisation of the IEM. In spite of sharing this common definition, RG reports in the following sections show different sensitivities from one country to another about what to label "of European significance": the European subsidiary principle applies, and similar issues can reported of European importance in one country (and possibly received European funding to be solved), and not in another.

The present Chapter gives an overview of all the expected investment needs of European significance on the power grid for the coming ten years. This information is presented graphically on maps of the six ENTSO-E Regional Groups (RG) of countries. Investments needs are also sorted between midterm and long term ones, i.e. approximately for respectively the coming five-year period and the following one.

The investment needs are sorted in categories (each being highlighted with a specific colour on the map):

- Demand growth: cities or regions, where the security of supply can be at risk;
- Future generation evacuation: places where new generation facilities asked (or are likely to ask) for connection, be they large power plants and/or distributed generation,

RES or not, and the existing network does not assure an adequate evacuation and integration into the system;

- Existing generation evacuation: places where existing generation cannot be evacuated reliably in all situations because of a change in surrounding power flow patterns;
- Generation decommissioning: places where large power plants are decommissioned, modifying the surrounding power flow patterns, or causing local voltage level concerns;
- Insufficient cross-border capacity, i.e. structural market congestion between price zones[29]. Two subset of structural congestion are specifically identified:
  - Change in exchange patterns: grid section, the transfer capability of which may appear no more appropriate to accommodate power exchanges, that is new (or recent) congestion.
  - Isolated systems to be connected: typically islands to be connected to the mainland.
- Reliable grid operation: substations, where risks of current and voltage limits violation require upgrade of HV equipment to withstand now likely high short circuit currents, to manage reactive power issues, transient stability issues, etc. in steady state and fault situations.
- Ageing/obsolescence of existing network equipment: asset requiring replacement or heavy refurbishment in order to maintain the grid transfer capability at its present standards, but possibly address new environmental concerns (e.g. higher standards against climatic conditions).

Maps also show qualitatively likely trends for bulk power flows in Europe tomorrow.

5.2 Regional Group Continental South West

For the midterm in the CSW Region the main investment need is the development of the interconnections and the accommodation of the existing internal networks to those new projects, taking into account the fact that the Iberian Peninsula is almost an electric island with only four tie-lines (2 of 220 kV and 2 of 400 kV) between France and Spain, the last one having been built in 1982, and that they face continuous congestions. Therefore, France and Spain have the shared goal to increase their transfer capacities. The objective is to reach a short-term capacity of 2800 MW, and 4000 MW in the long term. On the other hand, also Portugal and Spain have the objective to increase their NTC up to 3000 MW in order to avoid current congestions and thus facilitating the functioning of the Iberian Electricity Market (MIBEL).

The connection and evacuation of renewable sources, mainly wind, hydro and solar in the Iberian Peninsula, is also one of the most important investment needs in the South-Western region of Europe. The ambitious renewable plans in Spain and Portugal need an important investment in transmission infrastructure. One reason is that new wind farms are usually

[29] Specific grid sections with limited transfer capability within a price zone may also be highlighted the same way.

located in areas without existent connection, or with a poor connection, to the transmission network (such as the South of Aragón, the area of Baza in Andalucia or the western part of Spain and the North-East Trás-os-Montes area and the inland middle Beiras region in Portugal). On the other hand, the production of this new generation plants induces new flows that need to be accommodated in the electric system, which was designed for different flows (for instance, the congestions between the Cantabrian and the Mediterranean seas). Nevertheless, conventional generation evacuation is also another driver, mainly in areas with a big attraction as a production site. Lavos and Sines in Portugal, the area of Fos in France or the North-western part of the Peninsula, Escombreras, Huelva or Sagunto in Spain are examples of potentially congested areas due to conventional generation if nothing is done (some of those areas are already experiencing congestion).

Last but not least, the need of guaranteeing the demand supply and enhancing its quality is also an important investment need. On this topic, supply to big cities is the main concern, as well as the Gerona, Levante areas and the Balearic Islands in Spain, and the Montpellier area in Southern France. In addition, the supply to the High Speed Train in the Iberian Peninsula is also another issue, because it requires several injection points in a route and that the selected nodes must be strong enough in order to avoid influencing the quality of supply of the surrounding area. In some cases these requirements necessitate the construction of completely new OHL corridors and substations.

For the long term the main identified investment need in the CSW Region is also the development of the interconnections, mainly France-Spain. Some congestion is still expected on this border even after commissioning the planned project in Eastern Pyrenees. An interconnection capacity up to 4 GW could be needed in the long term. Improving the quality of supply, and generation evacuation are expected to be also important investment needs, for example in the North for Portugal where there are plans of new large hydro and wind plants.

However, for the long term there is still a big uncertainty and therefore TSOs need more information regarding 202020 objectives and generation installation projects in order to be able to give more accurate details. During 2010 new national development plans will be launched in the countries of the region and after the analysis updated information will be available.

The main flows expected in Spain are towards Madrid mainly from the South and the Northwest (this last also towards the East and South), North-South flows in Mediterranean coast with injections from the Cantabrian Sea. In Portugal the main flows will go from internal areas to Lisbon and also flows from Spain are expected in the North while the South of Portugal will export to Spain. In France North to South flows (from the Massif Central) and East to West (from the Rhone Valley) are expected in the mid-term towards the Eastern Pyrenees and the Iberian Peninsula, whereas in the long term both directions through the Pyrenees border are expected.

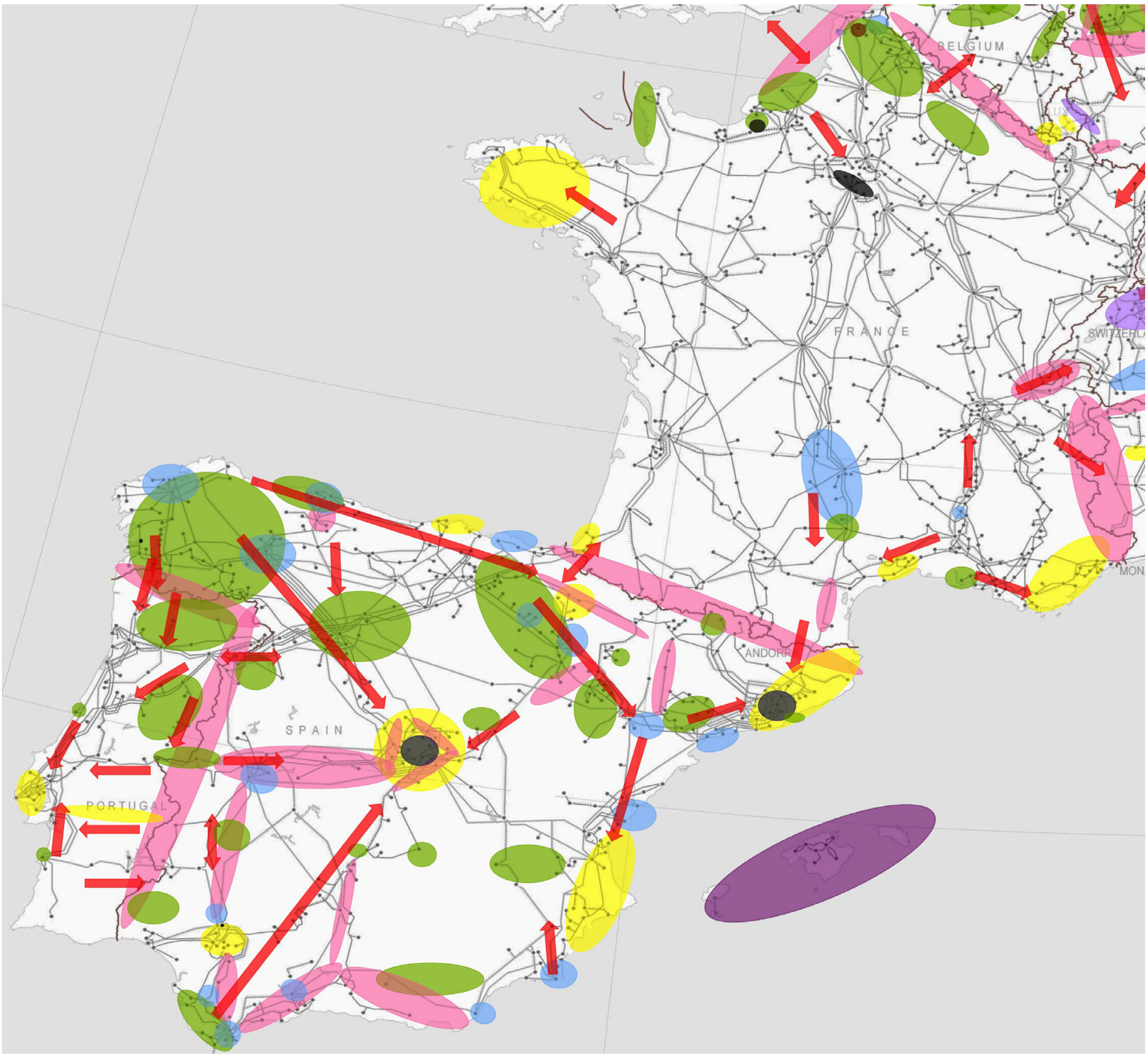
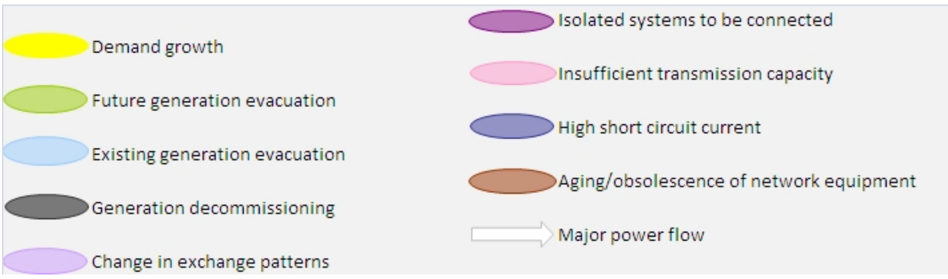


FIG. 30 MAP OF MID-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP CONTINENTAL SOUTH WEST



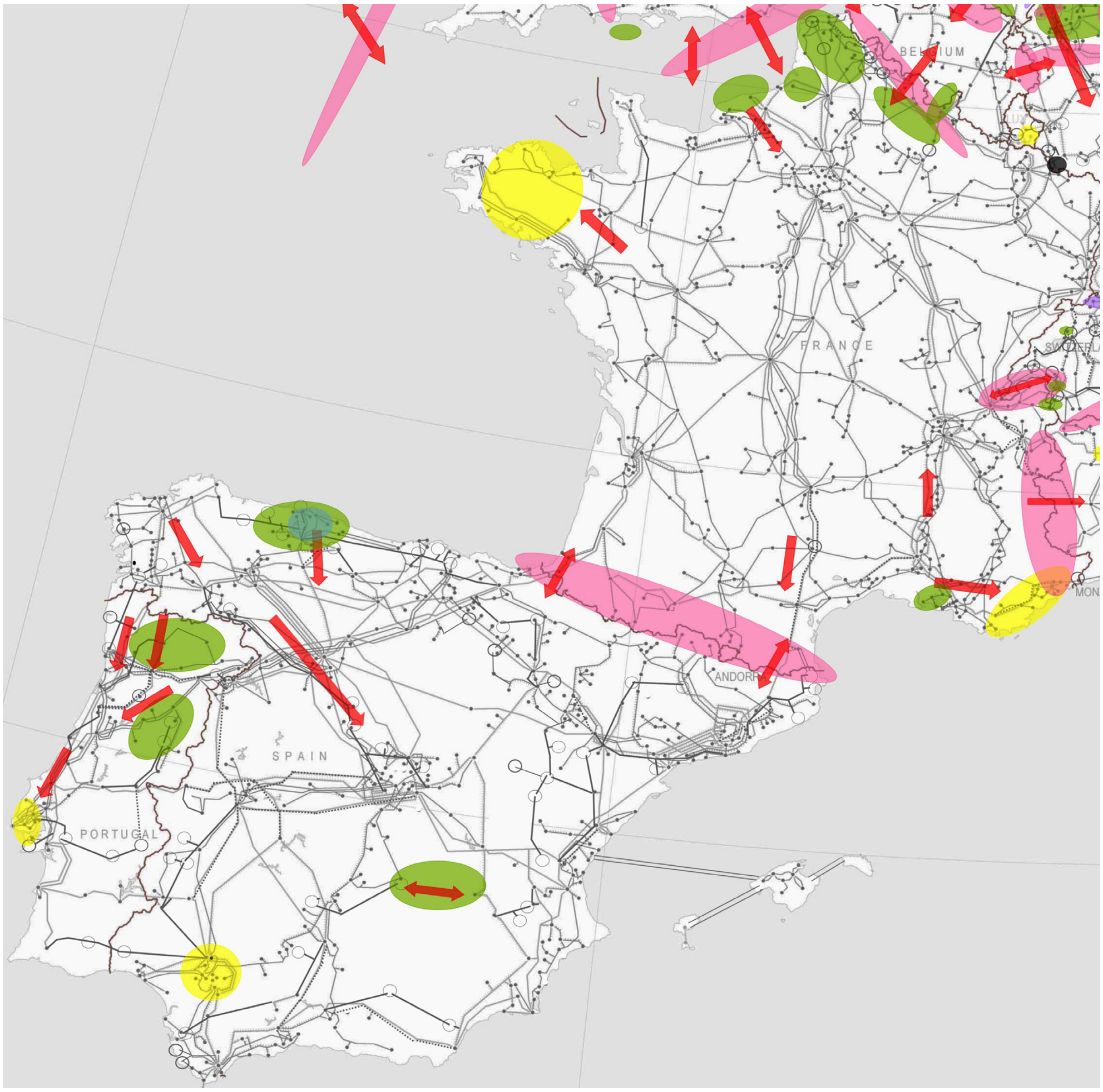


FIG. 31 MAP OF LONG-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP CONTINENTAL SOUTH WEST

- Demand growth
- Future generation evacuation
- Existing generation evacuation
- Generation decommissioning
- Change in exchange patterns
- Isolated systems to be connected
- Insufficient transmission capacity
- High short circuit current
- Aging/obsolescence of network equipment
- Major power flow

5.3 Regional Group Continental Central South

In the mid-term horizon, the development of the transmission grid in the CCS region has to face new challenges due to ongoing development of big amount of new generation plants, especially RES's, often located far from the main consumption centres and/or the HV transmission backbones. In addition, the security of supply is still an important issue in the CCS perimeter, for example in the French Riviera, an electric peninsula with no generation and connected to only one 400-kV line, the "Déclaration d'Utilité Publique" of the project planned to strengthen the connection to the main grid having been cancelled in 2006. Last, some of the Northern borders of Italy, especially France-Italy, are already congested.

Renewable energy, presently sharply increasing in Germany and Italy (at the borders of the CCS region), comes mainly from wind farms installed onshore (in the North and North-East of Germany and in the South of Italy) and offshore (in the North and Baltic sea). This configuration tends to create in some situations a huge amount of the vertical energy flows from the North of Germany to the South. Additionally, it is worth mentioning that Alps area is enhancing its energy storage facilities by installing new pumping storage power plants; therefore, the reinforcements of the transmission grid, along the North-South axis, from Germany to Italy, is strongly recommended in order to improve the integration of different sources of production and increase the cross border capacity.

In the longer term new changes will be faced requiring good coordination among TSOs. A further increase of the cross border capacity through the Alps area will be needed to improve security and reliability of the system and to avoid barriers on commercial exchanges taking in account the evolution of the generation parks in Europe. A strong central-European North-South transmission corridor will also allow a better integration of the intermittent sources by combining the wind farm generation in the North area with the pumping storage in the Alps, hence, helping to achieve a real central-European power balancing.

New pumping storage power plants in the Alps area will also foster the long-term possibility of importing a large amount of power from North Africa, with generation mainly based on RES, namely wind and solar sources. Power import from Maghreb could be made possible through the realization of HVDC submarine interconnections linking the Maghrebian Countries to the CCS region.

More specifically, it is worth underlining that the achievement of the target on the minimum level of RES generation will be favoured by joint projects between EU Member States and Third Countries as foreseen in art. 9 of the EC Directive 2009/28/EC. In this framework, investments to adapt the internal grid of the CCS, especially in Italy, shall be undertaken to make possible the integration in the longer term of the European grid with the Trans Mediterranean interconnectors. In the longer run the likely commissioning of several new trans-Mediterranean interconnectors is expected, following the launching in July 2008 of the Union for the Mediterranean Sea with a view of revitalising the existing EuroMed Partnership and EU relations with neighbouring countries from North Africa and the Middle East. Energy Ministers of EU Member States recognise that the Mediterranean region is of strategic importance to the European Union as regards access to resources, especially the EU strategy for diversifying energy supply. More specifically, among the priority areas the EU agrees on the promotion of sustainable development in the Mediterranean region and initiatives of common interest such as greater integration of the energy markets by completing the Mediterranean electricity and gas rings.

On the wake of the above initiative, the Mediterranean Solar Plan was launched in 2008 aiming at developing a large amount of solar and wind generation in the Southern and Eastern Mediterranean Countries to supply the increasing demand in these countries and to export the power surplus to Europe through new high capacity electricity corridors.

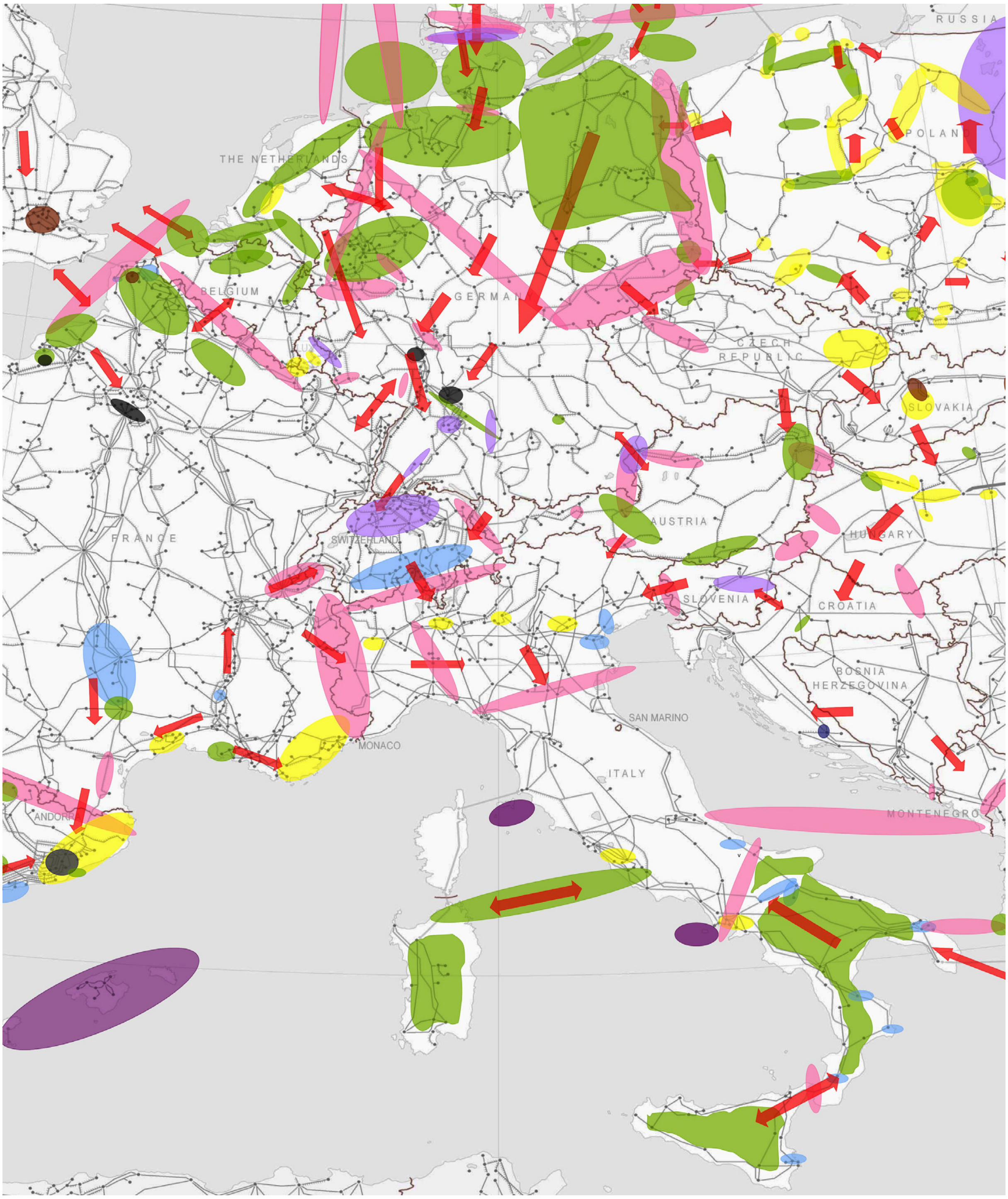
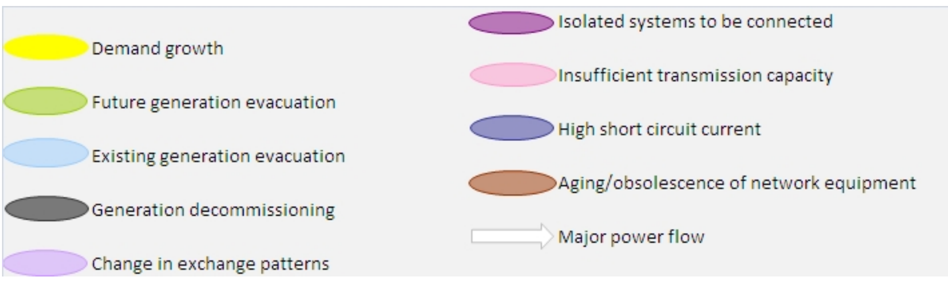


FIG. 32 MAP OF MID-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP CONTINENTAL CENTRAL SOUTH



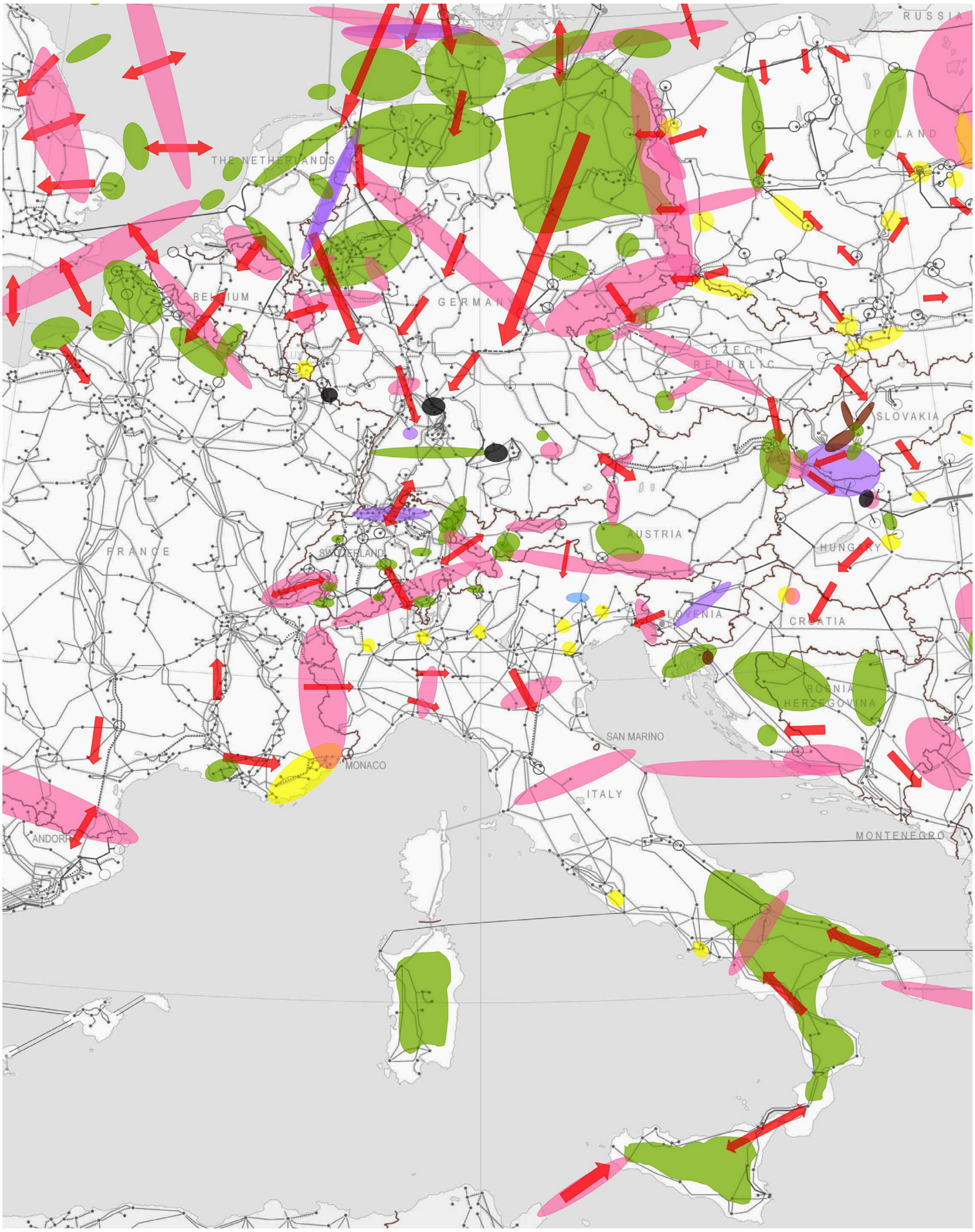


FIG. 33 MAP OF LONG-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP CONTINENTAL CENTRAL SOUTH

- Demand growth
- Future generation evacuation
- Existing generation evacuation
- Generation decommissioning
- Change in exchange patterns
- Isolated systems to be connected
- Insufficient transmission capacity
- High short circuit current
- Aging/obsolescence of network equipment
- Major power flow

5.4 REGIONAL GROUP CONTINENTAL SOUTH EAST

The transmission grid in the Continental South East European region is rather sparse compared to the relevant grid of the rest of the continent. As shown in the respective maps needs for new interconnectors (tie-lines) are identified in order to increase the import/export capabilities among the South East Europe countries and the Central Europe. The main drivers of the future developments, that are of European interest include:

- Contribution to market integration in the Region (i.e. necessary network reinforcements to accommodate new conventional generation as well as to increase transfer capacities and consequently the volume of power exchanges)
- Accommodation of future RES production
- Possible extension of the synchronous zone to the East.

Predominant power flows in the Continental South East Region are in the North-South and East-West direction. These are dictated by the power balances and market prices of the member countries. For instance, the block including Greece, FYR of Macedonia and Albania as well as Italy are usually importers. Imports of these countries from Bulgaria and Romania that have a surplus of generation and from countries on the North borders of the South East Europe Region are defining the above principal power flow directions.

Strengthening of the Regional network in the predominant power flow directions, in order to assist market integration, is a main driver that stimulates investment needs in the medium term as well as in the long run. This driver is identified mainly in the North borders of the Region and in the South part.

In the medium-term period investment needs to accommodate foreseen new generation arise in Bulgaria, Greece, Hungary and Croatia. These needs create further needs for increasing transfer capacities between South-East European countries and Italy, in order to extend towards the Italian and Western Europe electricity market.

In the long-run period investment needs for accommodating new conventional generation are extending to other South-East European countries including Bosnia& Herzegovina, Romania, Serbia and Albania. As a result, increase of transfer capacities between South-East European countries and Italy continues to be an investment driver in this period also. It should be mentioned that strengthening the Regional network in order to cope with the above investment needs, concerns both the construction of new tie-lines and the enhancement of internal networks.

For the medium term, accommodation of RES generation appears as a driver for investment needs mostly in Italy and Greece which are the countries that have at present the highest wind penetration in the region. In the long-run period the driver extends also to other countries and especially Bulgaria and Romania.

Regarding the foreseen extension of the synchronous zone to the East, in the medium run period, investment needs are identified to Bulgaria and Greece and are related to the possible future interconnection of Turkey. In the long run investment needs are identified in Romania and are related to the possible future interconnection of Moldova and Ukraine with continental synchronous system. This project could cause increased flows from the East to the West.

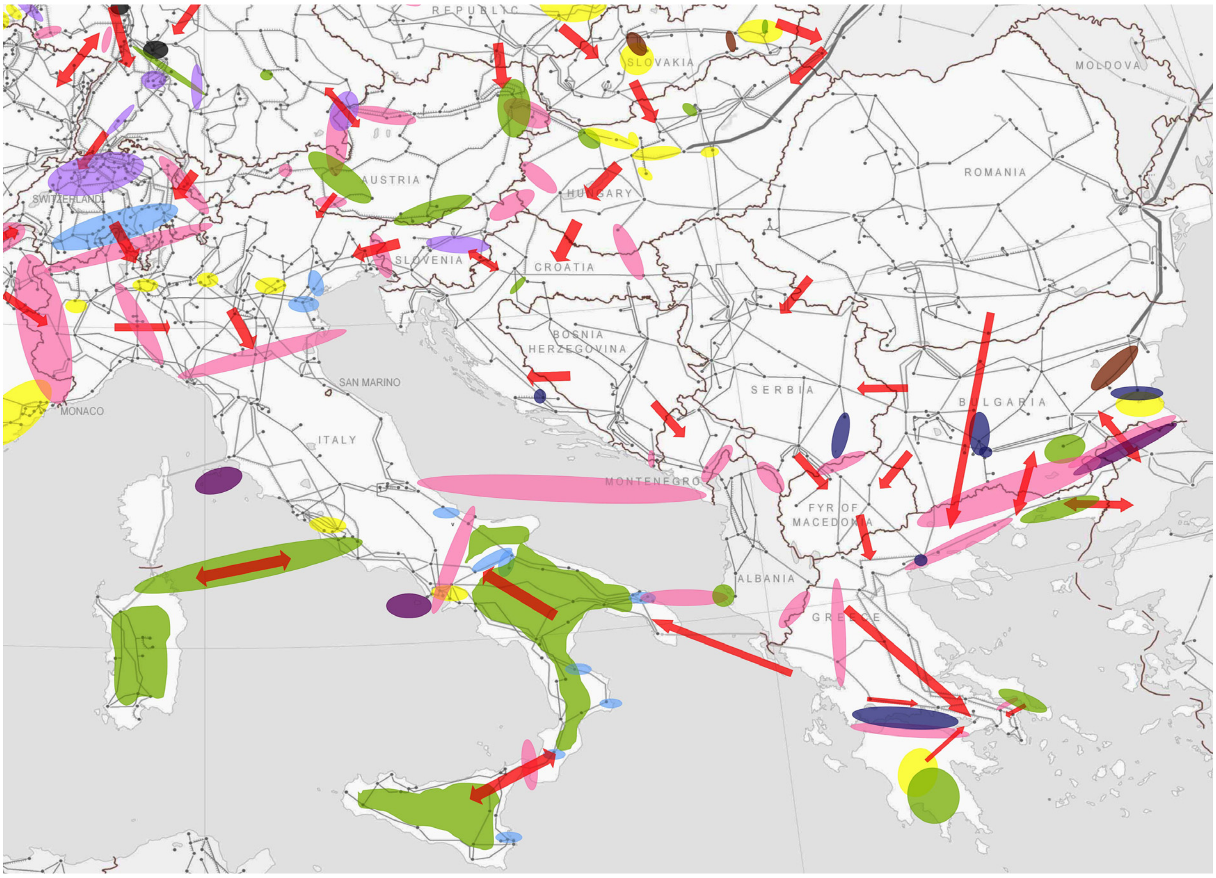
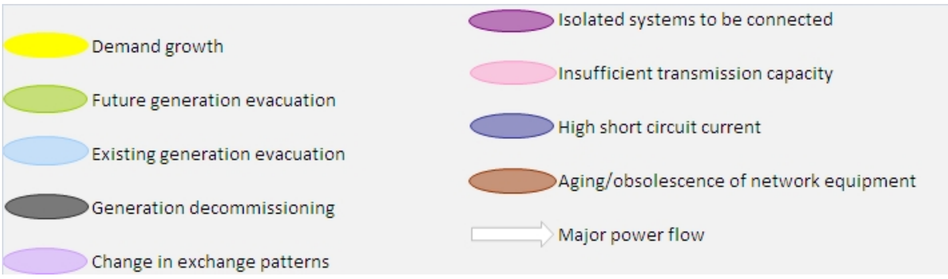


FIG. 34 MAP OF MID-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP CONTINENTAL SOUTH EAST



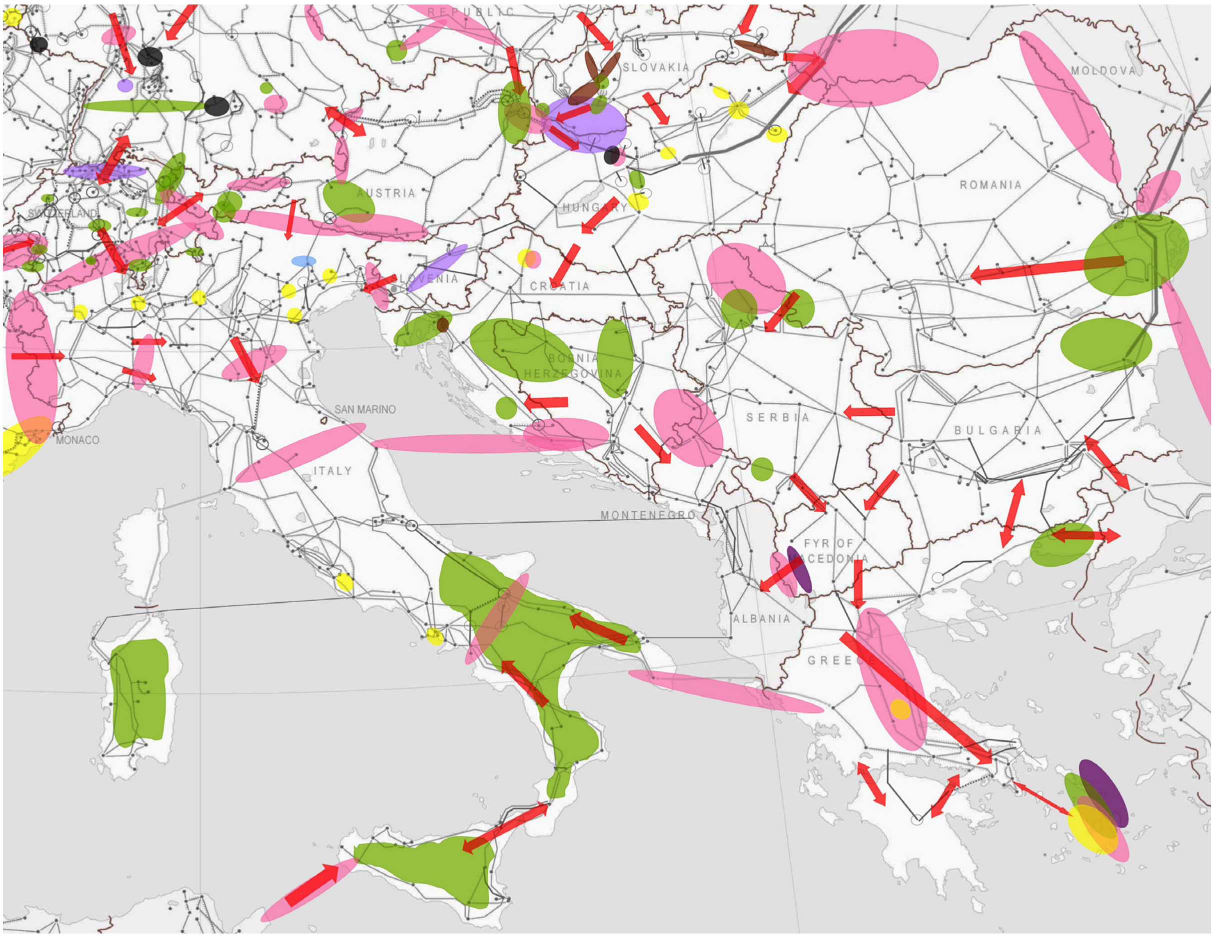
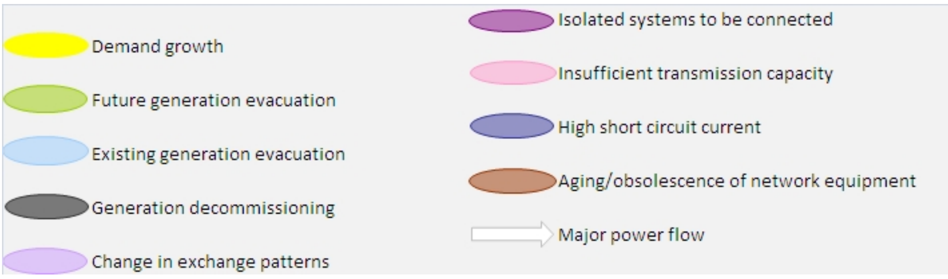


FIG. 35 MAP OF LONG-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP CONTINENTAL SOUTH EAST



5.5 Regional Group Continental Central East

The main mid-term needs in the Continental Central East region are the following:

- The connection and evacuation of new generation, in about all countries: about 3.5 GW in Poland, 0.9 GW of CCGTs and lignite units in Hungary, etc. In the Czech Republic, new lignite and CHP of more than 1500 MW of capacity, as well as several hundred MWs of renewable sources generation are expected before 2015 increasing the West to East power flow across the country. In the past, presently and in the future, renewable energy, mainly by wind power plants develop onshore in the North and North-East of Germany summing up to about 25 GW (dated end of 2009) and offshore in the North and Baltic sea. The renewable energy act together with climate protection program of the German government promotes the financing and the guaranteed return of renewable energy generating facilities to fulfil the climate protection goals. Additionally, new conventional power plants are mainly sited in Northern Germany (due to the expected lower variable operation costs).
- Changing power flow patterns, especially in Germany: whereas older units are decommissioned all over the Germany, most of new generation units are built in the North; load recession is noticeable in the North East, but demand rises in the Southern part of the country; all in all, distance is increasing between generation (e.g. from North and Baltic Seas shores and waters) and load centres (or balancing equipment like pump storage plants in the German low mountain range or in the Alps), which the surplus of energy in the North has to be transported to. This situations leads to a huge horizontal transit from the North/Northeast of the country to the South.
- Too low transfer capability to cope with challenging, strong and variable power flows, especially in the South and Western parts: the evacuation of wind generation originating in the north of Germany to the Polish and Czech systems, requiring to adapt the transfer capacity between these areas. In Austria, Slovenia, Hungary, Croatia, changing and stronger power flows cause growing operational security concerns.
- The Security of supply, mainly highlighted in the Eastern part of the Region. Demand growth is an issue for the Hungarian system, which requires a strengthening of the 400 kV network, while at the same time considering challenging capacity exchange with Croatia, Austria, and Slovenia.
- Ageing or obsolescence of equipment, requiring – and giving opportunity to – restructuring of assets. In particular, the 750 kV substation Albertirsa in Hungary, end of the tie-line to Ukraine (Burshtyn Island) reaches its lifetime around 2012, must be rebuilt, but possibly in some other location. Ageing equipment in the Slovak system also prevents the appropriate supply of growing demand.

In the long-term, due to North to South parallel flows, cross-border capacity expansion is deemed necessary between Slovakia, Hungary and Austria; also low cross-border capacity and changes in power flow patterns remain a main issue between Germany, Poland and Czech Republic, especially while new interconnections with Baltic states are developed.

Connection and evacuation of generation remain an important concern. In Poland, the connection of 8 GW additional new units is foreseen. In Austria, a massive increase of the installed capacity of pumped storage power plants is expected by 2020, which are spatially concentrated in the Central Alps. In the Czech Republic, the potential to increase power generation contribution from nuclear power plants in the South part of the country and RES integration mainly from distribution system may trigger further investment for generation evacuation.

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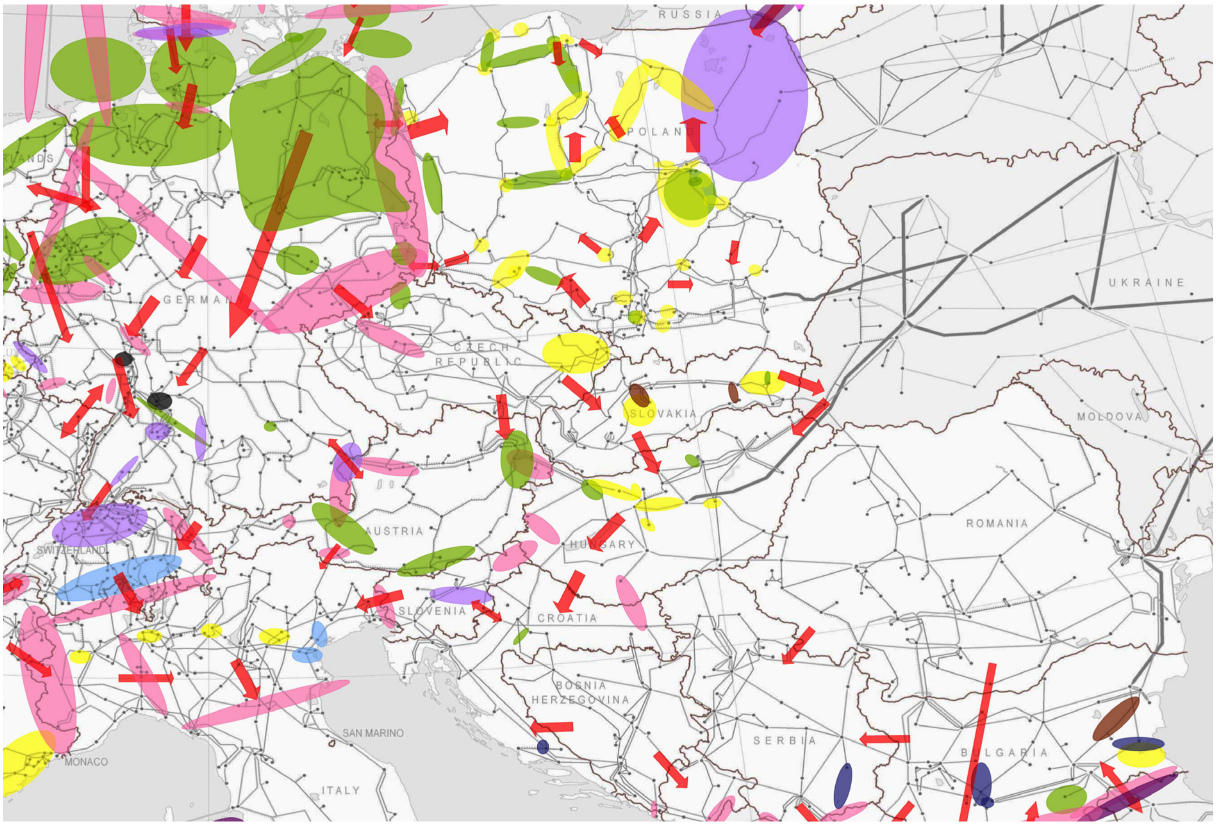
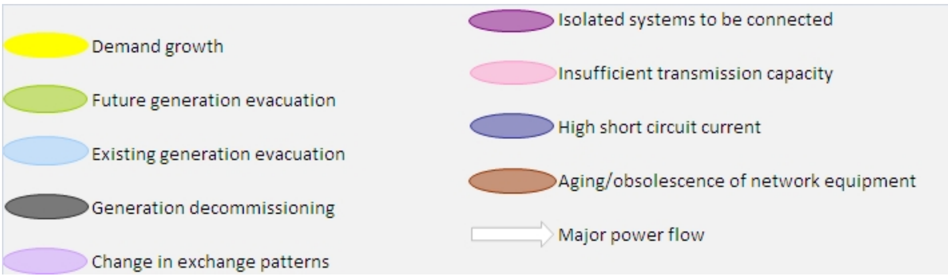


Fig. 36 Map of mid-term investment needs in the regional group Continental Central East



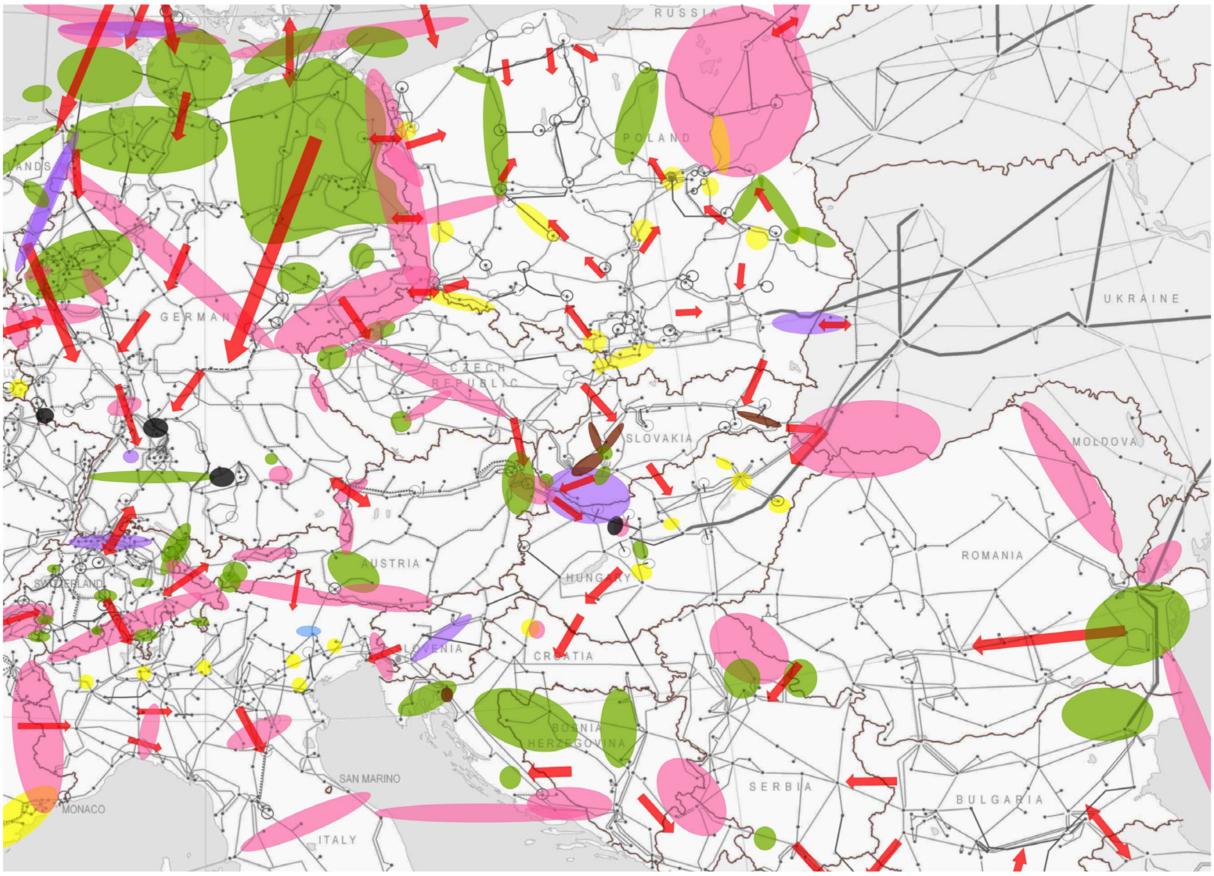
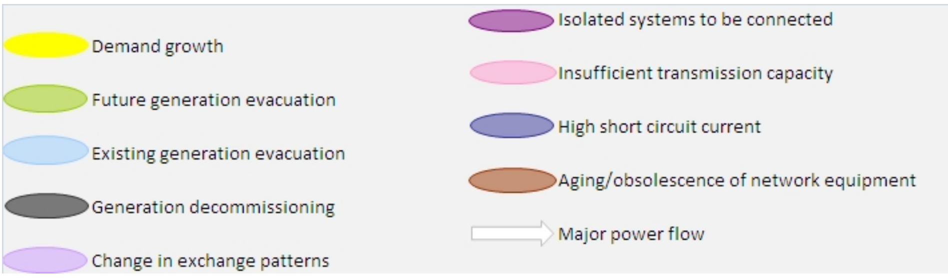


FIG. 37 MAP OF LONG-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP CONTINENTAL CENTRAL EAST



5.6 Regional Group Baltic Sea

The grid development cooperation in the region surrounding the Baltic sea was previously organized in several regional organizations: Nordel, Baltso, and partly UCTE.

Nordel produced several Nordic grid master plans during the years, the last one in 2008, and Baltso produced common Baltic grid plans. In the recent years it was concluded that it is necessary to look further beyond the synchronous regions in the development of the grid. A Multiregional study was performed in 2007-2009, involving Nordel, Baltso and PSE Operator S.A. (the Polish TSO). The objective was to establish a common electricity market modelling tool and to evaluate the market benefits of new interconnections.

Two initiatives, namely the Baltic Sea Energy strategy from the Baltic Council of Ministers' Energy Committee in 1999 (which supports the results from the Multiregional plan) and the EU Commission Energy Market Interconnection Plan (BEMIP) launched in 2008 aim at the full integration of the three Baltic States into the European energy market, through the strengthening of interconnections with their EU neighbouring countries.

The successful regional co-operation on system planning aims at developing the grid from a regional perspective taking into account the Pan-European aspects and paying attention to environmental impacts.

In the medium term, market integration is the most important driver for grid investments in the Baltic Sea Region:

- New interconnections between the Baltic states and the European energy market;
- Further integration of the Nordic countries;
- New interconnections between the Nordic countries and the continental Europe, not least because of the expected change in transmission patterns due to the growing wind power projects in Europe;
- Regional wind power integration.

Inside the region there are also some sub-regions where the demand growth drives for new interconnectors, either due to expanding industry (Arctic region and Mid Norway) or near large cities (Baltic States). In addition, some aging grid assets need to be replaced.

Lithuania's Ignalina nuclear power plant (NPP) was shut down end of 2009. This has affected the power flow patterns in the region, and is an important driver for interconnecting the transmission grids of the Baltic States to the Nordic system and Poland, as well as reinforcements inside and between the Baltic States.

Integration of RES (mainly wind power, and some hydro) is the most important driver seen in the long run in the region. The 2020 targets will lead to a substantial energy surplus in the Nordic countries.

- Regional RES integration and the change in the power flow patterns due to that;
- Continental interconnections and north-south reinforcements in the Nordic countries.

In the long term, the market integration between the hydro-dominated Nordic region and the northern part of the continental system with a large amount of wind generation is expected to give significant economic benefits. RES lead also to internal investment needs from the northern part of Sweden/Norway/Finland to the south.

In Finland there have been submitted several permit applications for a new nuclear power plant. The possible new units will need a grid connection with new power lines to be constructed and they might require reinforcements elsewhere in the 400 kV grid as well.

In the Baltic states, the new connections to Finland, Sweden and Poland will create a need for internal investments in the Baltic countries.

Also in Poland the internal grid needs to be reinforced in order to better use the capability of the new interconnection between Poland and Lithuania.

Additional investment needs are expected to be seen as the national plans for reaching the 20/20/20 goals are developed.

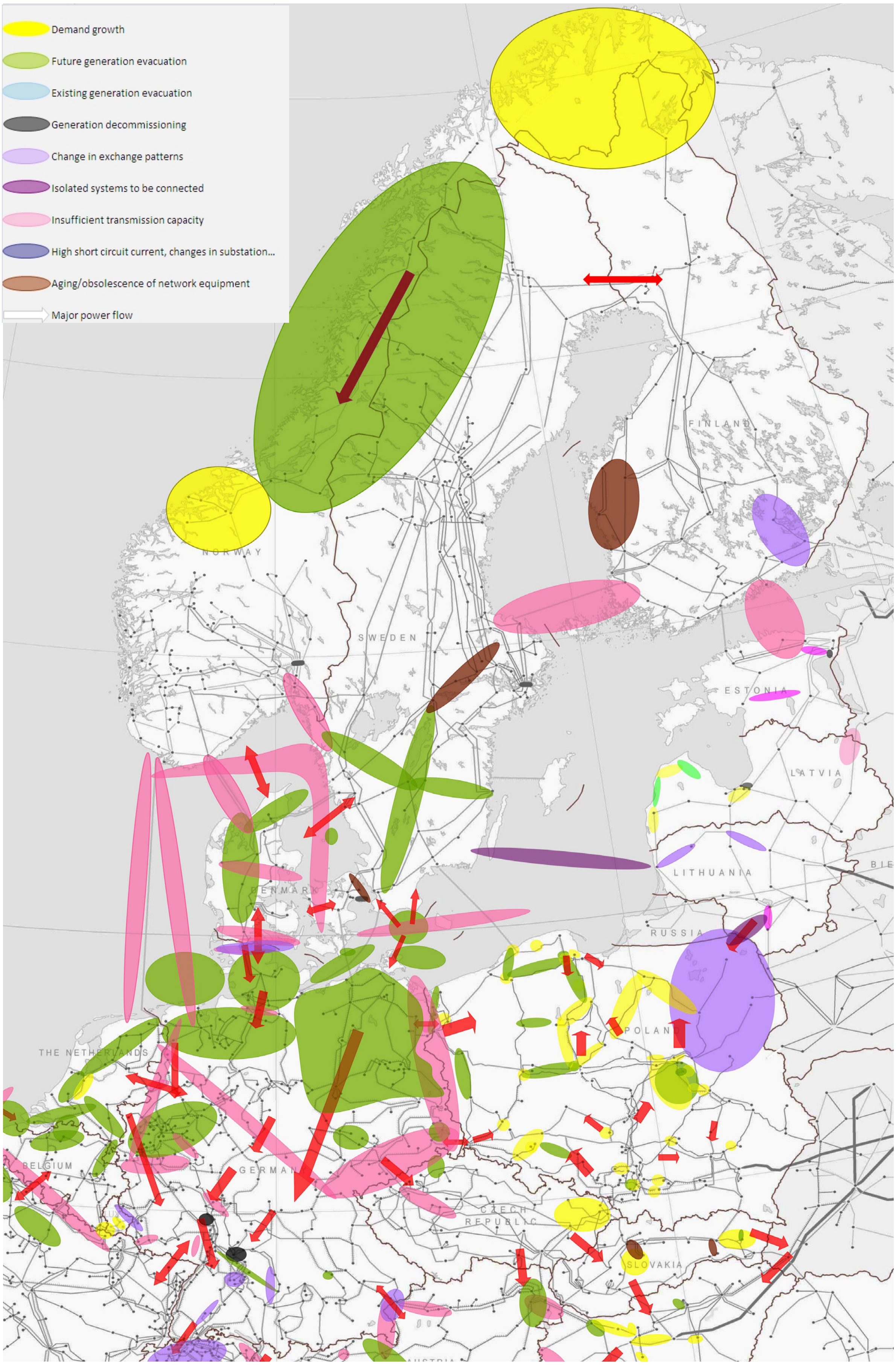


FIG. 38 **MAP OF MID-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP BALTIC SEA**

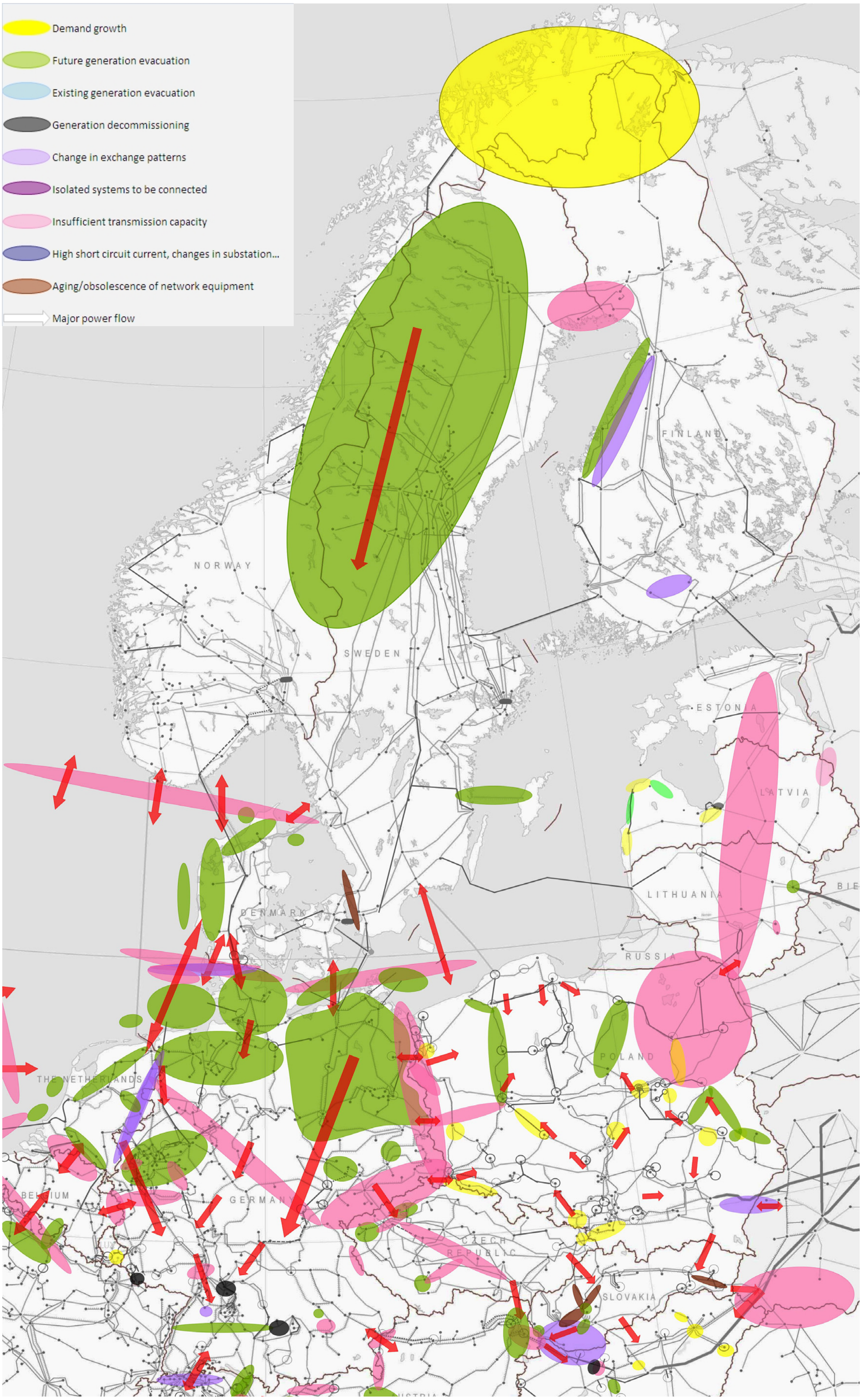


FIG. 39 MAP OF LONG-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP BALTIC SEA

5.7 Regional Group North Sea

The North Sea Region consists of four areas, namely Ireland, Great Britain, Nordic countries and five "PLEF" countries in continental Europe[30]. These sub-systems are rather thinly-interconnected with one another.

Every country in the North Sea Region faces similar major challenges relating to grid development and planning on the way towards a reliable and secure European network, a deep penetration of renewable energy sources in Europe and a well-functioning European electricity market. In this perspective, system development within the North Sea Region can be opportunely based on common or complementary solutions among countries composing it.

5.7.1 Connection and Integration of Renewable Energy Sources (RES) and of New Conventional Power Plants

In order to fulfil both the European and national targets regarding the climate protection, signals were given by national governments to increase the installed Renewable Energy Sources in electricity grids. As a result of that context, many RES projects were initiated within the Region North Sea and they have to be connected to the grid. However, some of them are located in places where the transmission grid was not historically developed. Therefore, TSOs are facing major challenges to extend their grid to get *new onshore RES plants connected*. Onshore plants needing grid extensions can be found in the midterm in the south, west and north of the island of Ireland, in north Scotland, in Denmark, in north Germany, north-western France, and onshore along the Norwegian coast. In the long run, complementary grid extension needs are foreseen as a result of other new additional RES projects in the same areas. The extension of onshore grids is a prerequisite to integrate all the new RES infeeds.

This is even more a concern for *offshore wind power plants* which have somehow to be connected to the onshore transmission grid. Such power plants can be found in the coastal areas of eastern Ireland, Belgium, north-western France, in the German North Sea coast and in the Baltic coastal zone of Germany and Denmark. In the long run, additional installations are expected in those areas as well as in the coastal areas of United Kingdom and of The Netherlands.

Once connected, due to *imbalances in some countries between high RES penetration and low local consumption level*, energy has to be transmitted by transmission lines, historically sized in accordance with these low consumption levels and in some cases low local generation levels. As more RES generation plants are connected the energy must be transmitted over more increasing distances. In this context, some parts of national onshore transmission grids, not even but particular in the North Sea Region, have to be strengthened to integrate this wind energy with an adequate level of reliability.

The same phenomenon can be found in a *regional perspective*. The differences in the national targets and incentives, combined with the various availabilities of renewable resources across the regions in Europe, lead to a greater penetration of some RES technologies in some areas than in others. This effect increases considerably the power exchange opportunities all over the North Sea Region, inducing power flows in the existing grid, mainly, between the northern part of the zone (northern Germany and Scandinavia),

[30] Belgium, France, Germany, Luxembourg and The Netherlands, the Ministries of which signed a MoU to devise a common enhanced market organisation and security of supply tools – see Section 6 of Appendix 2.

Ireland, United Kingdom and the southern part of it (France, Belgium, The Netherlands, southern Germany) and highlighting some needs to reinforce the transmission grid between and within those countries.

Another important attribute in RES development is the fact that Nordic Countries, Norway in front, holds almost 50% of the European *hydropower reservoirs* capacity. This is an important driver for interconnectors between Norway and Europe. Easy adjustable hydropower may act as a battery for Europe's increasing intermittent RES production.

It has also to be stressed that renewable integration only starts with having transmission capacity to evacuate the generation. Afterwards, operational market design challenges will be to cope with.

Finally, many existing conventional power plants are ageing in the North Sea Region and need to be replaced in the next decades. Combined with the increasing consumption, the market liberalization and the nuclear phase out stated in some countries, this situation creates opportunities to producers to deploy their new units, integrating renewable and conventional energy sources, considering new technologies and new locations. As a result, in addition to the dynamic of RES integration in Europe, producers are planning to build *new conventional power plants* sometimes in addition to existing plants in the same areas, also to be connected and integrated to the grid so that it has to be strengthened in many areas of the region.

5.7.2 INTERNAL ENERGY MARKET (IEM)

Besides the large-scale RES integration, the realization of the Internal Energy Market (IEM) also includes open grid access and trading which especially increases cross-border exchanges. Those exchanges, if permitted, could endanger the security of supply and must therefore be limited due to current grid constraints, resulting in sub-optimality for the European generation economical dispatch. Moreover, the future evolution of the European generation pattern will lead to a change in exchanges leading to new grid constraints. These future constraints should become more and more volatile as deep wind penetration in the North Sea Region should give rise to more and more variable flows across the grid.

In order to *take advantage of economically complementary generation mixes* and to manage very large amounts of volatile wind generation, the North Sea countries must further develop existing interconnections and integrate their four subsystems into a stronger network in the coming decade.

In the mid run, needs to increase exchange capacities are coming up between Ireland and Northern Ireland, Ireland and Great Britain, Belgium and France, The Netherlands and Germany, Germany and Denmark, Denmark and Scandinavia, and globally between Great Britain and Continental Europe. In the long run, in addition to the mid-term needs, complementary needs to develop or extend interconnections are foreseen between Belgium and Germany, and from Nordic countries to other countries of the North Sea Region.

In this context, the important contingents of offshore RES expected to be installed both in coastal areas of the region and in the middle of the North Sea will require solutions for connection and integration that could take advantage of the new interconnections between the surrounding areas. In that matter, developing an *offshore grid*, connecting countries of the North Sea Region and offshore wind farms, would enable further integration of its offshore renewable energy and its electricity markets. In addition to the reinforced onshore grid, the offshore grid could be seen as a key building block to develop the European energy market and to exchange renewable energy among European countries.

5.7.3 Change in generation patterns and increasing consumption in some areas

The incremental change in generation patterns within the North Sea Region and/or in some part of it the increasing consumption may put security of supply at risk if adequate grid reinforcements and grid extensions cannot be realised in the coming years. This concerns mainly areas of Luxembourg, France, Germany, The Netherlands and parts of the Republic of Ireland.

In the Republic of Ireland, security of supply in parts of the south-east, midlands and north-west regions is a concern in the medium term and is the driver behind a number of existing projects. In the medium to long term, the supply to other parts of the south-east, Dublin and the north-east region will be at risk in the absence of further grid development.

The security of supply may be at risk in Brittany (France) if no additional generation is commissioned in the area.

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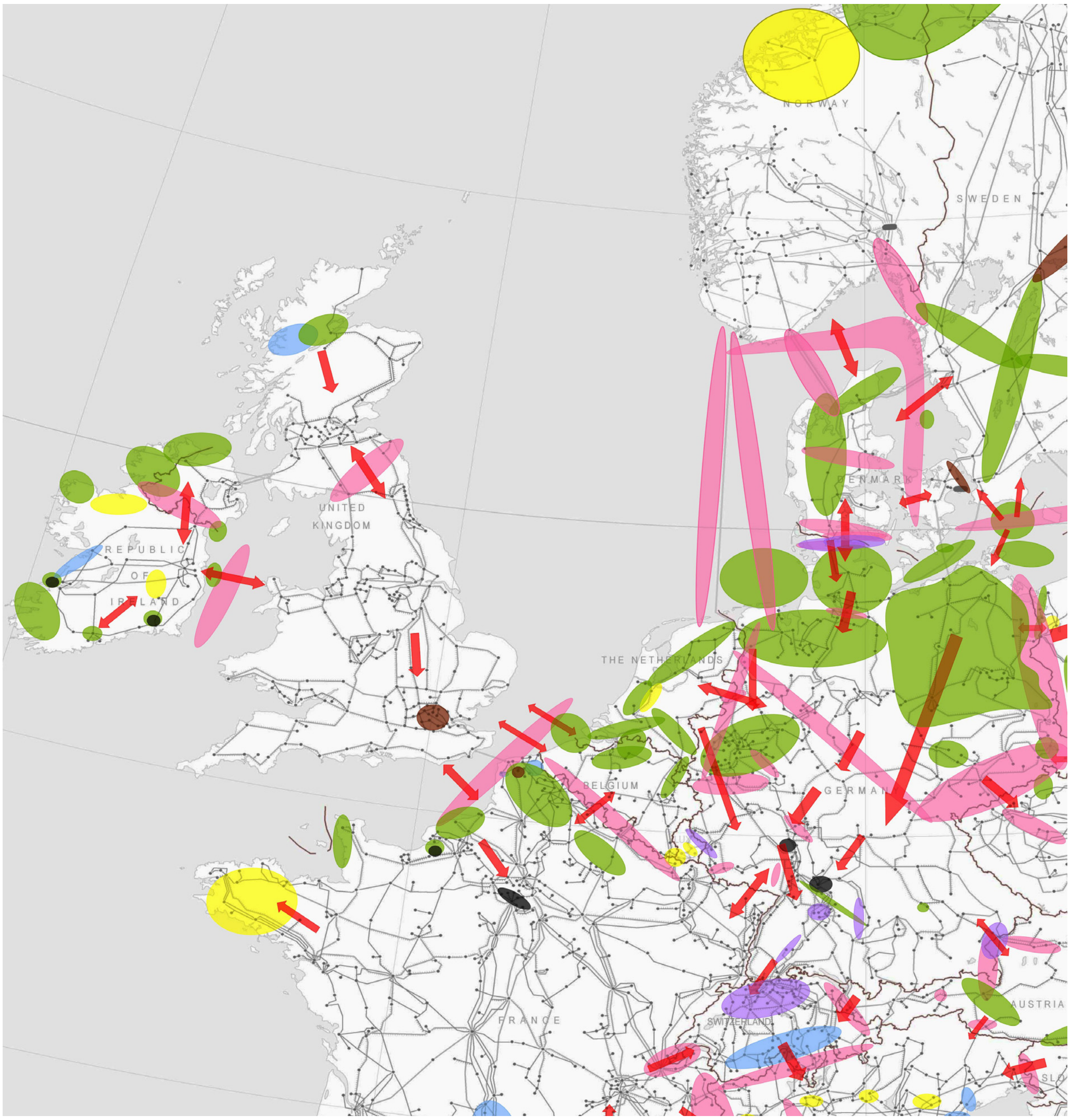
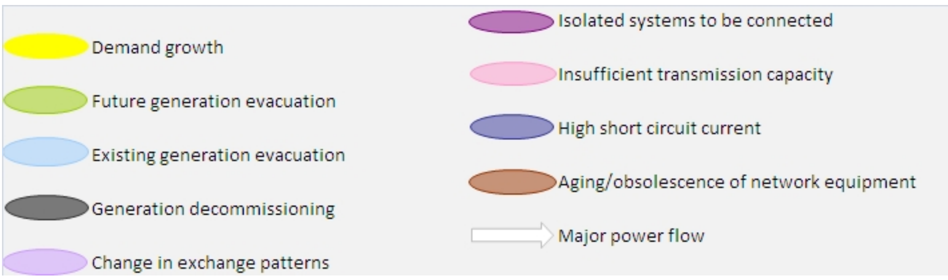


FIG. 40 MAP OF MID-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP NORTH SEA



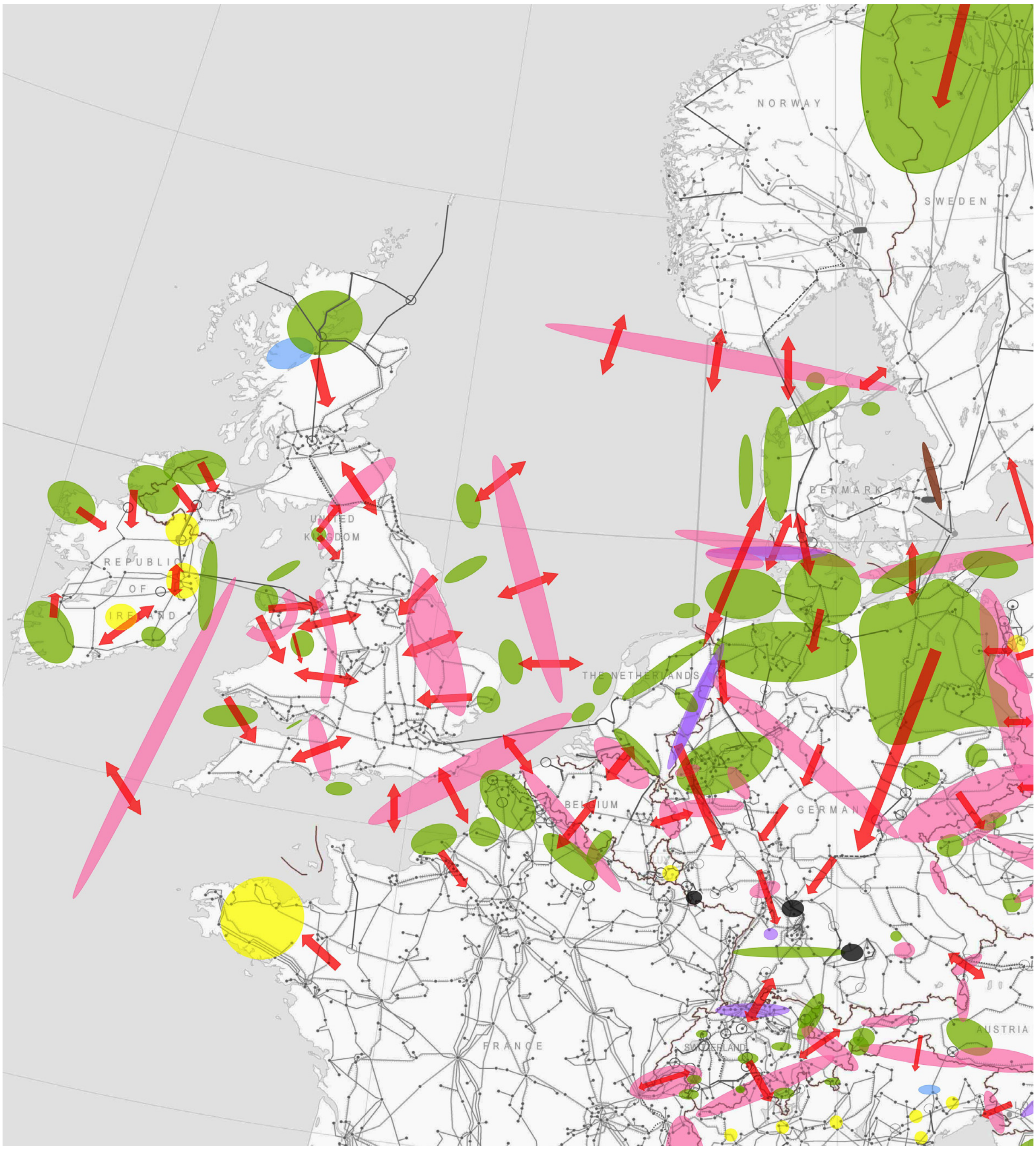
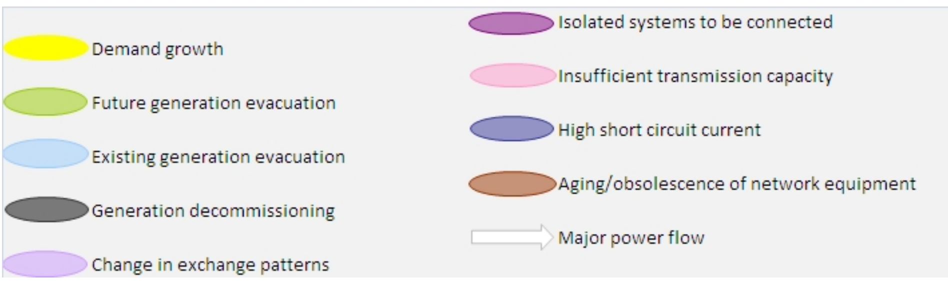


FIG. 41 MAP OF LONG-TERM INVESTMENT NEEDS IN THE REGIONAL GROUP NORTH SEA



5.8 CONCLUSION

The maps show the very large amount and the complexity of investment needs, which TSOs have to handle, and all at once – concerns cannot be dealt with one by one. It must be addressed that there is an uncertainty in the expiration of future generation scenarios with the strong change to “green” energy production and therefore the framework is not stable yet.

Pink and green colour dominate on all maps: abolishing IEM barriers and connection of new generation, especially RES, are really the two main issues TSOs face for the coming years. One can notice the size of areas, where new generation is likely to be connected – with various degrees likeliness – and better understand in which respect identifying and launching appropriate investments at the right places is then quite complex, and is really a challenge for TSOs as stated in Chapter 3.

Load growth is still an issue in some places, but with less uncertainty as new generation, and the concern can be easier controlled.

Limited cross-border transfer capability appear thus as an important, but not as the sole issue of European significance to address in the TYNDP report. It cannot be addressed disregarding other investment needs, particularly those (new location and features of generation), most influencing power flows in a rather near future.

Seven mains investment needs clusters can be briefly identified:

- *Massive renewable integration in the North part of Europe:* the connection of renewable sources, mainly wind, is one of the most important triggers of this plan. The reason is that wind farms are often located in remote areas where the network was not initially developed to accommodate them. Furthermore, the impact of these new plants on the flow patterns can be noticeable. Produced renewable energy has to be evacuated either within the North Sea and the Baltic Sea regions or to the East and to the South. Therefore, impacts are not limited to these two regions but also to the surrounding ones as investment needs are threefold: the connection itself, the transmission of the power through the onshore networks and the efficient balancing of the system. According to the last one, one can say that both offshore interconnections and optimised usage of available hydroelectric facilities will trigger new investments.
- *Massive renewable integration in the South part of Europe:* the connection and evacuation of renewable sources, mainly wind, hydro and solar in the Iberian Peninsula, is one of the most important investment needs in the South-Western and Center-South region of Europe. The ambitious renewable plans in Italy, Spain and Portugal necessitate an important investment in transmission infrastructure. One reason is that new wind power plants are usually located in areas with weak or nonexistent connection to the transmission network. On the other hand, the production of these new generation plants results in new power flows that need to be accommodated in the electric system, which was designed for different power flows. It triggers not only internal reinforcements but also emphasises the need to increase the interconnection capacity with the rest of the continent and especially with France. With regards to Italian System the wind farm development in the in the South part of Italy triggers a huge reinforcement in transmission capacity.
- *Important North-South and East -West flows in the Central South / South-East Region:* these investment needs are dictated by the power balances and market

prices of the member countries. The block including Greece, FYR of Macedonia, Albania, and Italy is usually importing electricity. Strengthening of the Regional network in the predominant power flow directions, in order to assist market integration, is a main driver that stimulates investment needs. North-South flow will even rise in importance as new generation in Bulgaria, Hungary and Croatia will have to be accommodated. The same increasing trend is valid for the East–West flows but for different reasons, namely the interconnections of new systems with continental synchronous system (possibly Turkey's system in the short term and Moldova's and Ukraine's later on). Also, the strong increase of generation and pumping capacity (new hydro pump storage power plants of several thousand MW) especially in the Austrian and Swiss Alps will have a strong influence on the power exchange in that region in the future. A strong correlation with the wind power generation especially in North Germany is expected which will increase the need of transmission capacity between those two regions. A future increase of the wind generation in France and Italy will in a similar way lead to a need for investments to increase the exchange capacity between those regions.

- *Baltic States integration:* EU commission launched a Baltic Sea Energy strategy, which supports the results from the Multiregional plan and an Energy Market Interconnection Plan (BEMIP) was launched at autumn 2008 by the EU commission. The goal is the full integration of the three Baltic States into the European energy market, through the strengthening of interconnections with their EU neighbouring countries. The new connections to Finland, Sweden and Poland will create a need for internal investments in the Baltic countries.
- Complementary to RES integration, *connection of new conventional power plants* totalling more than 100 GW is foreseen all over Europe in the next decade either to replace old, decommissioned plant or to cope with load growth and system balancing.
- *The power supply of some European cities and regions* will be an issue in Europe, (in Spain, France, Hungary, Slovakia, Poland, Czech Republic, etc.). The concern is of European relevance especially when interacting with other investments needs in the area, and limiting cross-border capacity.
- With new sitting and clustering of generation units, and greater variations of the generated power, *market integration* is more than ever the key to ensure that wherever power is available, it can be efficiently brought to consumption areas, with no curtailment. The grid development and the adaptation of grid access rules complement each other to propose the most appropriate market framework.

HIGHLIGHTS:

- A set of maps is provided, showing investment needs which grid planning has to address all at once, and which reshape trends for bulk power flows in Europe tomorrow.
- Abolishing IEM barriers and connection of new generation, especially RES, are the two main issues TSOs will have to face for the coming years.
- Load growth causes also still some investment needs in some places.

[6] FORESEEN INVESTMENTS ON THE EUROPEAN GRID

6.1 INTRODUCTION

All investment needs identified in Chapter 5 are being addressed by TSOs. Depending on the horizon and criticality of the needs, TSOs propose projects at different stage of maturity to accommodate them.

The present Chapter presents an overview of all grid reinforcement projects proposed by TSOs, mirroring the structure of Chapter 5 – investments needs divided in 6 European regions, and mid/long term (2010-2014 / 2015 and beyond). More detailed information on every project is available in Appendix 1.

NB: some projects are quite mature, already under construction; others are only under study. No filter with respect to maturity has been applied so as to deliver the most transparent and comprehensive information to the reader.

6.2 REGIONAL GROUP CONTINENTAL SOUTH WEST

6.2.1 RG CSW MID-TERM PROJECTS

Regarding interconnection development the main projects in the CSW are:

- A new interconnection France-Spain is required in the midterm in order to fulfil the 2800 MW objective. After being classified as Priority Project by the European Commission, and after the involvement of Mario Monti as European Union Coordinator it was stated that the unique feasible alternative for the development of the Spanish-French interconnection by the Eastern Pyrenees, was a solution in DC totally buried for the cross-border section of the interconnection (Baixas-Sta Llogaia), with a terrestrial drawing up, and using as far as possible existing infrastructures corridors within a certain area[31]. Internal reinforcements both in Spain and France are required: some upgrading of existing lines both in France and Spain, and also in Spain a new 400kV line between Sta Llogaia and Bescano in order to accommodate the new flows and connect to the existing network.
- Between Portugal and Spain three new lines are planned: a new 400 kV interconnection line through the Duero corridor (400 kV Aldeadavila (ES) - Lagoaça (PT) line), in addition to some changes in the topology of the existing 220 kV lines in the same area, a new southern interconnection: 400 kV Guillena (ES) –Puebla de Guzman (ES) – Tavira (PT)– Portimão (PT) , and a new northern interconnection 400 kV Bóboras (ES)- O Covelo (ES) – Vila Fria (PT) – Vila do Conde (PT) – Recarei (PT). All of them require the accommodation in the internal network to the new flows.

Some other projects to highlight in the region are directly related to security of supply:

- The change of conductors on French 400 kV lines between the Pyrenées Orientales and the main grid of Southern Massif Central and Rhone Valley in order to cope with

[31] http://ec.europa.eu/energy/infrastructure/tent_e/coordinators_en.htm

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the North to South and East to West flows due to upstream generation evacuation and supply of local load while accommodating increased power flows to the Iberian Peninsula.

- The new HVDC link that connects Mallorca to the Mainland in Morvedre, and the connection of Mallorca with Ibiza and reinforcement of the connection with Menorca.
- The axis at 400 kV crossing the Portuguese Alto Alentejo region connecting Falagueira and Palmela substations is to supply the high speed train and reinforce local load supply.
- The new axis that connects generation areas with the central Region (as the most important demand area in Spain) such as the SUMA project from Northwestern Region to Madrid, the new Almaraz-Guillena axis, the upgrades in the 400kV lines on the west of the country and the new axis from Cadiz to the North. These projects are also related to generation integration, mainly RES.

The rest of significant projects are highly related to accommodate new generation, mainly RES, for instance:

- The North axis projects from Galicia to the French border and the new axis Cantabrian Sea-Mediterranean Sea (both towards Levante and Cataluña), that help to accommodate flows from areas with production surplus to demanding areas.
- The Trás-os-Montes 220 kV network in Portugal associated to renewable generation.
- The reinforcement of the axis between Litoral and Caparacena in Andalucia (a new line and upgrades), and many 220 kV projects overall Spain, planned to accommodate new renewables production.
- The new 400 kV lines from Covilhã to Pego in the inland middle region of Portugal for new renewable generation.
- The two 400 kV lines Batalha-Lavos and Lavos-Paraimo to evacuate production of new combined cycle power plants connected to Lavos substation.

6.2.2 RG CSW LONG-TERM PROJECTS

In the long term another interconnection between France and Spain would be required to reach the long term objective of 4000 MW. Every possible solution along the border will be considered, but it is already stated that the route will not be in the French Department of Pyrenees Orientales, nor in Catalunya.

Other important projects in Spain in the long term are the 400 kV Sevilla Ring associated to security of supply, the Trasmanchega project associated to renewables, and the 400 kV Asturias Ring associated to conventional energy.

In Portugal emphasis is done on important new 400 kV reinforcements at Minho and Trás-os-Montes regions in order to evacuate significant amounts of new hydro production from the Portuguese National Plan for Hydro Power Plants and from the power reinforcement of already existent plants. Mention is also done to the creation of a 400 kV axis from the west zone of Serra da Estrela up to littoral to accommodate new hydro and wind generation and important reinforcements on 400 kV network near Lisbon to supply this region.

The initiative of the Union for the Mediterranean Sea looks for a greater integration of the South Europe and North Africa energy markets by completing the Mediterranean electricity and gas rings. Also, the Mediterranean Solar Plan launched in 2008 pretends to install thousands of renewable MWs in the Maghreb countries that could supply the increasing demand in these countries, whereas the surplus could be exported to Europe. In the long term, this situation can affect the power flow patterns in the Morocco-Spain existing interconnection, and also in the internal networks, necessitating new investments in the long-term.

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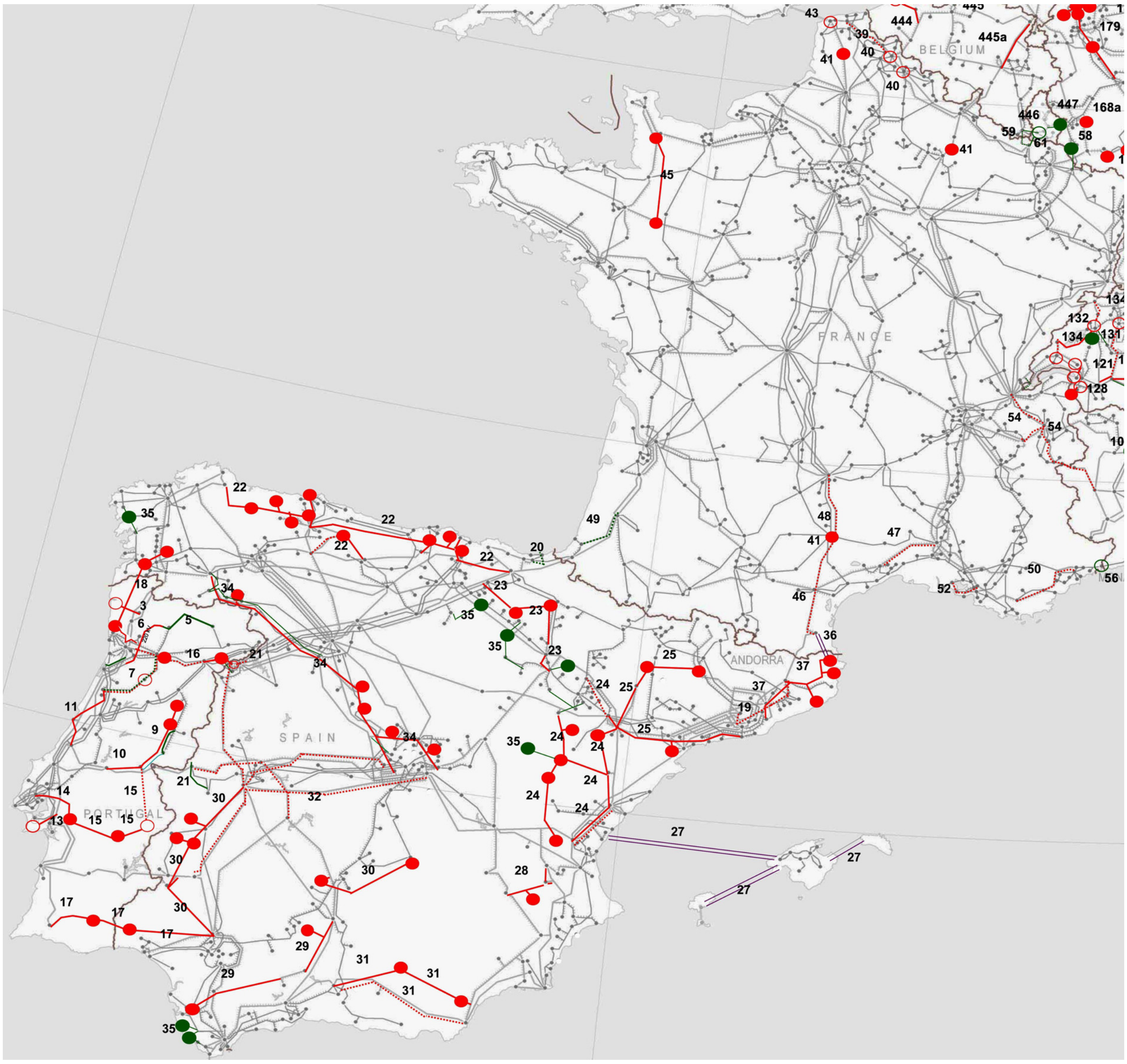
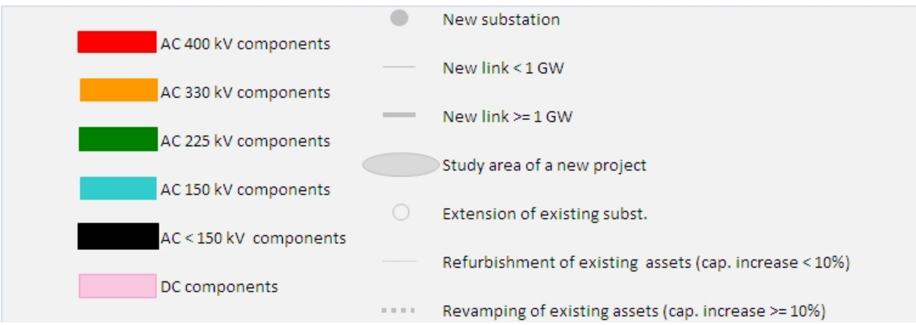


FIG. 42 MAP OF MID-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL SOUTH WEST



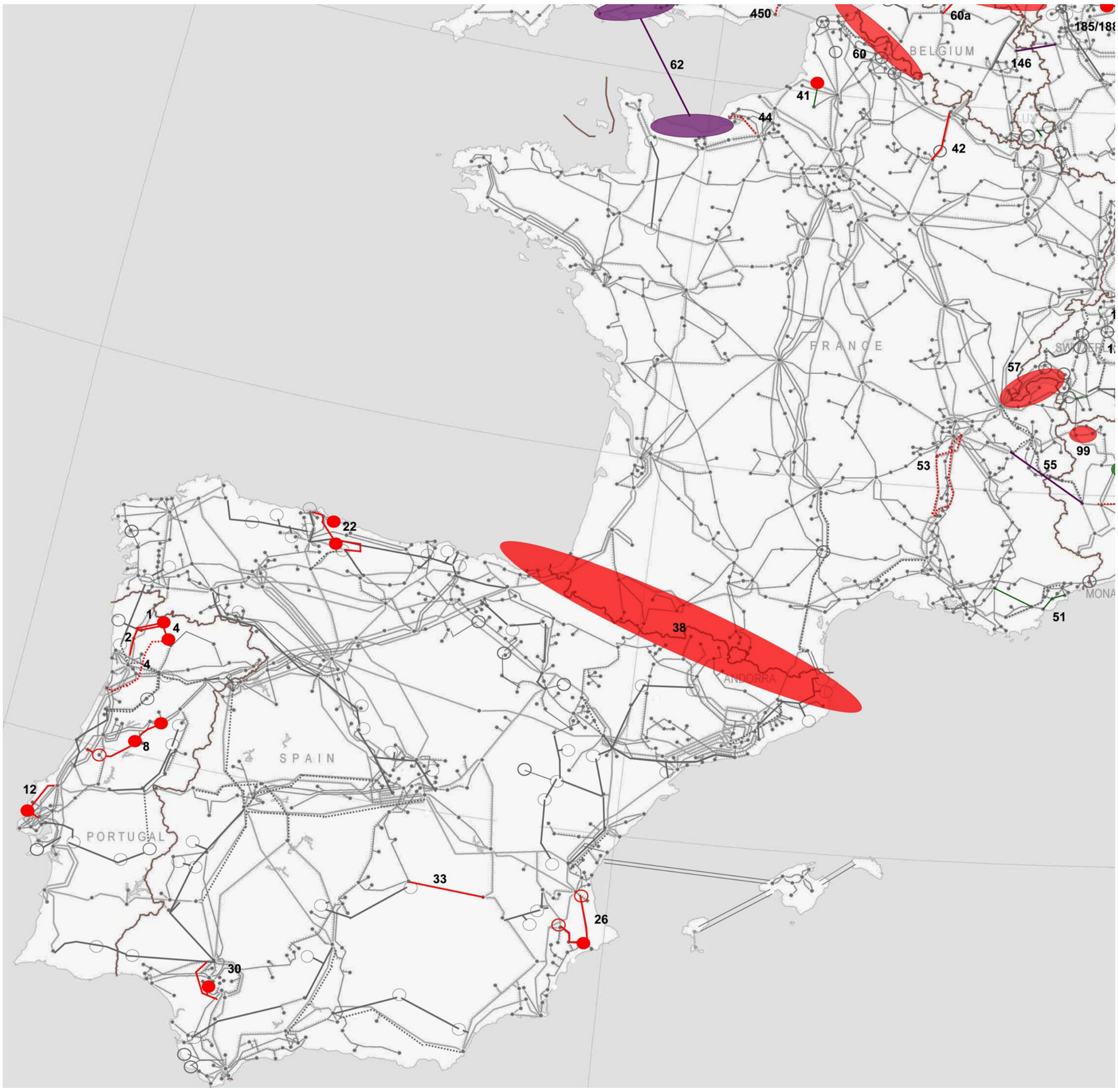
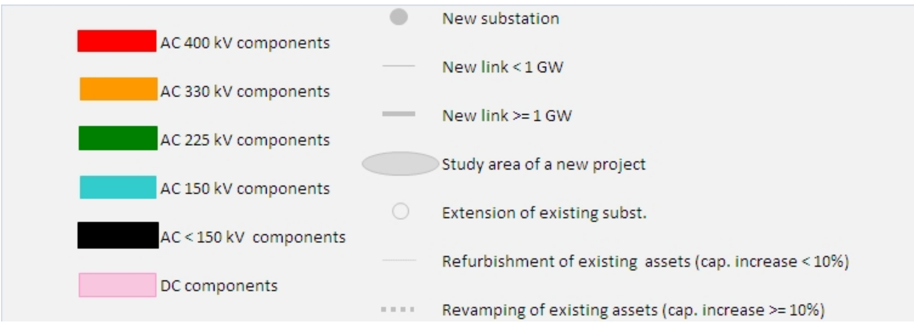


FIG. 43 MAP OF LONG-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL SOUTH WEST



6.3 Regional Group Continental Central South

6.3.1 RG CCS mid-term projects

The mid-term investment projects in the region are focused on two big challenges: the first is to find and investigate solutions to adapt the network to the constraints and to increase the internal and also the external transmission capacity of the grid. In this respect, the completion of the HVDC 1000 MW Sardinia-Mainland (IT), the double circuit 2000 MW AC link Sicily-Mainland (IT) and interconnection between Italy and South-East Europe are preliminary steps for the realization of the Mediterranean subsea grid.

The upgrading of the existing power lines (from 220 kV voltage level to 400 kV, either internal or tie-lines), such as Westtirol-ZellZiller (AT), S.Peter-Ernsthofen (AT), Calenzano-Colunga (IT), Feuillane-Realtor (FR), second circuit of Neoules-Broc Carros (FR), Avise-Villeneuve-Chatillon (IT), Chippis-Lavorgo (CH), are some of the first efforts to be pursued.

Since the realisation of new lines must be accepted by the concerned population and authorities, in some cases non-conventional solutions are adopted, like:

- Re-conductoring with low sag high temperature wires allowing to transport more power energy without increasing the length of the network, with projects on the French-Italian border;
- Installation of PST devices to maximise the use of existing transmission capacity and to control power flows; e.g. the planned PST in Divaca (SI), Lienz (AT), Camporosso, Foggia and Villanova (IT).

Further investments are related to the improvement of the reactive power management in order to warrant a better voltage stability of the systems in which the new power plants (e. g. North sea region) have been installed away from the load centres or storage facilities (e. g. pumping storage in the Alps). Var compensation devices shall be installed in South Germany and Italy to ensure a smooth voltage profile, which is expected to become critical especially during low load situations.

6.3.2 RG CCS long-term projects

The development of the transmission grid is deeply impacted by the change of the load flows in relation with the development of renewable (wind and solar) generation, as in Germany, in the Alps region and in Italy (reinforcements in South Italy and the new 400 kV ring in Sicily). Besides new interconnections are being considered between France and Switzerland in the area of the Geneva lake and between Germany and the Czech Republic in order to accommodate RES production. Other internal projects are Obersielach (AT)-Lienz (AT) 400 kV and new interconnection projects are planned in order to comply with the promotion of the IEM by reducing these current/future constraints and by creating an added value for the market (e.g. IT- AT and reinforcements between Italy and South-East Europe).

Large investments are needed in order to adapt the transmission grid to favour the attainment of the new European binding targets (EU 2020), in particular taking into account the global collaboration for the integration of the common European market and the possible synergies of the European infrastructural corridors (e.g. HVDC IT-FR – see also Appendix 4 for further details).

The technical feasibility and economic viability of the new Mediterranean subsea corridors needed for the interconnection of the Region with Northern Africa and South-East Europe are at present under discussion; however, it is evident already now that they will represent important pillars in the development of the Trans Mediterranean supergrid linking the EU Member States with non-EU Countries. The main expected advantages related to the commissioning of the Trans Mediterranean submarine corridors, to be quantified by means of dedicated studies, are related to the promotion of competitive electricity markets also in Maghreb, the support of new low cost conventional generation, the incentive in the installation of RES (wind and solar) power plants in the Mediterranean Basin.

What mentioned above shows a strong political support, particularly from the EU, for the development of new interconnections in the Mediterranean basin. As a matter of fact, the Mediterranean interconnections, both South-North and South-South, have been included in the European priority project (axis EL 9) since the year 2003.

The first project in the long run consists of the HVDC link Tunisia-Italy, already in the authorisation phase.

For more information about projects and studies connected to this group and Mediterranean supergrid see Chapter 10 and Appendix 4.

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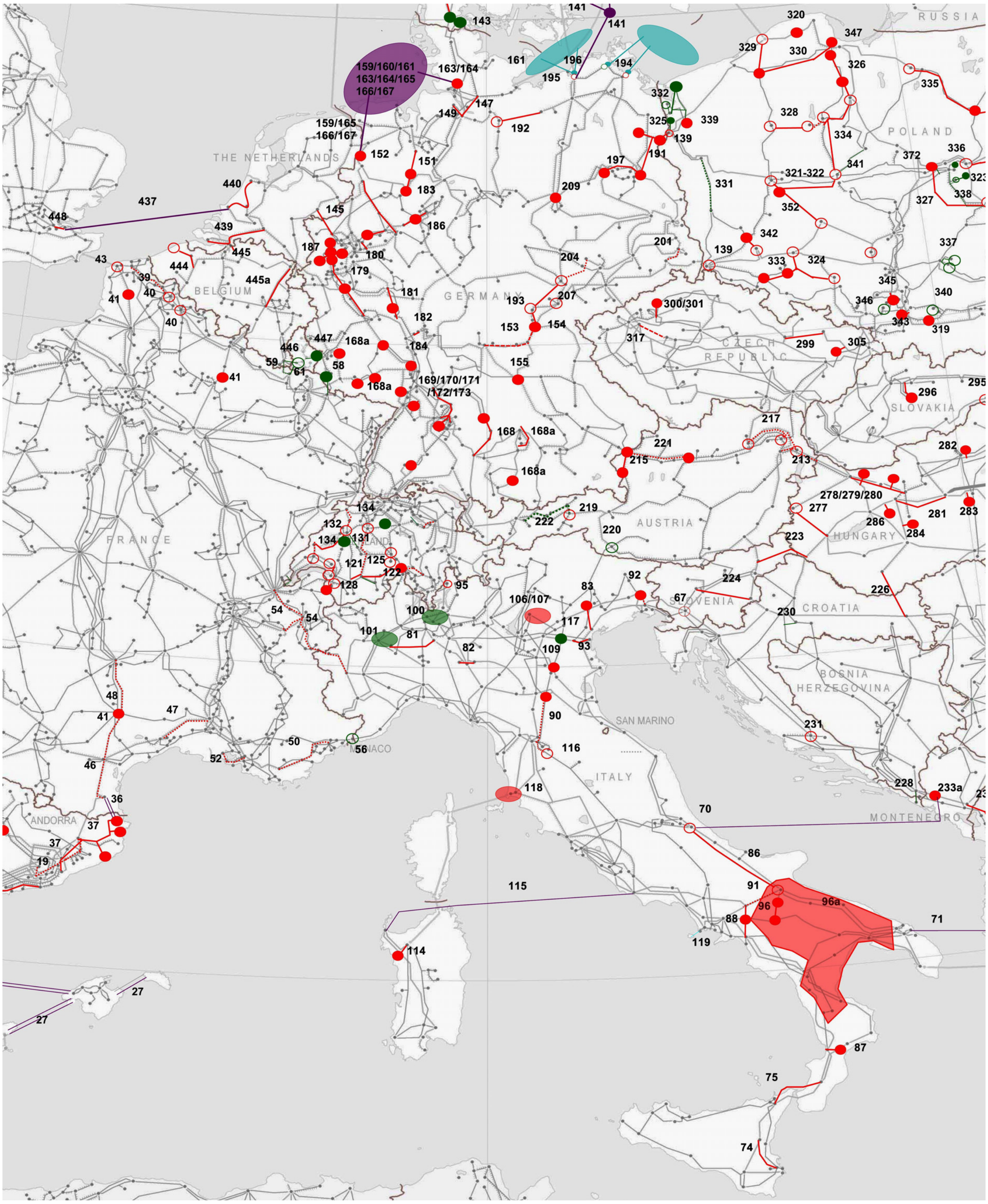


FIG. 44 MAP OF MID-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL CENTRAL SOUTH

- AC 400 kV components
- AC 330 kV components
- AC 225 kV components
- AC 150 kV components
- AC < 150 kV components
- DC components
- New substation
- New link < 1 GW
- New link >= 1 GW
- Study area of a new project
- Extension of existing subst.
- Refurbishment of existing assets (cap. increase < 10%)
- Revamping of existing assets (cap. increase >= 10%)

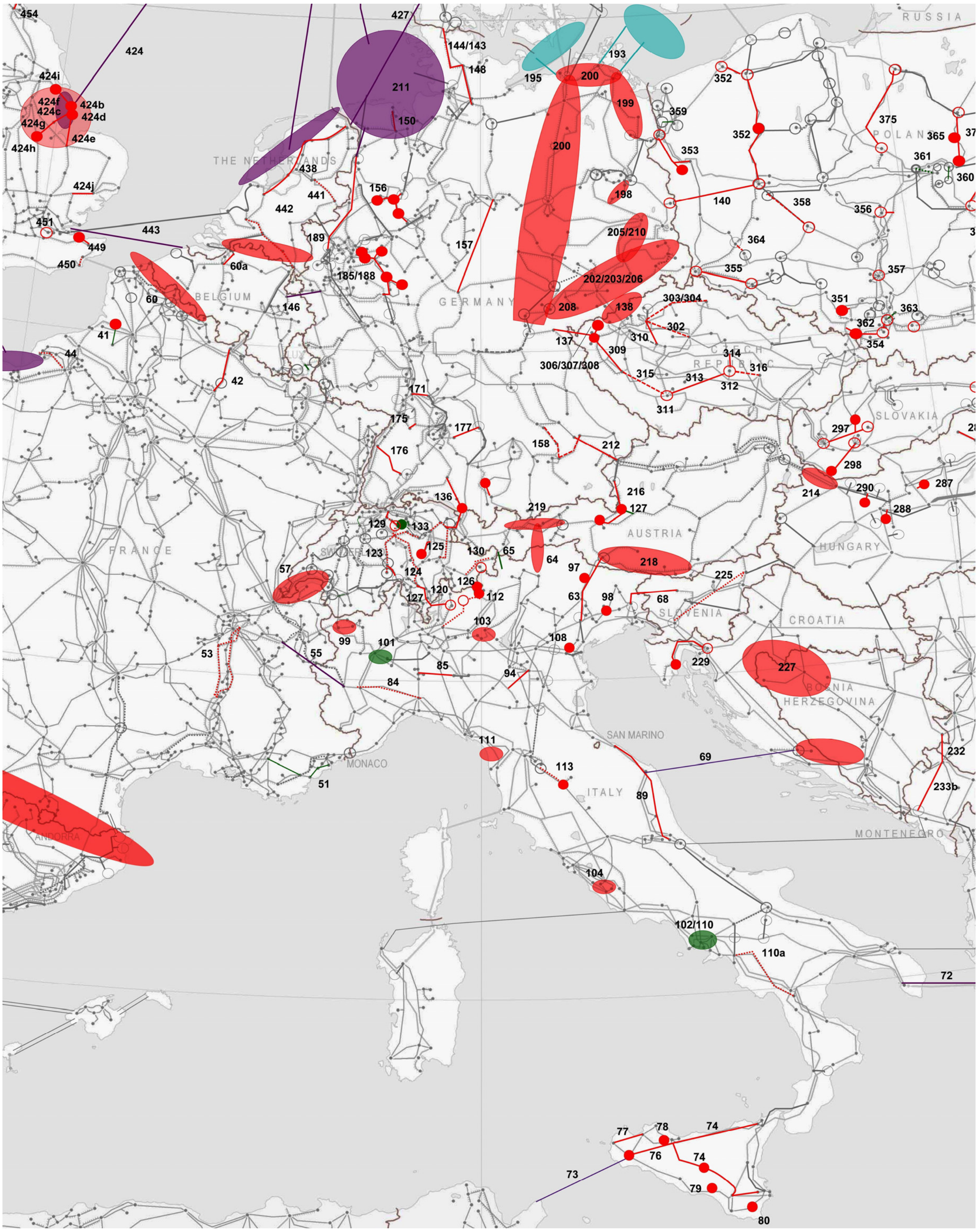
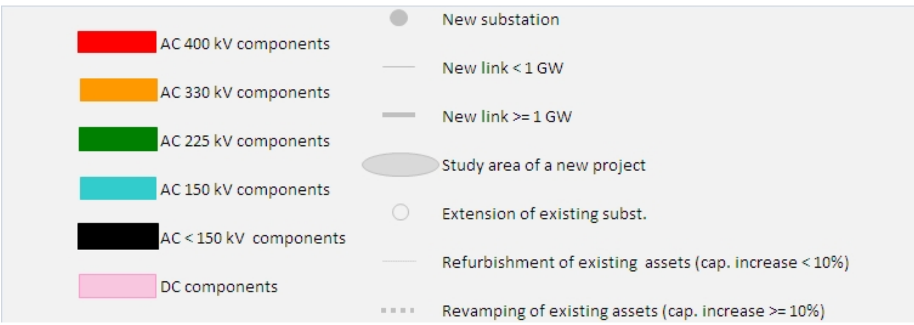


FIG. 45 MAP OF LONG-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL CENTRAL SOUTH



6.4 Regional Group Continental South East

6.4.1 RG CSE mid-term projects

The planned projects in the region are driven by the needs reported in Chapter 5. Concerning the medium term period, most of the projects have a high probability to be commissioned by the reference date.

In this period a number of important cross-border projects (tie-lines), aiming at strengthening the grid across predominant power flow directions, are in the construction phase. The first 400kV interconnection line between Slovenia and Hungary (via a one circuit of new 400 kV double circuit line Cirkovce (SI) – Pince / Heviz (HU) while the other circuit will be used for the new interconnection between Slovenia and Croatia) will strengthen the interconnections in the Northern borders of the region. The 400kV interconnection line Ernestinovo (HR) – Pecs (HU) is expected to be completed in 2010. This line is expected to increase import capability of the Region from Central-East Europe and Ukraine. The 400 kV interconnection line Stip (MK) – Nis (RS) is expected to be completed between 2011 and 2013. This line will strengthen considerably the South part of the South-East European power system and will increase transfer capacities towards the block of FYR of Macedonia, Albania and Greece. The 400kV interconnection line Podgorica (ME) – Tirana (AL) is expected to be completed in 2010. This line is very important since it will establish a new 400 kV corridor from Greece to Italy along the Adriatic coast. All the described projects are crucial for the market integration in the region.

Expected increase of conventional generation in the SE region creates possibilities of exports to Italy and West Europe. In the medium term two new DC interconnections with Italy are foreseen:

- The first one is between Italy and Montenegro which is in the design and permitting phase and is expected to be completed in the period 2014-2015.
- Between Italy and Albania; this is a merchant line that is in the design and permitting phase and is expected to be finished in the period 2013-2014.

A number of internal transmission projects are foreseen in Greece in order to allow the safe increase of RES penetration and especially wind. These include mainly the extension of 400 kV network to Peloponnese peninsula, and the construction of a new 150 kV line in the Evia island during the medium term period.

Concerning the foreseen extension of the synchronous zone to Turkey, a number of projects are included in the medium run period. These projects concern the extension of 400 kV network in North Greece as well as important grid reinforcements in the South part of the 400 kV Bulgarian network. These projects will assist also towards the safe accommodation of new RES and conventional integration in both countries (see also Appendix 4 for further details).

6.4.2 RG CSE long-term projects

Two important projects aiming at strengthening the regional grid are shown at the beginning of the long term period. The 400 kV interconnection line Pancevo (RS) – Resita (RO) is expected to increase transfer capacities in the East – West direction. Two additional DC tie-lines between Italy-Croatia and Italy-Greece are long run projects under study (scenario post 2020). A number of other projects that will increase the transfer capacity to Western Europe are also included. The 400 kV line Okroglo (SI) – Udine (IT) has been planned in order to increase transmission capacity of SI-IT borders. The 400 kV line Visegrad (BA) – Pljevlja (ME) aims to provide a corridor for the evacuation of the new generation foreseen in Bosnia & Herzegovina to Italy through the future IT-ME DC-link. Finally, a new 400 kV line between Bitola (MK) – Elbasan (AL) is under consideration. This project aims to provide opportunities for increased power exports towards Italy from countries with surplus power (BG, RO).

Regarding RES integration, in the long-run period several small islands in the Cycladic complex shall be interconnected with the mainland Hellenic power system, allowing further exploitation of the high wind potential of this area. In the long-run period important projects, aiming at the integration of expected high wind penetration, are foreseen in Romania and Bulgaria. In Romania, these projects have been planned mainly in areas with high wind penetration including Banat in South West, borders with Moldova in North East and Dobrogea in South East. In Bulgaria, main projects aiming to increase transmission capacity in windy areas have been planned in North-East of the country, close to the borders with Romania.

Concerning the foreseen extension of the synchronous zone to the East, in the long-term period, the planning of a new 400kV transmission line Suceava (RO) – Balti (MO) is included. This project is foreseen to increase export opportunities from Ukraine to the SE region (Portile de Fier-Resita-Timisoara-Sacalaz-Arad in the direction to Serbia and Hungary). Studies of connection of Ukraine and Moldova have also been launched; any reinforcements needed shall be included in next plans.

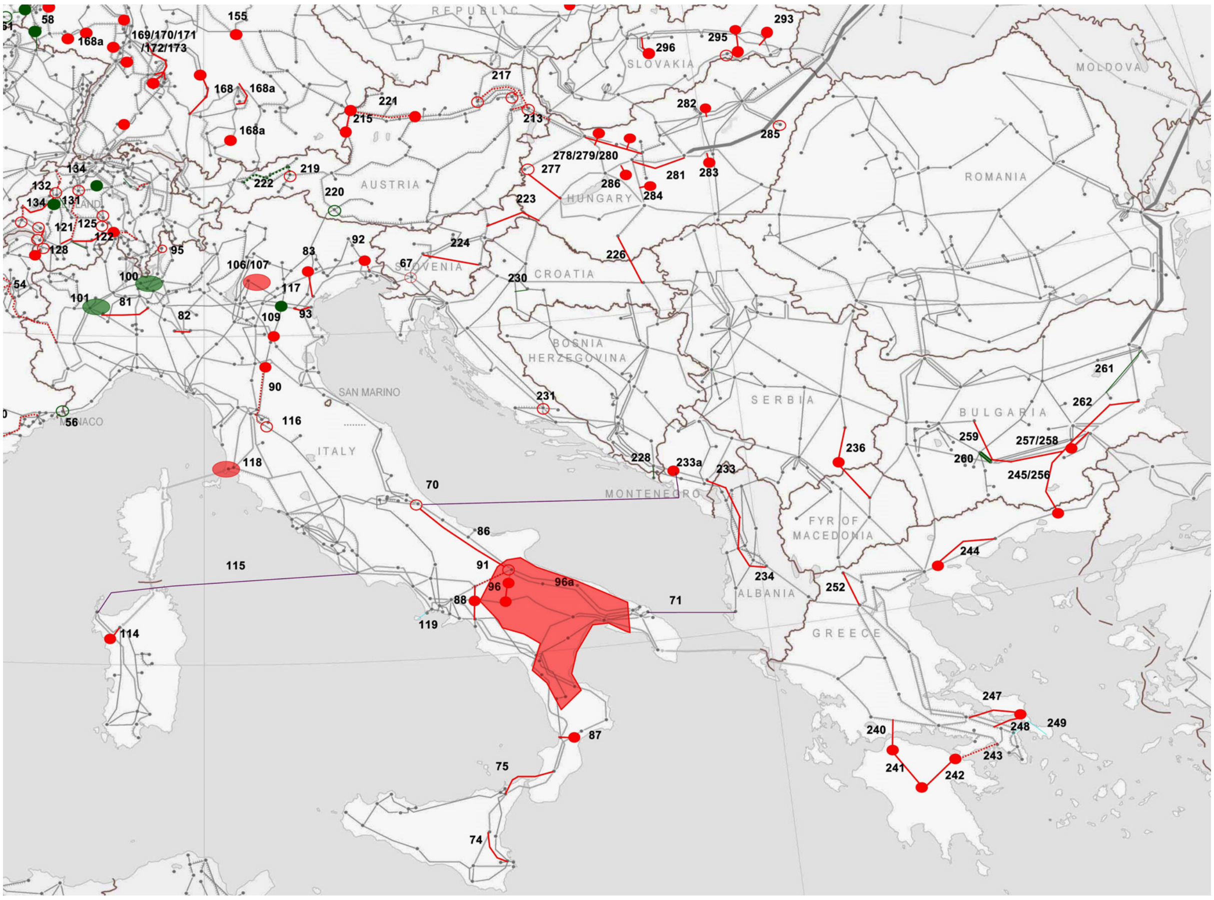
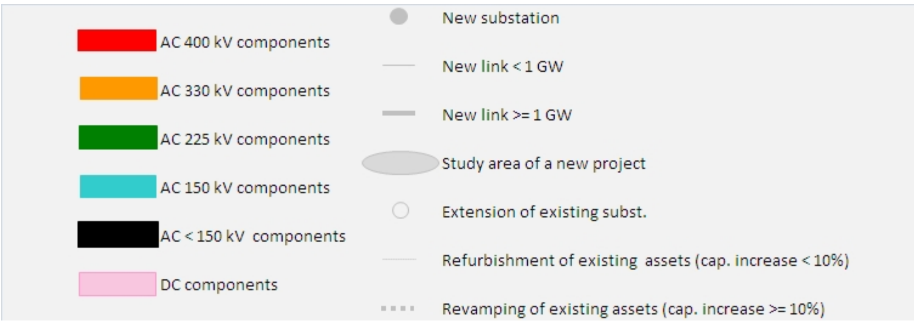


FIG. 46 MAP OF MID-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL SOUTH EAST



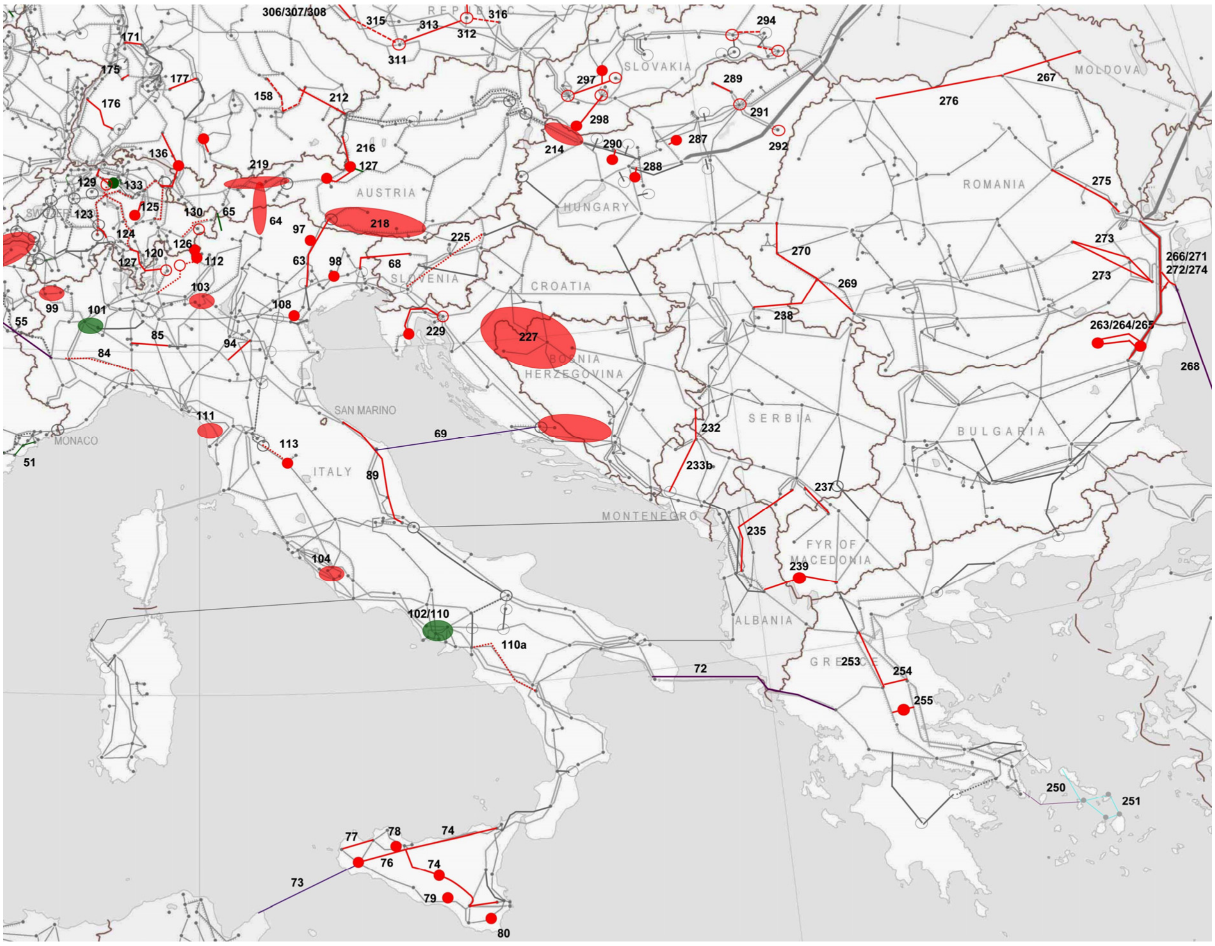
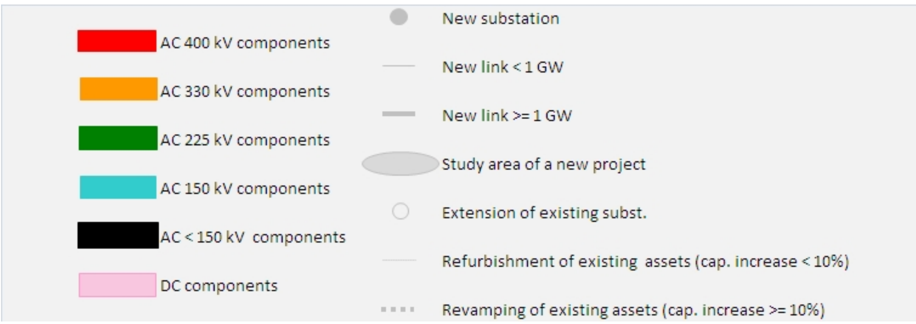


FIG. 47 MAP OF LONG-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL SOUTH EAST



6.5 Regional Group Continental Central East

6.5.1 RG CCE mid-term projects

New generation triggers a lot of projects in the region, both regarding connection (e.g. North of Germany, North-West of Czech Republic, North of Hungary in Gönyü Mátra/Detk, etc.); but also reinforcements as power flow patterns can change dramatically.

The situation is particularly challenging in Germany. Finding cost effective solutions to adapt the network to the new conditions under rapidly changing and uncertain constraints and to increase the internal and also the external transmission capacity of the German grids is one of the main focuses of German TSOs. New lines are needed additionally to other solutions – like the upgrading of existing lines. The new Southwest interconnecting project Halle/Saale – Schweinfurt is a good example: this coupling line will keep the grid security at its high level and allow renewable energy to be distributed horizontally in Germany. One can also notice that higher utilisation and transit loads in the German grid demand reactive power production to ensure voltage stability.

Another goal is a conversion of existing 220 kV double circuit line Krajnik (PL)-Vierraden (DE) into a 400 kV line together with phase shifting transformers installation on 400 kV lines Krajnik (PL) – Vierraden (DE) and Mikułowa (PL) – Hagenverder (DE) aiming to reduce the loop flow from Germany to Poland and to eastern part of Czech Republic and Slovakia, however this phase shifting transformers installation will increase significantly the flow from Germany to western part of Czech republic (loop flow from Germany to Czech republic). Due to the special characteristic of the Polish HV grid (i.e. it operates in parallel with the meshed 110 kV distribution network) the majority of investments in inner grid are related with strengthening 400 kV transmission grid, replacing the 220 kV transmission grid and adding new and reinforce existing 400/110 kV and 220/110 kV transformer stations, as required by forecasted demand growth in agglomeration areas. Another goal due to fulfil the EU ecological requirements are connections of new RES (wind parks) and evacuation of green power mainly from north – western part of country to the south.

Austria, Slovenia, Croatia and Hungary also develop both their inner grid and their interconnections. Considerable expansions are needed in the power grid of APG in order to be able to meet the future requirements, aiming at completing a 400 kV ring. Beyond PSTs in selected corridors to increase NTCs, Slovenia upgrades an internal 220 kV network to 400 kV line voltage level and builds also an internal 400 kV network loop to secure operation. A reinforcement of the corridor in the direction of north-west to east in the Czech Republic (i.e. Chotejovice-Vyskov-Cechy Stred) is in the final stage of preparation before construction phase starts, this will facilitate the power flow in the west-east direction. Closing of the 400 kV network loop Krasikov-Horni Zivotice and construction of a new 400/110 kV substation in the Moravian area is another target in the Czech Republic. Due to the special characteristic of the Croatian HV grid the majority of investments in this area are related with strengthening the internal 400 kV, 220 kV and 110 kV transmission grids, to eliminate expected internal bottlenecks. Double power line 400 kV Ernestinovo – Pecs is under construction and will be commissioned in 2010. This double tie line between Croatia and Hungary is expected to increase operational security in the region. In Hungary developments of the 400 kV network address both local security of supply (with new transformations towards 110 kV) and international power flows. A new 750/400 kV station may be built in Eastern Hungary at

Debrecen, instead of being reconstructed in Albertirsa, because of improved cost-benefit and increased operational security.

In Slovakia, the replacement of the 220 kV transmission grid is the main task in the mid-term horizon. Reconstruction of 220 kV substation Medzibrod onto 400 kV level by splitting of existing 400 kV line between substations Sučany and Liptovská Mara (due to its age and expected consumption increase). A new 400 kV line (Lemešany – Košice – Moldava) will replace existing old 220 kV double line between Lemešany and one big consumer of electricity and major employer in this area of Slovakia (substation Košice and the part of the line between Moldava and Košice substations is already in operation). With reference to consumption growth the old 220 kV substation Voľa will be reconstructed onto 400 kV level and connected into single 400 kV line Lemešany – Veľké Kapušany. Slovenia plans to strengthen its internal loop, a connection between Krsko-Bericevo.

6.5.2 RG CCE LONG-TERM PROJECTS

Quite a number of projects are foreseen in the longer run, mostly 400 kV, and aiming at relieving cross-border or inter-regional transfer limitations. Some projects, especially in Germany, and Austria are still under study, with no precise location. Others are already well defined, as in the Czech Republic where the main concern will be a completion of the network reinforcement in the direction of north-west to east, i.e. corridor Vyskov-Babylon-Bezdecin; a corridor from Kocin, a node where an increase of power generation from nuclear energy is expected will be constructed into the direction of north-east and reinforcement towards to the west. Moreover, Poland – with especially a new 400 kV double circuit interconnection Plewiska (PL) - Eisenhuettenstadt (DE); Hungary, securing the supply of 110 kV networks); and Slovakia, with mainly the continuation of the upgrade of the ageing grid: reconstruction of old single 400 kV line between Lemešany and Veľké Kapušany new double 400 kV line from Horná Ždaňa to Križovany and liquidation of old existing 220 kV lines (plus erection of the 400 kV substation at Bystričany to connect a new power plant). The new 2x400 kV line between substations Gabčíkovo and Veľký Ďur is being planned due to new possible generation evacuation in this area of Slovakia (totally about 2 GW). This new generation however needs also strengthening of Slovak – Hungarian profile, which is still an object of common studies between SEPS and Mavir (APG).

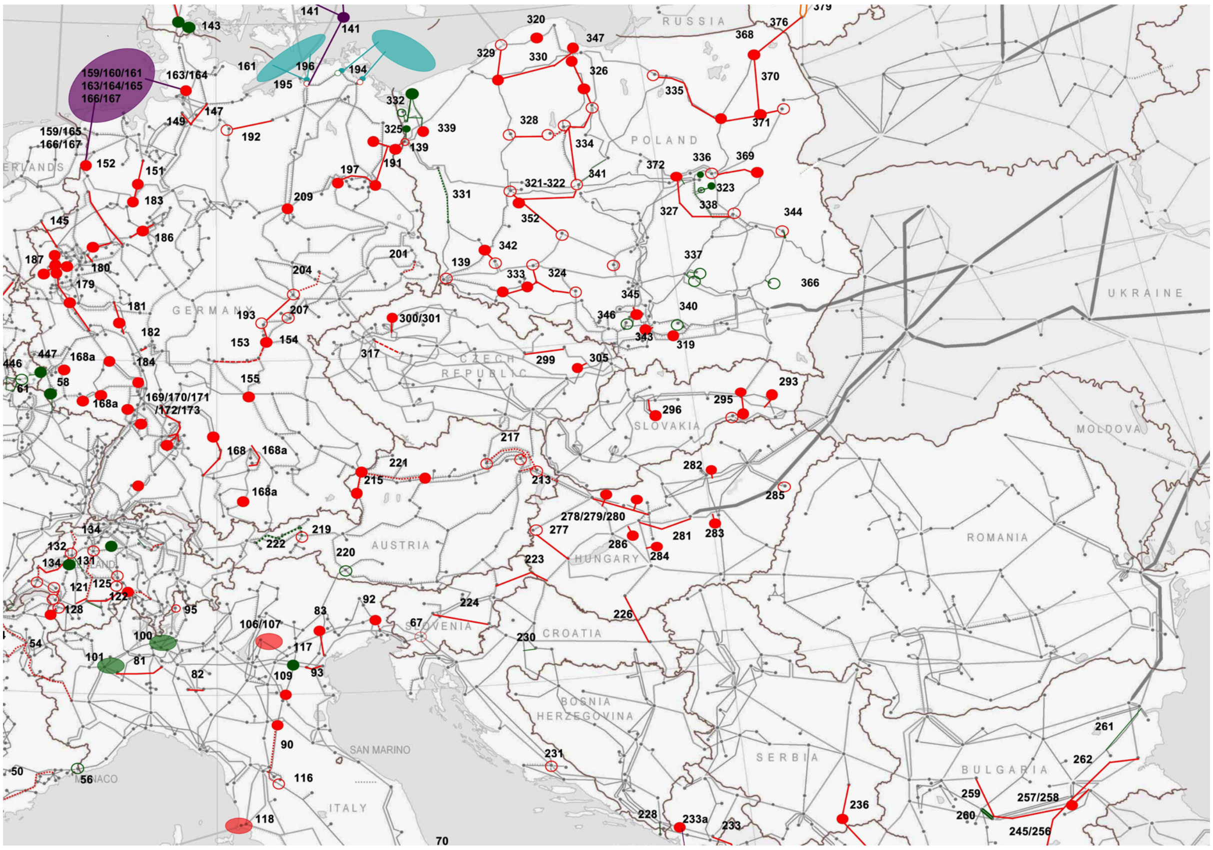
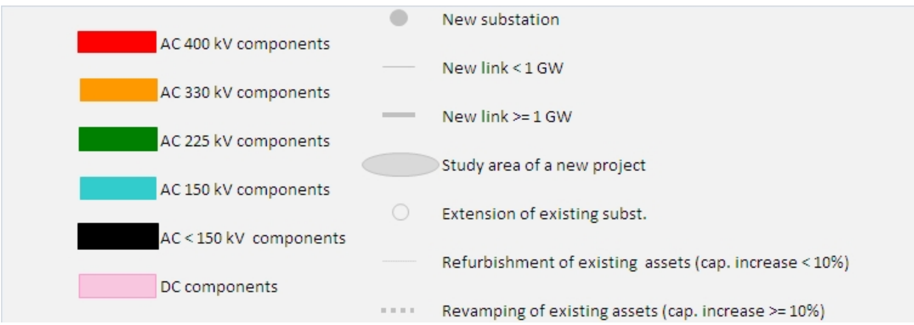


FIG. 48 MAP OF MID-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL CENTRAL EAST



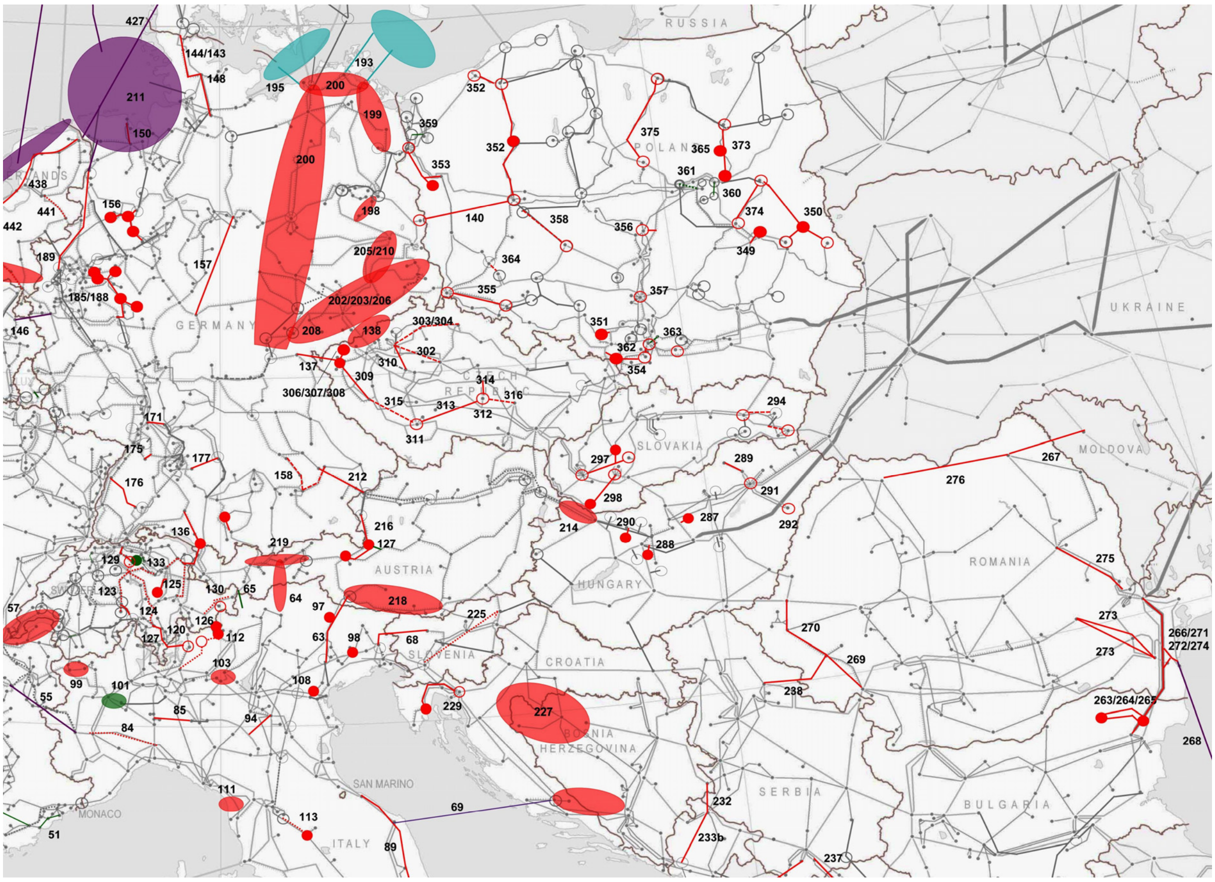
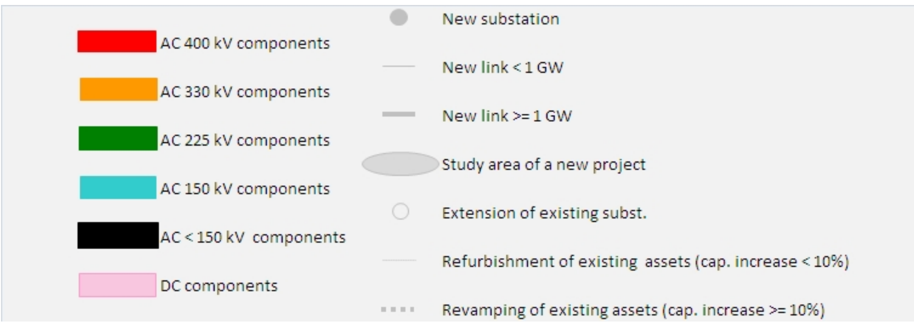


FIG. 49 MAP OF LONG-TERM PROJECTS COVERING THE REGIONAL GROUP CONTINENTAL CENTRAL EAST



6.6 Regional Group Baltic Sea

6.6.1 RG BS mid-term projects

The midterm projects shown in the map include the previously agreed "5 prioritised projects" from the Nordel studies, the proposed projects from the Multiregional plan and parts of the projects from the last Nordic Grid Master Plan.

- Skagerrak 4, HVDC link between Norway and Denmark, in parallel with the three existing links. Licensing process has been started. The planned capacity is 700 MW.
- Fenno-Skan 2, HVDC link between Finland and Sweden. On the Swedish side, a 70 km direct current overhead line will be built to a new substation Finnböle where the converter station will be placed. The planned capacity is 800 MW.
- North-South part of South-West link. A three-terminal VSC HVDC link will connect the Oslo region in Norway to Skåne in Sweden with a terminal midway in Sweden. From that terminal a 400 kV AC line will be used towards the north. The north-south part (between Hallsberg and Skåne in Sweden) has been decided, and will be in operation in the medium term. The western part (between Norway and Sweden) is expected on the long term.
- GreatBelt HVDC link, Interconnection between eastern and western Denmark to exchange windpower & regulationpower.
- Ørskog-Fardal, new link - critical for the security of supply for the Mid-Norway area, as well as the integration of renewable production in Western Norway.
- Ofoten-Balsfjord, the new line will double the capacity between Ofoten and Balsfjord (present bottleneck). The increased capacity is necessary to maintain security of supply and meet the needs from development of the petroleum industry in Northern Norway.
- Estlink 2 HVDC link between Finland and Estonia. The planned capacity is 650 MW.
- Interconnection of Lithuania and Polish transmission grids. New back-to-back convertor station 2x500MW and strengthening internal high voltage transmission grids in Poland and Lithuania. Capacity increase on the midterm 600 MW.
- NordBalt. HVDC connection between Sweden and Lithuania. New HVDC connection between Nordic and Baltic countries. The planned capacity is 700 MW.
- Kurzeme Ring. Reinforcement of transmission network in Latvian Western part, new AC 330kV transmission network construction. Kurzeme Ring is part of NordBalt project. The planned capacity is 600MW.

These projects are mainly driven by the increase of NTC (Net Transfer Capacity), i.e. market integration, and by security of supply. However, projects seldom have only one driver; for instance, the projects affecting the NTC greatly improve the possibilities of the renewable integration in the region and also in the neighbouring regions. A number of projects also help to reduce grid losses.

Kriegers Flak is an example of a proposed project that could affect also the cross border capacity while the main driver would be the integration of the wind power. Kriegers Flak is separately described in Chapter 10 of this report. The medium term plans lead approximately up to 1350 additional capacity between the Nordic synchronous system and the continental system (SK4, Great Belt, Kriegers Flak). The three projects between Baltics and the rest of the European system give up to 1950 MW additional capacity. Also the capacity between the Nordic countries will be increased.

6.6.2 RG BS LONG-TERM PROJECTS

Long terms projects shown in the map will further strengthen the grid capacity within the Nordic system, integrate the Nordic energy market to the continent and enhance the cross border capacity between Poland and Lithuania and increase the system security in the Baltic system. They will also actualise a strong grid around the Baltic Sea. There are several interconnections in planning which will improve both the RES integration and the market integration between the systems:

- Western part of the South-West link.
- Balsfjord-Hammerfest. Arctic region, Security of Supply for the Finnmark area. This will be the first 400 kV transmission line in the world to go further north than 70^{o}N. The increased capacity is necessary to meet the needs from development of the petroleum industry in Northern Norway. It will also enable RES (wind power) in Northern Norway.
- Northern Sweden-Northern Finland. Third AC line between the countries with expected benefits being the increase of NTC and the Security of Supply.
- Northern Norway-Finland. An reinforcement between countries is being studied, expected benefits Security of Supply in the Finnmark area.
- Increasing security of supply of the Baltic countries and full usage of interconnections Finland-Estonia and Lithuania-Poland (1000 MW both directions) by reinforcing internal Baltic grid in South-North axis (construction of 330 kV lines Alytus-Kruonis; Kruonis-Ignalina; Ignalina-Liksna; Harku-Sindi-Riga).

Market integration is mentioned as the main driver for most of the projects, but as for the mid-term projects also the renewable integration is made easier both in the Nordic and in the northern continental system with increased capacity between the systems. In Norway and Sweden, there is some special attention to the challenges related to the development of renewables in the northern part of the countries:

- A master plan for the north-south grid development is being prepared
- Several of the Norwegian projects will increase the north-south capacity of the Nordic grid (voltage uprating of existing lines from Nedre Røssåga in mid Norway to Fåberg in the southern part of Norway)

In addition to the projects shown in the mid-term, the long-term projects may lead up to 1400-2800 MW additional capacity (Nord.Link 700-1400, NorNed 700-1400,) between the Nordic system and the continental system and additional 400 MW capacity between the Baltic system and the rest of the European system in the long term (Poland-Lithuanian interconnection).

Some of the additional capacity will add gradually from the mid-term, since additional internal reinforcements will be finished at the long term timeframe, for example the additional internal transmission grid reinforcement in Poland improve security of supply and increase possible power transfer capacity on the Lithuanian interconnector up to 1000 MW (extra 400 MW capacity and possible exchange in both directions).

In long-term perspective the third interconnector between Western parts of Estonia and Latvia will be constructed. The interconnection will increase transmission capacity between Latvia and Estonia and provide the network platform for efficient exploitation of wind power sources in Latvia and Estonia. The planned interconnection capacity is 500-700MW.

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There are several different DC-links shown, both in the mid-term and in the long-term. For some of these projects conventional HVDC is the most likely technology, while others will most likely use the VSC technology.

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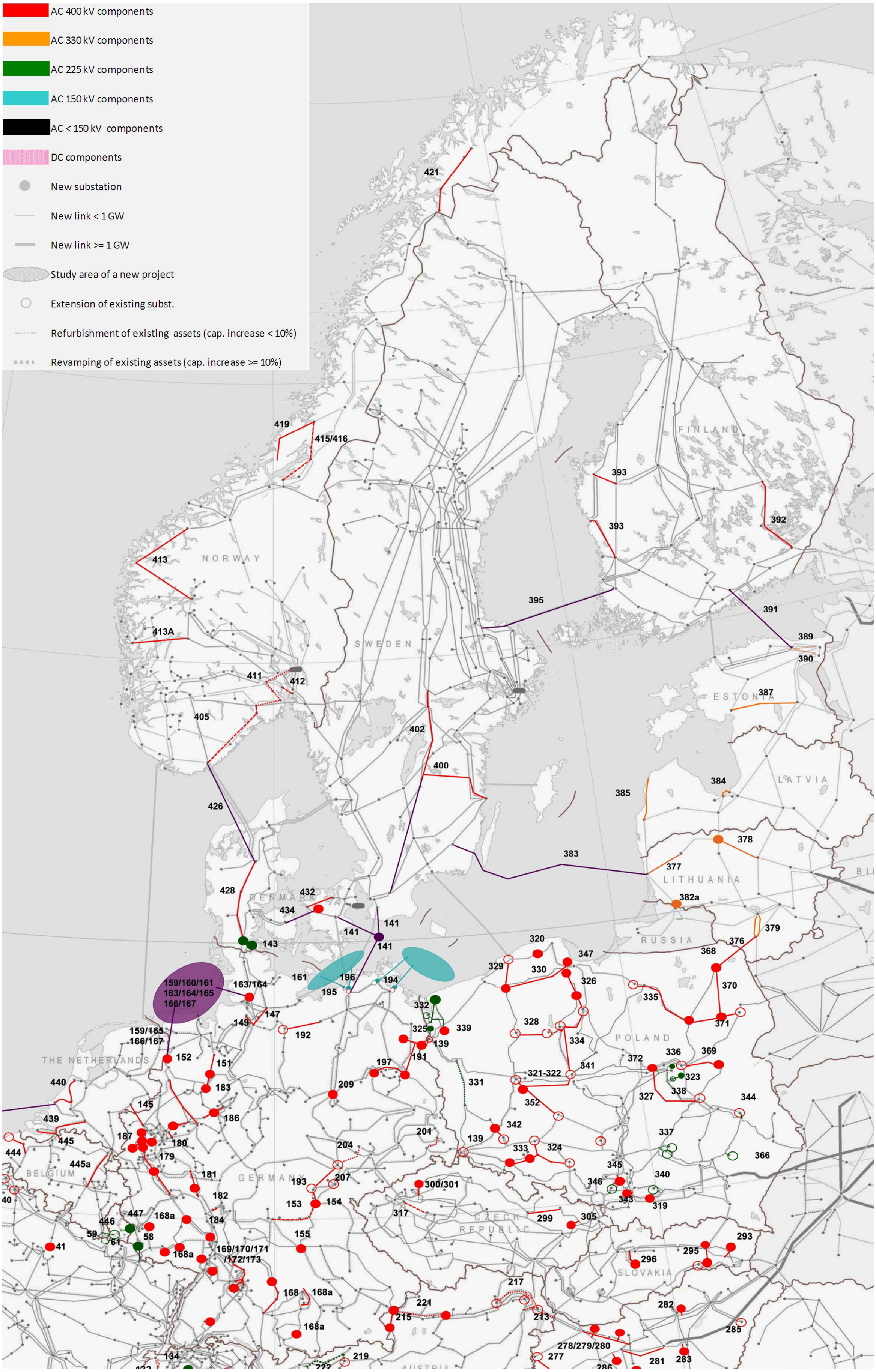

FIG. 50 MAP OF MID-TERM PROJECTS COVERING THE REGIONAL GROUP BALTIC SEA

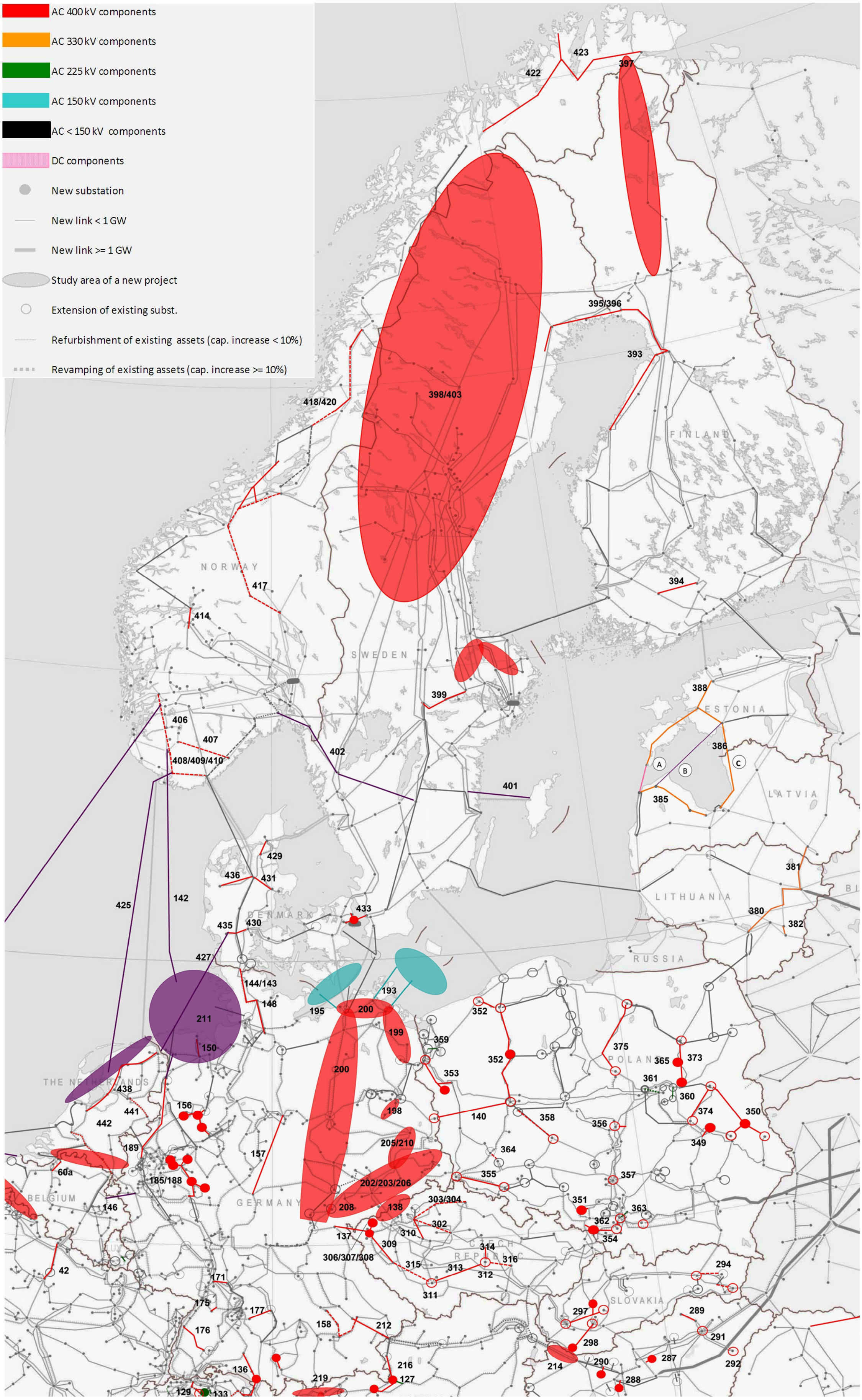

FIG. 51 MAP OF LONG-TERM PROJECTS COVERING THE REGIONAL GROUP BALTIC SEA

6.7 REGIONAL GROUP NORTH SEA

As stressed in the previous Chapter 5, the TSOs within the North Sea Region must plan and implement projects aimed at maintaining security of supply, the large-scale integration of renewable energy sources and the development of the integrated European electricity market.

6.7.1 MID-TERM PROJECTS

The integration of the internal electricity market needs to increase the exchange capacities between countries. TSOs in the North Sea Region are conducting seven interconnection projects in the area: between the United Kingdom and The Netherlands, between Germany and the Netherlands, between Luxembourg and Belgium, two between Ireland and the United Kingdom, between France and Belgium and between Norway and Denmark.

Other internal grid reinforcement projects, such as Kasso-Tjele in Denmark, the replacement of conductors with HTLS ones on Warande-Weppes-Avelin in France, the installation of a second circuit on the existing line between Gramme and Massenhoven in Belgium or several internal reinforcements in Germany, will also remove bottlenecks limiting power exchanges, transmission of local generation and improve market integration.

The connection and integration of renewable energy source (mainly wind) plants leads TSOs to plan and implement major infrastructure projects to reinforce their internal grid. Such development can be found across Germany, across Scotland, at the Belgian coast and at The Netherlands coast.

Connecting new conventional production units drives a large number of internal projects within the North Sea Region, as for examples the French project Cotentin-Maine, the so called “Brabo” project in the harbor of Antwerp. Such projects arise in northern France, north and north eastern Belgium, The Netherlands, the north of Germany, the United Kingdom and the south of Ireland.

Some internal projects are needed to maintain security of supply in the face of demand growth and are planned around Luxembourg, along the coast of Netherlands and in south-east and north-west of Ireland.

6.7.2 LONG-TERM PROJECTS

In the long run, in addition to the above mentioned internal projects, the will to develop an integrated European electricity market and the emergence of major power flows across Europe, as a result of the integration of renewable energy sources or the connection of new conventional production units, bring TSOs to reinforce existing or to develop new interconnections in the Region (mainly at 400 kV). Every border of the continental part of the North Sea Region (Luxembourg, Belgium, France, Netherlands, Germany and Denmark) is affected by some projects aimed at increasing the cross-border capacity. The exact design of most of these projects is still under study.

However, next to those projects making use of AC conventional technology, the most striking impression, when one looks to the maps is made by quite numerous new DC subsea cables that are planned to enhance the interconnection between Ireland, United Kingdom, France, Belgium, the Netherlands, Denmark and Norway. In that matter, developing an offshore grid, connecting countries of the North Sea Region and offshore wind farms, and carrying out the necessary on-shore reinforcements, are major challenges. In addition to the reinforced onshore grid, the offshore grid can be seen as a key building block to develop the European energy market and to exchange renewable energy among European countries. It will connect different wind production areas and power systems including Norwegian hydro system. ENTSO-E's preparation for this long term vision is based on close coordination between TSOs in order to design this network, to support R&D program and to make technology standardization possible. DC Interconnectors today in planning or realization phase will be part of this future offshore grid.

The feasibility of offshore-grid solutions is being investigated by ENTSO-E's North Sea Regional Group in economical and technical perspectives, as supported by the North Seas Countries Offshore Grid Initiative Political Declaration, on December 7th 2009, joined by Norway since February 2nd 2010.

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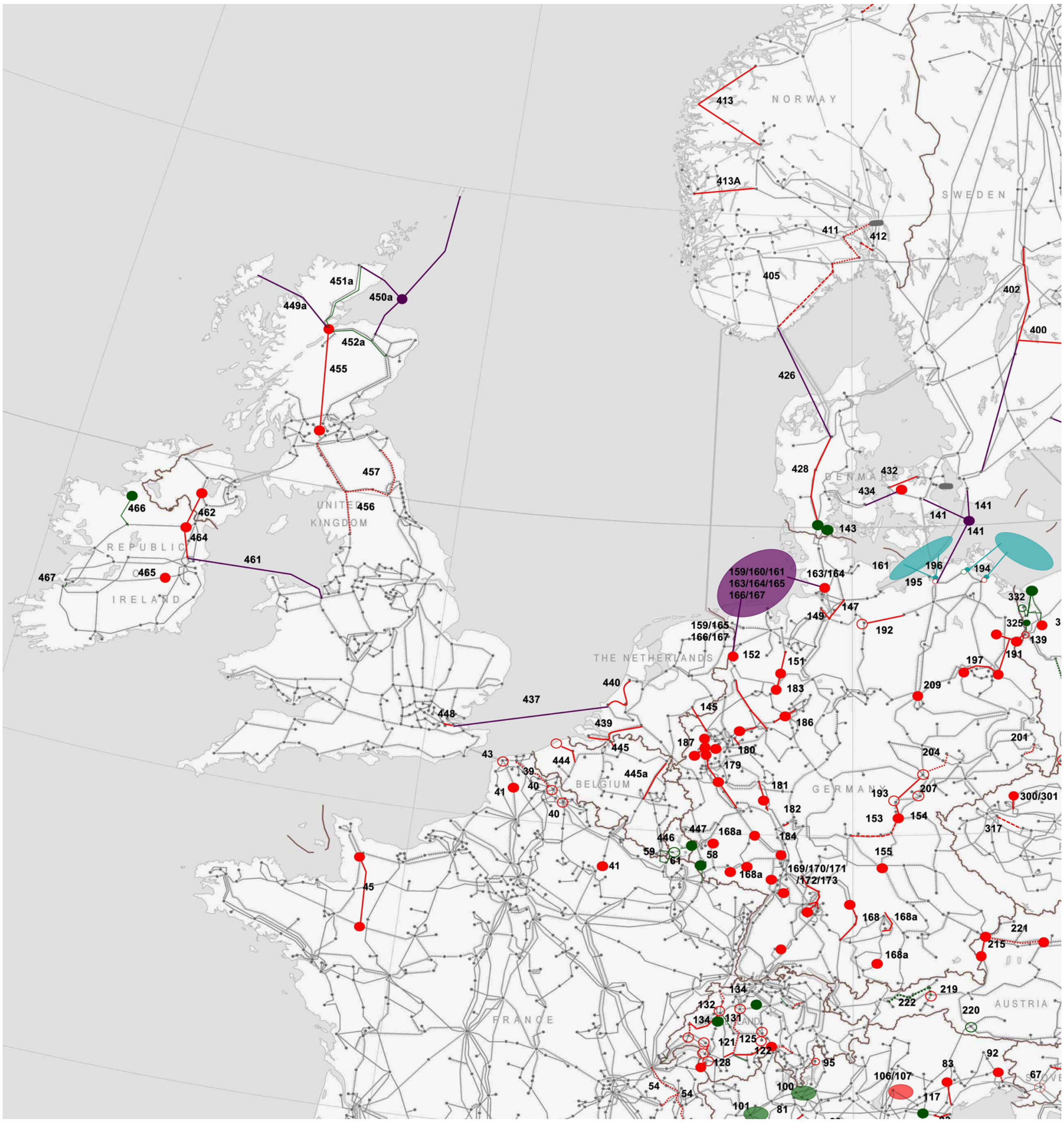
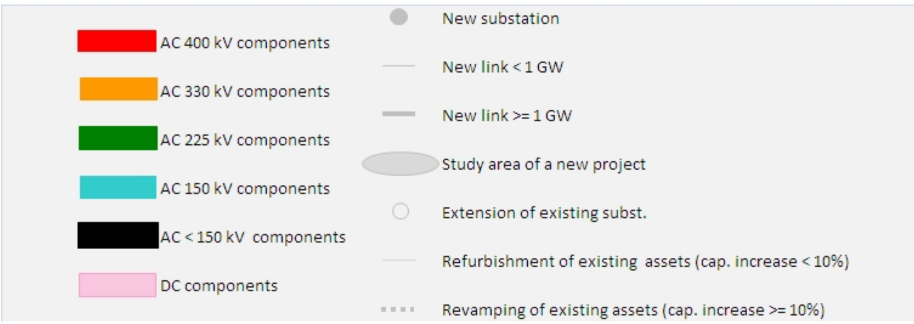


FIG. 52 **MAP OF MID-TERM PROJECTS COVERING THE REGIONAL GROUP NORTH SEA**



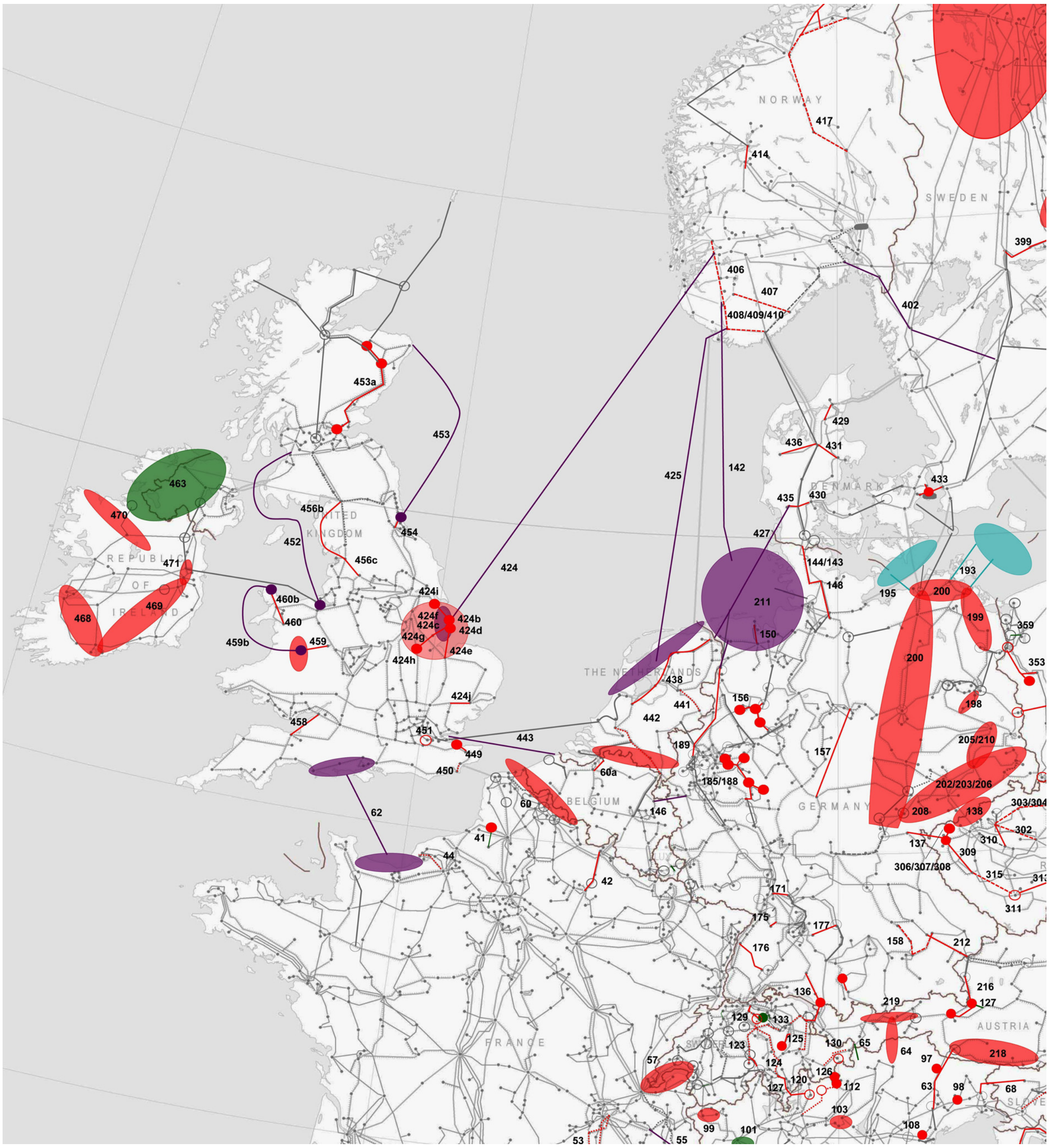


FIG. 53 MAP OF LONG-TERM PROJECTS COVERING THE REGIONAL NORTH SEA

- AC 400 kV components
- AC 330 kV components
- AC 225 kV components
- AC 150 kV components
- AC < 150 kV components
- DC components
- New substation
- New link < 1 GW
- New link >= 1 GW
- Study area of a new project
- Extension of existing subst.
- Refurbishment of existing assets (cap. increase < 10%)
- Revamping of existing assets (cap. increase >= 10%)

6.8 CONCLUSION

6.8.1 A LARGE NUMBER OF PROJECTS

In spite of increasing complexity in projects procedures, TSOs do foresee a large number of projects in the coming 10 years.

If the perspectives of network development in the coming ten years in Europe must be summed up with one simple indicator, the total length of new and refurbished power lines can be considered[32]:

TABLE 7 LENGTH OF NEW AND REFURBISHED POWER LINES UNTIL 2020 (PROJECTS OF EUROPEAN SIGNIFICANCE)

Project tehcnology	Total Length Km	Length of new connections Km	Length of upgraded connections Km
AC	32500	25700	6900
of which >300kV	*29600*	*23200*	*6400*
DC (mainly subsea)	9600	9600	0
TOTAL	**42100**	**35300**	**6900**
of which in mid-term	*18700*		

Remark: These figures only account for projects "of European significance", i.e. reported in Appendix 1 to the present report, thus not accounting for all transmission projects TSOs conduct.

Globally, about 42100 km of network routes will be either build or refurbished:

- With about 23200 km, new OHL 400kV AC routes accounts for more than half of the total reported.
- On the other hand, about 25% of total are new DC links (almost all sub-sea or underground cables), The refurbishment of 6800 km of AC existing lines is also planned, i.e. more than 15%.

New 400 kV AC OHL projects are in technical, economic, and ecological terms the most efficient solution for long distance electricity transmission. Indeed, such reinforcements integrate straightforwardly into the existing grid since this technology has been the standard for a long time. In addition, other solutions are implemented to accommodate specific situations when necessary.

Out of the 42100 km, TSOs plan to complete about 18700 km in the coming five years, and 23400 km in the next five-year period. Of course, a lot of long run projects are still under study and their length is not always provided, so that the latter figure is probably underestimated.

In Fig. 54, the new or refurbished transmission lines are classified according to their contribution to the EU Energy Policy objectives. It must be noted that the total number of kilometres of lines reported in this figure is about double the number of kilometres physically constructed (as in Table 7) as a single project may respond to several needs at once. This is

[32] Lengths are reported only for about 90% of new lines. In particular, this information is missing for a great share of projects still under study. However, the compiled figures in this section look representative enough to analyse trends.

an illustration of the network effect (the value of the network is greater than the sum of the values of its components).

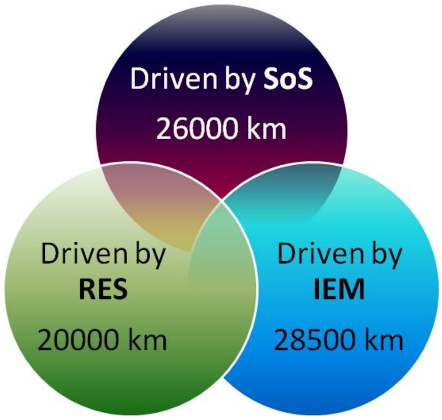


FIG. 54 MAIN DRIVERS FOR INVESTMENT IN NEW OR REFURBISHED POWER LINES (PROJECTS OF EUROPEAN SIGNIFICANCE)

6.8.2 TRANSMISSION CAPACITY INCREASE

The set of projects enables some major transmission capacity increase in the coming ten years compared to the present situation (see Chapter 2). The following maps attempt to provide a synthetic overview of such major transmission capacity increase to be expected, for the coming 5 years, and then for the next 5-year period.

The purpose of many transmission projects is to continue to ensure a high security of supply in Europe although dramatically changes in the generation structure are expected in the future (see Fig 19 and 20). Because the increase of RES is mostly located and concentrated in areas which are far away from the consumption centers the distance between generation and load is increasing continuously and this is actually a main driver for the development of the European transmission system. Many other projects allow also the connection and transmission of power of new power plants (not only from RES) which are sometime connected near to national borders. Those projects have mostly also an influence on the commercial exchange capacity between those countries.

The following maps try to give an indicative overview of the expected increase of cross border exchange capacities in Europe. It derives from all information available in Appendix 1 to the report. The reader is reminded that there is no direct relation between the thermal rating of new individual circuits and the resulting cross border transfer capability increases, as stressed in §2.2.2. Although the maps are hence simplified indicative outlooks, they illustrate that cross border transfer capability is scheduled to improve on almost all borders in Europe. We put attention on the fact that the indicated increase is depending on many factors (especially load flow situation and generation dispatch in Europe) and is not binding. Increases of transfer capability internally to countries, and/or accommodating new generation or load increase are not shown on these maps.

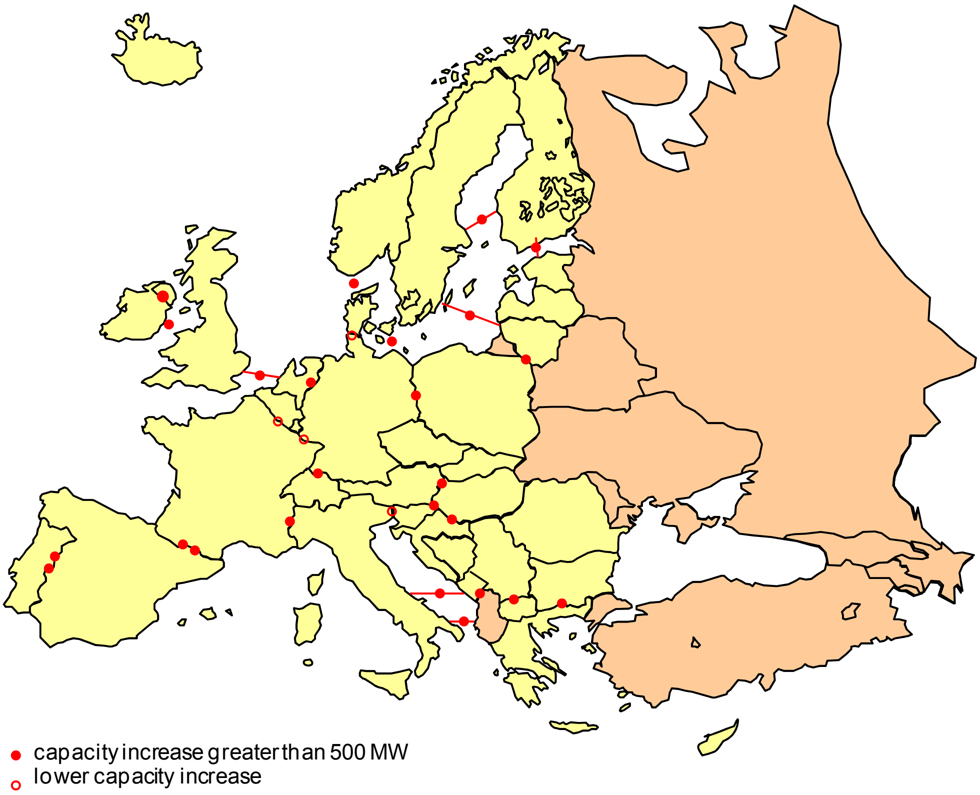


FIG. 55 MAIN TRANSMISSION CAPACITY INCREASE, MID-TERM.

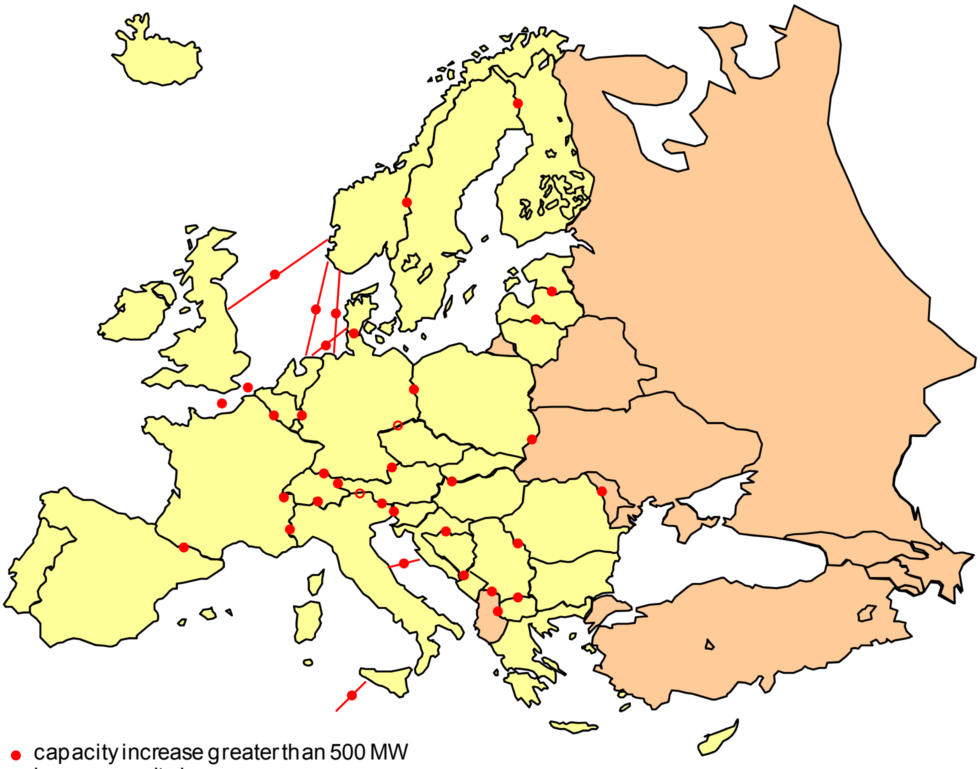


FIG. 56 MAIN TRANSMISSION CAPACITY INCREASE, LONG-TERM.

6.8.3 MERCHANT LINES

This section gives a specific focus on new interconnectors, which are granted an exemption by regulatory bodies in accordance with Article 7 of EC Regulation 1228/2003[33] and which are commonly called "merchant lines". Such exempted assets do not fall into the regulated asset base, and thus their costs are not recovered through the regulated grid access tariffs; the investment must not be approved by NRAs through approval of regulated assets but is acknowledged through the exemption decision.

According to the regulation, exemption may be granted to a new interconnector project, provided that this project responds to the conditions defined in article 7.1 of EC Regulation 1228/2003[34].

Regulated investment is the rule, and there are of course very few of exempted lines in the total number of transmission projects. However, it is not easy to make a review of all of them, and give a clear synthetic picture. Especially:

- Some presently exempted assets may become ultimately regulated ones as the exemptions are granted for a certain duration only;

[33] Article 17 of EC Regulation 714/2009 shall apply from 3 March 2011.

[34] Direct lines, as they are another specific case, are not dealt with here. (they are defined under Article 1 of Directive 2003/54/CE as "*either an electricity line linking an isolated production site with an isolated customer or an electricity line linking an electricity producer and an electricity supply undertaking to supply directly their own premises, subsidiaries and eligible customers*").

- Partial exemption may be granted, a project being exempted in one Member State, and not in the neighbouring one;
- Regulated TSOs may develop directly or indirectly (i.e. via subsidiaries, as a consortium member) exempted assets;
- Promoters of exempted lines are usually not TSOs, and to ensure the confidentiality of commercial sensitive information, related projects – possibly known to TSOs, whom they applied for connection to – cannot be mentioned in the present report.

When projects reported in Appendix 1 can be reported as exempted one, this information is to be found with appropriate comments in the last column of the table.

Although exemptions were proposed as an additional possible recourse for grid development, complementary to the regulated process, the co-existence of regulated and exempted projects may cause some serious consistency issues, making the grid development process more complex. Among these:

- Exemption is granted by NRAs, and nothing prevents today the same asset to be granted an exemption in one Member State and not in another, making the organisation of fair non-discriminatory third party access a legal issue. Regulation of non EU countries must also be accounted for, whenever required. More generally, the status of such assets must be made clearer and harmonised among EU countries by regulatory authorities.
- The perimeter of exempted investment must then be devised carefully so as to achieve overall social welfare, with a fair costs and profits sharing among regulated and exempted activities. Especially the appropriate share investments costs for upstream reinforcements of regulated parts of the grid, which would be required to connect some new exempted tie-line, should be covered by incomes generated from new cross-border capacity, a priori falling out of the regulated perimeter.

The public consultation shows concerns from stakeholders to include projects in the ENTSO-E TYNDP which do not stem from ENTSO-E members, in particular – but not only – merchant lines developed by third parties (e.g. NorGer project). For the next issue, process and criteria will be developed so as to provide proper inputs to the next release in a non-discriminatory manner.

6.8.4 INVESTMENT COSTS

Reliable investments costs figures are available for relatively mature projects. For a lot of long run projects still under study costs are not yet known. Project uncertainties or a still wide range of technical options (routes, technology, etc.) for some projects make investments costs information only available as costs ranges, all the wider that the project is expected to be completed at a farther date. More solid information can be compiled when considering a shorter horizon and aggregated figures. The following table presents the amount of money TSOs will spend for projects of European significance, expected to be completed in the coming five 5-year period, and presently either under construction or in the “design and permitting” phase:

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TABLE 8 INVESTMENT COSTS OF TRANSMISSION PROJECTS OF EUROPEAN SIGNIFICANCE TO BE COMPLETED BETWEEN 2010-2014

Perimeter	Investments (billion €)
RG North Sea	12 to 14
RG Baltic Sea	11 to 13
RG CCS	11 to 12
RG CCE	8 to 9
RG CSW	6 to 7
RG CSE	4 to 5
Total ENTSO-E	**23 to 28**

Remarks:

- The above figures do not take into account expenses foreseen between 2010 and 2014 for projects completed at a later date;
- As a few countries belong to more than one RG, it is counted in every of them and the ENTSO-E total is not the sum of the six overlapping regions.
- These figure only account for projects "of European significance", i.e. reported in Appendix 1 to the present report, not accounting thus for all transmission projects TSOs conduct.

Therefore, in the coming five years, investments in transmission projects of European significance amount hence about 23 to 28bn€.

With increasing lengths of DC, subsea, underground and more sophisticated projects, the unitary cost of new power routes also tends to increase significantly. For instance, the total projects costs for the period 2015-2020 are on average 30% higher than the projects developed between 2010-2015. This relative increase is due to the higher number of underground and subsea cables that will be developed during 2015-2020.

Moreover, unitary costs of individual projects show great discrepancies from one to another. For instance, when it was proposed to implement the new France-Spain interconnection in Eastern Pyrenees via DC underground cable instead of double-circuit 400 kV OHL, an increase of the cost of the project by a factor 5.5 to 8 had to be accepted by the TSOs[35]. Grid investment costs can thus sometimes now compare to generation investment costs on a rough per MW or MWh basic, while in the past transmission projects costs showed always a smaller order of magnitude compared to generation projects.

6.8.5 RESILIENCE ISSUES

HV investments are expensive infrastructure projects, with a long lifetime (around 40 years), setting precedence for coming projects and requiring years to be carried out. Both in order to

[35] European Coordinator Mario Monti Report – available at: http://ec.europa.eu/energy/infrastructure/tent_e/doc/high_voltage/2008_06_high_voltage_report_fr.pdf.

avoid stranded costs and to meet grid users' expectations on time with appropriate solutions, TSOs check the resilience of their projects. This assessment is performed in 4 directions:

- Sustainable, safe operation: investment should participate to an improved quality of service and not put the reliability of the system at risk;
- Economic performance: investments should prove useful and profitable in as much as possible future situations, bringing more benefits to the European population than they cost;
- Technical sustainability: as long lasting expensive infrastructure components, investments should take advantage of technology evolution so as to optimise their performance and ensure they do not to become obsolete in the course of their expected lifetime;
- Compatibility with longer run challenges looking of 2030 or 2050: present projects must be appropriate steps to meet future challenges and fit into wider and longer term perspectives.

The following chapters provide a more detailed description of the resilience requirements for every of the four directions, and check as far as possible in this first edition of the TYNDP, the resilience of the presented set of projects.

HIGHLIGHTS:

- 42100 km of transmission projects of European significance either new routes or refurbishments in the coming 10 years.
- 23 to 28 billion € invested for transmission projects of European significance completed in the coming 5-year period.
- The main technology remains 400kV AC OHL but other technical solutions are being implemented in specific situations: DC links, underground cables, subsea cables, etc.

[7] TECHNICAL ANALYSES AND CRITERIA

As described in the Chapter 6, new and more sophisticated types of generating machines and transmission equipments – with specific behaviour, and possibly design constraints or different sensitivity to faults – are being connected to the grid. Moreover, the European system enlarges to neighbouring countries.

New dynamics and interactions within the system may therefore appear. TSOs must ensure that new grid structures and components at least support – and possibly improve, and do not jeopardise – the high reliability standards the grid supplies to users.

The main objective of transmission system planning is to ensure, with respect to mid and long term horizon, the development of an adequate transmission system which:

- Ensures safe system operation and provides a high level of security of supply;
- Contributes to a sustainable development, by allowing for the integration of renewable energy sources;
- Facilitates grid access to all market participants;
- Contributes to social welfare through internal market integration and harmonization.

After recalling briefly some general principles of grid planning, this chapter deals with the technical part of grid planning, from network studies to project engineering studies, that TSOs perform to ensure that the future operation of the grid will be at least as reliable as – or even more reliable than – it is today. Project economic assessment and prioritisation criteria are addressed in Chapter 8.

7.1 GRID PLANNING PRINCIPLES

Transmission system development focuses on the long-term preparation and scheduling of reinforcements and extensions to the existing transmission grid.

The planning process begins with the definition of scenarios, depicting uncertainties on future developments on both the generation and demand sides, as well as a number of alternative grid operational conditions and development states that have to be considered to ensure the secure and efficient operation of the transmission grid in the future. In order to incorporate these uncertainties in the planning process, a number of cases are built taking into account forecasted future demand, mix of generating units and cross-border power exchange patterns. Thus, a large number of representative operational cases, relevant for assessing overall behaviour and dimensioning of the transmission system are taken into account.

Selected cases are then analysed, using general methodologies for system analysis and evaluated based on standard technical criteria. Basically, they entail simulations of a merit-order generation dispatch to supply load, and load-flow computations (i.e. a dispatch of power flows on grid components) in various contingency conditions. Simulation results are checked regarding a whole range of criteria. This process is further developed in Section 7.2.

When planning criteria are violated at the previous stage, mitigation measures are proposed, tested though additional simulations, evaluated and prioritized. The engineering process of solutions to identified constraints is dealt with in Section 7.3.

The general methodology implies thus scenario definition, network studies and identification of possible candidate solutions, briefly described in Fig. 57:

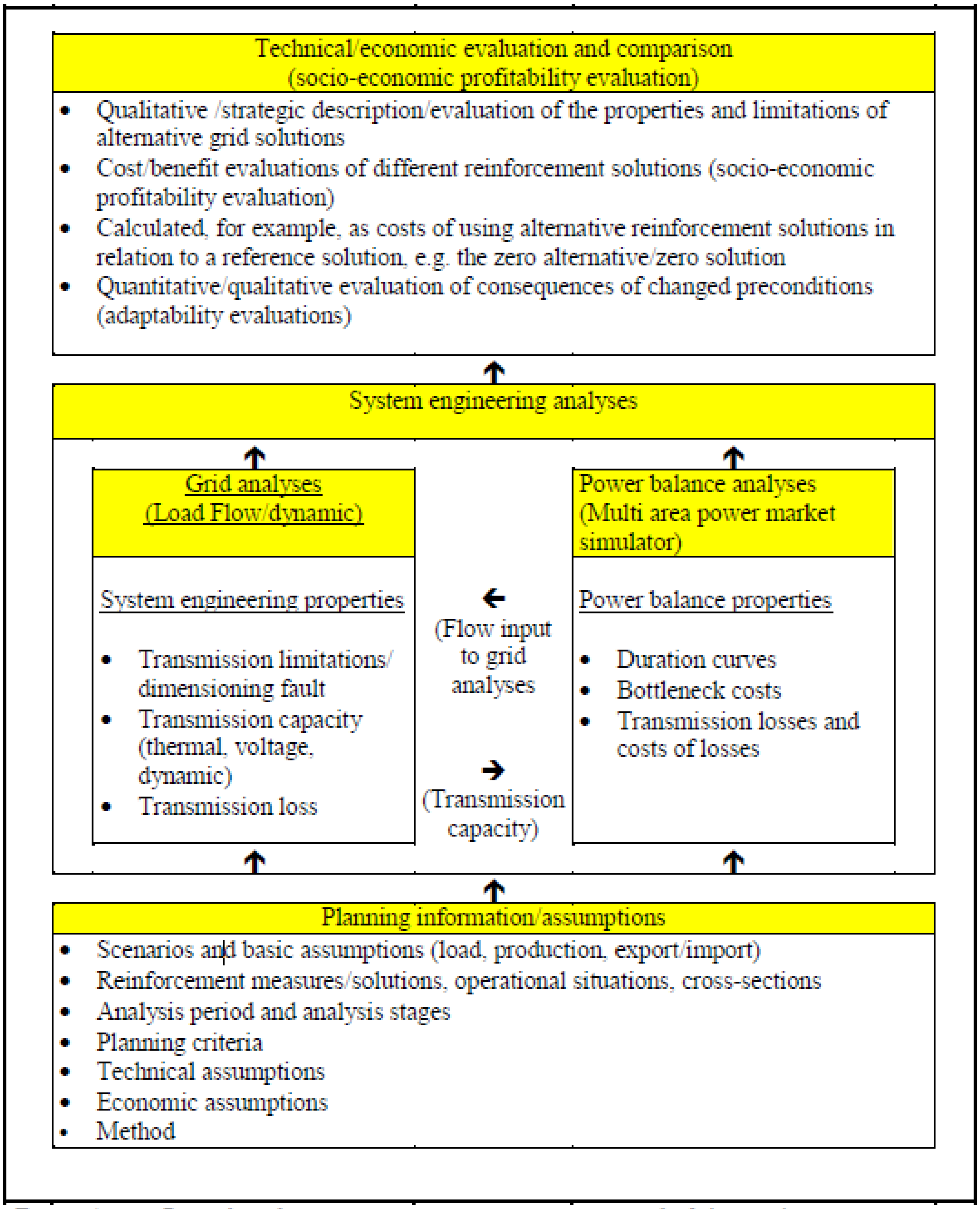

FIG. 57 ILLUSTRATION OF THE OVERALL GRID PLANNING PROCESS

7.2 TECHNICAL CRITERIA AND METHODOLOGY OF NETWORK STUDIES

There are several fundamental reasons why TSOs must consider uncertainty and therefore risk in transmission evaluation. First, changes in future system conditions can affect benefits from transmission expansion significantly. Historically the relationship between transmission benefits and underlying system conditions was found many times to be nonlinear. Thus, evaluating a transmission project based only on assumptions of average future system conditions might greatly underestimate or overestimate the true benefit of the project and may lead to less than optimal decision making. To make sure TSOs fully capture all impacts the project may have, they must examine a wide range of possible system conditions. Second, historical evidence suggests that transmission upgrades have been particularly valuable during extreme conditions.

Furthermore it takes much longer to get a new transmission line approved and built (minimum 5 years and in most cases more) than similar procedures for new generation facilities (e.g. gas fired power plants in only 2-3 years). Therefore the development of the transmission grid always lags behind the development of generation. This can only be taken into account by using different scenarios.

Methodologies and criteria developed by TSOs focus on risk assessment and mitigation, building both on their past experience and scenarios to envisage future situations. They assess the resilience of the system in whatever situation it may have to face: high/low load, generation dispatch patterns, adverse climatic conditions (defined in the scenario phase), contingencies, etc.

7.2.1 Grid Analysis

7.2.1.1 Perimeter of a Study

Depending on the scope of the study the geographical perimeter of the analysis is defined. As the electric system in Europe is highly meshed it is necessary to take into account the whole grid of a synchronous system for the grid analysis. With increased market integration and stochastic, climate-dependent RES generation, it becomes more and more important to use scenarios for boundary conditions with respect to power exchanges with neighbouring systems and focus on the variation of local parameters.

Different perimeters can be chosen in order to better focus the scope of the analysis, depending on the goal of the assessment and of the wideness of the Transmission System Area involved.

- Pan-European level : e.g. projects who involve the whole European network, such as EWIS and MedRing, that have to take into account grid reinforcements in all Europe;
- Regional European level (involving more than one National Transmission System) : e.g. projects who involve single interconnections, such as a new single circuit Extra High Voltage OHL between two countries;
- National level: e.g. projects that do not have a significant impact on the interconnections, such as a new single circuit Extra High Voltage OHL very far from a country's border or a transformer;
- Sub-national National level: e.g. projects that do not have an impact on the whole National Transmission System, but only on a small part of it, mainly aimed at satisfying local requirements.

Multilateral studies and coordination have been becoming the rule for a few years. Before the establishment of ENTSO-E, TSOs already used common data exchange tools in the framework of the former associations, and launched ad hoc cooperation frameworks. Good examples of such multilateral studies, are the Nordic Grid Master Plan (introduced in Section 1 of Appendix 3) or the trilateral study between Austria, Germany and Switzerland, building on UCTE network models, briefly depicted in Section 1 of Appendix 4.

7.2.1.2 INVESTIGATION OF BASE CASE POWER SYSTEM TOPOLOGY

Data used for the analysis are determined by the planning scenarios. For any relevant point in time, the expected state of the whole system, "with all network equipment available", forms the basis for the analysis ("Base case analysis"). Furthermore, for the selected scenario, varying states for certain parts of the system can be considered.

Different types of events (failures of network elements, loss of generation, etc.) are considered depending on their probability of occurrence.

7.2.1.3 N-1 CRITERION FOR GRID PLANNING.

The N-1 criterion is satisfied if operational security of the power system is not affected by the loss of a single element within the network, such as:

- Generator;
- Transmission circuit (overhead, underground or mixed, AC or DC);
- Transmission transformer;
- Shunt device;
- Network equipment for load flow control (phase shifter, FACTS, …).

This includes transient, dynamic and steady-state stability for both frequency and voltage conditions. The N-1 criterion is systematically assessed taking into account each single contingency of one of the elements mentioned above.

7.2.1.4 RESILIENCE TO OTHER SEVERE CONTINGENCIES

More severe contingencies than those contemplated in the N-1 criterion can be assessed in some cases defined by the TSOs based on the probability of occurrence and/or the severity of consequences.

- Examination of rare, but severe failures. In some cases, rare but severe failures, like those leading to the loss of a busbar or busbar section, or multiple independent failures, may be assessed in order to prevent serious interruption of supply within a wide-spread area. This kind of assessment is done for specific cases chosen by the TSO depending on probability of occurrence and consequences.
- Examination of multiple failures due to common cause. The so-called common-mode failures include the failure of several elements due to one single cause. The potential outage of lines with double or multiple circuits will most probably become more relevant over the next years, as more and more power lines are going to be bundled on already existent routes (several circuits on the same tower) and as conductors with higher thermal ratings are going to be used, allowing for higher power flows.

Such developments increase the probability of simultaneous multiple circuit loss as well as the severity of the consequences, and thus need to be investigated.

- Failures combined with maintenance. Certain combinations of possible failures and non-availabilities of transmission elements are considered in some occasions. Maintenance related non-availability of one element combined with a failure of another one are assessed. Such investigations are done by the TSO based on the probability of occurrence and/or based on the severity of the consequences, and are of particular relevance for network equipment that may be unavailable for a considerable period of time due to a failure, maintenance or overhaul.

7.2.2 EVALUATION OF RESULTS

The main indicators are checked to verify whether the consequences are acceptable:

- Thermal load limits. The base case and the case of failure must not result in a permanent excess of the permitted rated load of the network equipment. Depending on the weather conditions (different permitted thermal loads for overhead circuits in winter and summer periods) and further equipment specifications (e.g. certain transformers have a permitted rated load larger than 100%), possible deviations may be exceptionally tolerated in single cases. The overloading of lines, cables or transformers can be admitted to a certain degree when these overloads can be eliminated by operational countermeasures within a defined time interval.
- Voltage range. The base case and the case of failure shall not result in a voltage collapse, nor in a permanent shortfall of the minimum voltage level of the extra-high and high voltage grids, which are needed to ensure acceptable voltage levels in the subordinated medium and low voltage grids. European standards as well as national regulations are to be met. The base case and the case of failure shall not result in a permanent excess of the maximum admissible voltage level of the extra-high and high voltage grids defined by equipment ratings. Temporary over voltages should be within equipment ratings.
- Cascade tripping. A single contingency must not result in any cascade tripping (i.e. further tripping of elements due to system protection schemes after clearance of the primary fault). Cascade tripping usually leads to a serious interruption of supply within a wide-spread area.
- Frequency range and stability conditions. Transient and steady-state stability are assessed when necessary in order to detect (potentially) instable system states that could lead to regional or large black-outs. These phenomena appear in particular when the grid is or becomes too weakly meshed so as to “dilute” the immediate impact of a disturbance. In this respect, the synchronous interconnection of two neighbouring systems via one or very few connections must be scrutinised in the study phase to ensure a safe and efficient operation of the whole system. Section 3 of Appendix 4 sketches the complexity of the studies to carry out.
- Short-circuit currents. Stronger, highly meshed networks prove more stable but must face risks of higher short circuits currents. The equipment rating for short-circuit current shall not be exceeded. Maximum symmetrical short-circuit currents are evaluated in every bus of the transmission network in the base case. In some cases the initial single-phase short-circuit current may be higher than the symmetrical short-circuit current and has to be considered then instead.

Acceptable consequences depend on the type of event that is assessed. For more probable events, maximum thermal load of elements and busbar voltage profiles in the admissible ranges are defined as acceptable conditions. In the case of less probable, but more severe, events, acceptable consequences depend on the extension of the incident, and can include a limited loss of load.

7.3 ENGINEERING OF MITIGATION MEASURES

Methodologies to identify possible mitigation measures to a network constraint largely vary depending on the situation at stake.

Basically grid design mitigation measures fall into one of the following three categories:

- System protection schemes;
- Upgrading of the existing components;
- Installing new grid components, and possibly creating new transmission routes.

These are ranked from the easier to implement – possibly sufficient, but often a temporary solution as the situation may worsen – to more powerful, long-lasting solutions – and also more complex to implement. Especially in situations where the need of transmission capacity is expected to increase in the long-term future it has to be checked if the measure is sustainable.

As the acceptance of new transmission assets is usually low, TSOs are encouraged to take advantage of existing power lines corridors or other infrastructure route. However, to reduce the risk of large common mode faults, the size of the substations should be acceptable in relation to the power in-feed and the number of power lines in one route should not be too high.

7.4 CONCLUSION

When planning, TSOs systematically perform complex network and engineering studies to ensure the infrastructure can be operated reliably. These studies aim at ensuring every project at least supports – and possibly improves, and does not jeopardise – the high service standards the grid supplies to users.

Network studies methodologies and criteria are generic enough to remain relevant to measure consequences of whatever event on the grid. (A key issue in this respect is the availability of input data to devise sound scenarios – realistic wind profiles, electrical characteristics of devices and power generation facilities connected to the grid, etc.).

Basically, every project depicted in Appendix 1, unless possibly some still under study at an early stage, has passed successfully this technical analysis. In this respect, unconventional ones, involving innovative technology are being scrutinised (see Chapter 9).

Nevertheless, further investigations are needed as the scenarios for generation patterns develop and change significantly. In addition new developments on the technology side are expected. Especially new specific long run larger scale issues as connection of large amounts of off-shore wind generation, (un)balanced wind situation in North Sea versus southern Europe, massive imports of solar generation from northern Africa, and harmonious operation of numerous active power devices (PST, DC connections…) in a meshed grid will

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have to be assessed. Some of these issues go beyond what a single TSO can assess by itself, therefore the corresponding studies will be conducted at least at regional level and, as a further step, as far as needed, at pan-European levels.

HIGHLIGHTS:

- Systematically when planning, TSOs perform complex network and engineering studies to ensure the infrastructure can still be operated reliably.
- The dynamics and possibly new interactions between system components in the future must be scrutinised so as to anticipate appropriate mitigation measures.

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[8] ECONOMIC ANALYSIS AND PRIORITISATION CRITERIA

8.1 GENERAL PRINCIPLES

Socio-economic assessment of a project is carried out in order to evaluate its economic viability and overall impact. TSOs systematically undertake such studies. In general, the assessment takes into account the foreseen investment costs and benefits of the new projects. The investment costs are subject to uncertainties concerning the permitting processes or other supply chain considerations, and include capital/operational cost, the salvage value of the assets, etc. On the other hand, benefit evaluation is a more demanding exercise since for example some technical improvements (for Security of Supply) or pursuing policy objectives (integration of renewable sources) are difficult to quantify. Fig. 58 shows a non-exhaustive set of criteria that TSOs consider when evaluating an investment project.

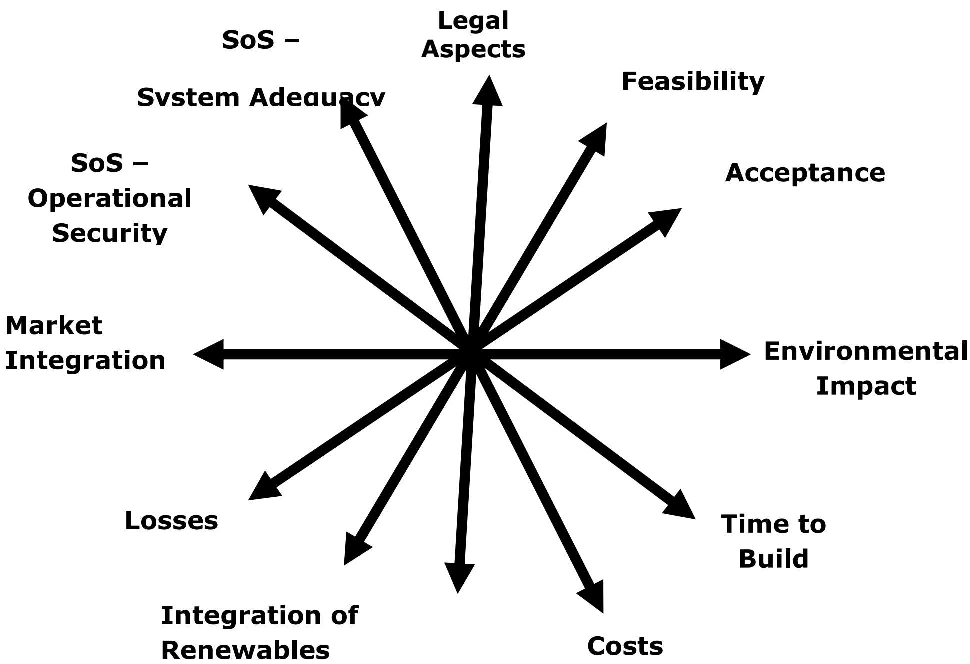

FIG. 58 OVERALL MULTI-CRITERIA APPROACH

The quantifiable benefits are then used for constructing standard indexes that determine the relative socio-economic value for society of each project. These indexes nevertheless depend on the regulatory regime and TSOs internal methods for cost calculation. Fig. 59 shows a simplified workflow of the overall approach extracted from the Nordic Grid Master Plan[36].

[36] Nordic Grid Master Plan 2008, http://www.entsoe.eu/_library/publications/nordic/planning/.

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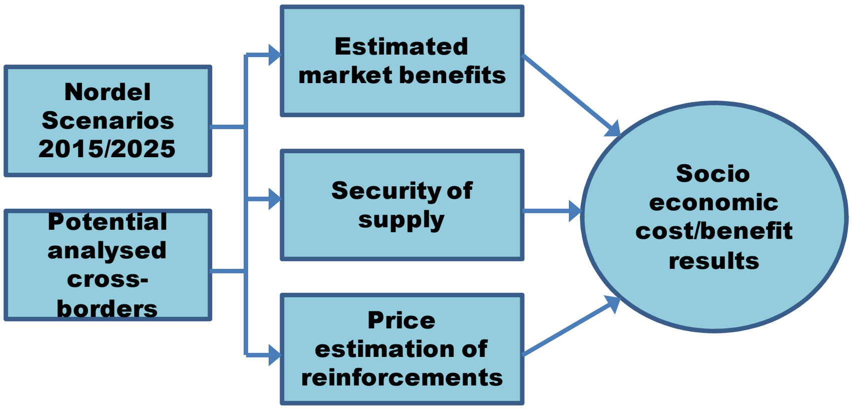

FIG. 59 WORKFLOW IN SOCIO-ECONOMIC ANALYSIS OF REINFORCEMENTS

8.2 PRIORITY CRITERIA FOR GRID DEVELOPMENT PROJECTS

Some aspects of the evaluation of projects can only be done in a qualitative way. On the other hand, quantitative evaluations are real challenges in terms of implementation. The integration of RES, the integration of the European markets, the environmental impact assessment and the analysis of public acceptance are very complex matters and are usually addressed in a project by project basis.

There is no unique method to evaluate the criteria shown in Fig. 58. In theory, common Market simulations and common grid calculations could give a quantitative hint regarding the impact of projects on Market Integration and Security of Supply. Most of the other aspects are subjective matters (like Environmental impact and public acceptance) and will always require subjective “ad hoc” methodologies. Those methodologies have to be assessed and agreed before being used as common criteria so that the right priorities can be given.

Project assessment requires the manipulation of a very large amount of data. Each project must be first assessed individually then each combination of projects must be analysed in order to identify the cross-impacts. Evidently, it is a very complex task to define and evaluate priorities of projects that have different objectives using a multi-criteria analysis.

8.2.1 SECURITY OF SUPPLY (SOS)

Security of supply may be defined as the ability of the electrical supply system to meet demand and load. Regarding the electrical system, two threats can jeopardize the security of supply of European consumers. The first regards the potential inability to have sufficient available generation capacity to operate the system in normal and outage conditions. As electricity cannot be stored in adequate quantities (with current technologies), generation capacities always have to be sufficient to cover the electrical demand. The second threat regards the possible inadequacy of interconnection capacities between areas that would permit an area (typically a country) with generation surplus to export to another area with generation deficit.

Any project characterized by a clear gain in Security of Supply and system stability should always have priority.

8.2.2 INTEGRATION OF RENEWABLE ENERGY SOURCES (RES)

Considering the ongoing massive RES (especially wind power) development in the Northern and Southern Europe and due to local/regional lack of adequate demand the wind energy has to be transmitted by a limited number of transmission lines over more and more increasing distances. In addition the differences in the national targets and therefore in the incentives in the different areas lead to have a better penetration of wind in some areas. This effect increases considerably the transmission flows all over the region.

A large number of projects presented in this report aim to reinforce the electricity system in order to overcome the grid and operation constraints that can affect growth of the share of energy produced from RES in Europe.

8.2.3 INTERNAL ENERGY MARKET (IEM)

The Internal Energy Market (IEM) as materialised in the form of open grid access and free trading between areas results in the amplification of cross-border electricity exchanges. These exchanges are sometimes limited due to current grid constraints in order not to endanger the safe operation of the system, resulting in sub-optimality for the European generation dispatch. Moreover, the future evolution of the European generation pattern will lead to a change in exchanges leading to new localisation of grid constraints.

Cross-border reinforcements and extensions, like projects presented in this report, comply with the promotion of the IEM by reducing these current or future constraints and by thus creating an added value for the European economy. This added value, the decrease in global prices due to a better optimization of the generation plants, should be compared to the global costs of the reinforcement or extension project. The economic efficiency of the projects regarding IEM could so be assessed and projects prioritized in regard with that efficiency.

8.2.4 ENVIRONMENTAL IMPACT (EI)

Ensuring sustainability and minimising adverse impact on the environment are crucial aspects to select and prioritize projects. All grid development projects should contribute to a sustainable development in the region. Every grid project should be viable in sustainable terms and regarding following issues, among others:

- Reducing the impact on Climate Change;
- Protecting nature, natural resources, environment and health;
- Urban planning and regional territorial arrangements.

When weighing up the environmental acceptability of a project, the following considerations could be taken into account:

Firstly, the right implementation of grid development plans coincides with environmental protection needs; above all, a more efficient grid leads to lower losses, hence less energy generation and fewer CO_2 emissions.

Secondly, a strategic reinforcement of the electricity system could lead to the growth of the share of energy produced from RES.

Thirdly, with respect to the land characteristics, the areas concerned by transmission projects may be classified as:

- areas in which any development is precluded (airports; military areas; continuous urbanized and points of historical/artistic/cultural assets);
- areas that preferably should not be involved in the projects except where no valid alternative in other area are possible (national or regional natural parks, areas at very high risk of landslides, etc.);
- areas to be privileged when possible, (motorway corridors; electrical corridors; infrastructural corridors, etc.).

Beyond environmental legal compliance, any project showing the greatest sustainable character, maximizing its environmental benefits and minimizing its environmental costs, should also have priority.

8.2.5 SOCIAL ACCEPTANCE

Without social acceptance, it may be impossible for TSOs to gain approval, permits or to find building sites for constructing new transmission infrastructure.

In terms of constructing transmission infrastructure, it is well known that the public may accept a general idea, but reject its implementation in their neighbourhood, the so-called NIMBY (Not in my backyard) effect. A well known case is wind power, widely accepted as a general idea, but strongly rejected in some local communities if transmission lines have to be built in their area. Social acceptance is an important aspect of the planning but to a certain extent disapproval is inevitable. The minimizing of the disapproval is one of the evaluation criteria.

8.2.6 TECHNICAL FEASIBILITY AND TIME TO BUILD

The technical feasibility of projects (engineering) and the possibility to build the infrastructure of projects within shortest delays should be weighted up when prioritising grid reinforcement and extensions.

8.3 ECONOMIC ANALYSIS

The elements of Fig. 58 all contribute to the notion of “social welfare” as it is used in this document. It is important to note that investment on transmission assets incurs benefits and costs to a wider set of stakeholders than market participants. These elements are not (or cannot be) internalised in the market, therefore limiting the evaluation on buyers’/sellers’ surplus in the marketplace is only part of the picture. For example, eliminating completely congestion from the network would maximise the benefits of market participants, nevertheless the external costs, for example the environmental impact, are forbidding to such an option. Further aspects as increasing the stability of the system cannot be quantified in Euros, but have to be taken into account as well.

8.3.1 Social Welfare

The common understanding is that the power system development should be conducted with the goal of maximising the social welfare. For practical implementation, one needs define and appraise all the components of social welfare. Two basic approaches exist to assess benefits for the social welfare:

- Benefits can be measured as system costs savings;
- Benefits can be measured as enhanced market surplus.

A whole range of methodologies combining the two approaches exist, reflecting different historical backgrounds, regulatory framework and market design from one country to another. However, they all derive from the same economic material, i.e. results of market studies (see Section 8.3.2). They complete (and in some extent can overlap) each other.

More details are provided in the next subsections.

8.3.1.1 System cost savings

The benefits of a project are measured by comparing system costs assessments computed a first time considering the grid with no reinforcement, and a second time after adding the project. Costs are considered in a broad extent, but only those that may be impacted by the reinforcement are computed. The different system costs considered are:

- With respect to the grid:
    - Assets investment and dismantling costs (including project costs and compensation measures);
    - Cost of network losses;
    - Other grid operating and maintenance costs;
- Generation fuel and CO_2 costs[37];
- Supply disruption assessment, as a measure of security of supply: assessment of the LOLE (loss of load expectation);
- Other costs as the case may be.

The LOLE is a measure of the Security of Supply. It estimates the energy that will probably not be delivered during a year to end users due to network unavailability. The economic value of lost load depends on e.g. the energy structure of each country (e.g. respective share of industrial and domestic customers), and the duration of the interruption of supply. The costs are usually many times higher that the market price of electricity, since the social value of a reliable network has far-reaching benefits, from the supply of sensitive sectors (hospitals, fire stations, etc.) to the incentives for foreign energy intensive industries to locate their production within the perimeter of the reliable system.

One must keep in mind however, that not every benefit is monetised (e.g. system stability increase).

As well as price convergence developed in the next section, generation costs savings is a measure of market integration, as it reveals that the generation merit order is the most

[37] For this kind of calculations, the investment cost for generation is not accounted for as the generation fleet is an assumption of the study and no generation investment is triggered.

efficient (and/or greener when environmental concerns are internalised) in a pan-European level.

8.3.1.2 MARKET CONSIDERATIONS OF SOCIAL WELFARE

Classical economic surplus measures are used to define the welfare of all participants in the electricity market. Such metric is powerful; but it may not prove really meaningful where consistent and mature market design is not enforced. As relying on marginal indicators, it is also really sensitive to the study input data (i.e. the scenarios).

In the electricity wholesale market, participants involved with physical production, transport, and use of electricity may be buyers (i.e. consumers), sellers (i.e. generators), and facilitators (i.e. transmission owners). Consumer surplus is the difference between what consumers are willing to pay for a product versus what they actually pay. Producer surplus is the difference between the total payment producers receive and the minimum payment they are willing to receive in order to sell.

If there is congestion on any line in the system, consumers' total payments will exceed the producers' revenues. This is because consumers are assumed to pay for electricity at their bidding area prices while generators are paid the prices at their generation area. The difference between these revenues is the congestion revenue. The consequence of congestion is that there will be buyers in one area that are willing to purchase energy in another area in which sellers are willing to sell for that price, and yet the transaction does not take place because of the physical constraints of the network. These unrealised surpluses are termed "deadweight loss".

The first step in benefit evaluation of any transmission project is to disaggregate the total societal benefit into three major components: consumer benefit, producer benefit, and transmission owner benefit (congestion revenue). If a transmission project's total societal benefits (in terms of reduced deadweight loss) exceed its total project cost, the project is beneficial to the market as a whole.

Projects aiming at increasing the transfer capacity between areas will cause the electricity prices in these areas to converge. The consequence of price convergence in a European level is that liquidity in all national markets is increased and competition is promoted. It also means that the generation dispatch is the most efficient (and/or greener when environmental concerns are internalised) in a pan-European level. Market signals are therefore good indicators for driving investments in generation.

Price convergence means that buyers in formerly high-price areas will be able to buy energy at lower prices while sellers will lose revenue. The converse will happen in the formerly low-price areas. At the same time, the transmission owner will see its (congestion) revenue reduced[38] (there are cases depending on the elasticity of prices that this may not be true but this is an extreme case). In total, the impact will be necessarily positive.

In countries where organised market places exist, and hence a reference price for the electricity can be relied upon (provided liquid markets span all relevant time horizons) then the needed calculations are more straightforward. In these markets, the willingness to pay/get paid of participants can be deducted from aggregate bid/offer curves. However,

[38] TSOs'revenues from congestion (or from selling hedging instruments against congestion) are regulated and returned to the system users via lower tariffs, new investments, or guarantees for the firmness of capacities. These costs/benefits are internalised by the market participants.

when such marketplaces are not yet mature, such calculations must rely on estimations of marginal and average costs for generation, something that is difficult to obtain.

In general, the benefit analysis framework should be consistent from one study to another so that alternative project investments can be evaluated against a common standard. The benefit framework should also be able to present the relative economics of a project from a variety of perspectives –consumer, producer, and transmission owner, and on a societal or regional basis. Obviously these concepts are worth further investigations in order to come to common assumptions.

However, it has to be addressed that the price and costs of electric energy can change fast and unexpectedly due to external factors (e.g. problems with gas supply, changes of international market price of primary energy, change of CO_2-regime). Price signals are usually only available for a time horizon up to three years from the market. Therefore, especially for the long term, this uncertainty must be taken into account when defining planning scenarios.

8.3.1.3 Simplified metric

The above-described notions are complex and one could think to devise a simpler criterion, easier to understand and monitor by all parties. Over-simplified criteria can be used as a guidance, but they cannot be relied upon alone in the decision making process, as one figure cannot sum up reliably all the various issues to address for a grid development project.

In this respect, the European Council[39] has proposed a very simple criterion for interconnection development, asking from every Member States a minimum interconnection capacity level equivalent to 10% of its installed production (by 2005). The advantage of this criterion is simplicity, but its limits are fairly obvious: for example, if the indicator is assessed for Spain, the suitable level of exchange capacity (with France, Portugal and Morocco) is lower than if the indicator is calculated for the whole Iberian peninsula (and therefore the exchange capacity being estimated with only France and Morocco), while the needs remain practically the same.

Moreover, it is desirable that the criterion takes into account some particular features of the system. For example, for two systems with the same load under normal conditions and generation installed power, the system with a high sensitivity of load to temperature or a high part of wind energy in the generation mix should need higher support from neighbours. Therefore the criterion should not be expressed with a single numeric value independent of the system particularities. Nevertheless, in the absence of more complete market study that would provide more detailed indicators, refining this target could be a useful approximation.

8.3.2 Market Studies

Simplifying the context put forth in chapters 4, 7, and 8, based on given *scenarios* for the evolution of load and generation, a *generation adequacy* study answers the question “is there going to be enough capacity in the future to cover the demand?”, a *market study* answers the question “which generation (location/type) is going to serve which demand (location) in any future instant?”, and a *grid study* answers the question “will the dispatch of

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

generation and load given in the market study result in power flows that endanger the safe operation of the system?". The outcomes of these studies give the necessary input to the economic criteria described above, or the technical criteria described in Chapter 7 in order to evaluate investments.

To perform a market study on given scenarios, the demand must be modelled, and usually as dependent on weather conditions. However, generation connected to the distribution level, and thus seen as negative demand from TSOs, or smart grids may lead to the need to enrich this model. At the same time, the generation (marginal) costs must be modelled, and these depend on several parameters such as raw material prices, financial situation, geopolitical evolutions, meteorological conditions, etc. Systems experiencing energy constraints, as for example those with significant part of hydro storage capacities, need to adopt annual or pluri-annual scopes in order to take into account time of production optimisation.

For many aspects, especially for mid-term and long-term studies, simplifications of the parameters are sufficient to evaluate their impact on a future grid. For some parameters a probabilistic approach should be considered. It should be mentioned that this approach is subject of ongoing development within TSOs, as its implementation increases noticeably the complexity of simulations and implies to develop the suitable tools and data. It should be noted here that if the probabilistic approach is widespread for generation adequacy and market studies analyses, it is not common practice for grid analyses, especially very technical ones like network stability assessment. Then the problem is tackled via a deterministic rule like the well-known "N-1" criterion. In particular, market models that take into account grid restrictions are not readily available or have limited network representation capability. Therefore, the grid description is usually skipped, considering for example one single node as representing one area or one country. Powerful simulation tools exist to perform efficiently and in a consistent manner generation adequacy and market analysis, although they lack the fully integrated market/grid analysis capability.

The EWIS study[40]demonstrates the implementation of such a study for the integration of wind generation, on a pan-European scope from scenario definition, market study to network studies, both static and dynamic. The EWIS consortium worked for more than two years, to address the operational/technical aspects, including grid development and grid connection codes issues, but also market organisation and regulatory /market-related requirements for the integration of wind power. For further studies, and TYNDP releases, the decentralised regional organisation of the ENTSO-E System Development Committee may however help in the future to de-multiply the efforts to address more needs.

Appendices to this report present other examples of joint economic evaluations and prioritisation performed by TSOs:

- Section 2 of Appendix 3 presents the economic benefit assessment of interconnection capacity increase in the CSW region. This is a market study performed in the framework of RG CSW. Methodology and main results are briefly depicted.
- Section 2.5 of Appendix 4 is another illustration of market studies being a basic tool to assess the benefits from new interconnection capacity increases.

[40] European Wind Integration Study – see full EWIS report on www.wind-integration.eu

- Section 3 of Appendix 3 provides a focus on methodologies developed by the PLEF[41] TSOs, taking advantage of probabilistic market studies to assess mean and more severe situations with respect to load/generation dispatch and resulting bulk power flows. These situations can become a set of assumptions for network studies aiming at checking whether the grid is able to face such situations.

Market studies and network studies must be wisely articulated to ensure consistency and efficiency, so as to address properly every concern with the appropriate modelling; and avoid a too complex "all in all" model either too complex to run or lacking detailed enough modelling of some aspects. This process must also account for specific, regional features (e.g. sound hydro modelling is a key for Nordic countries, and may be less relevant in some other parts of Europe).

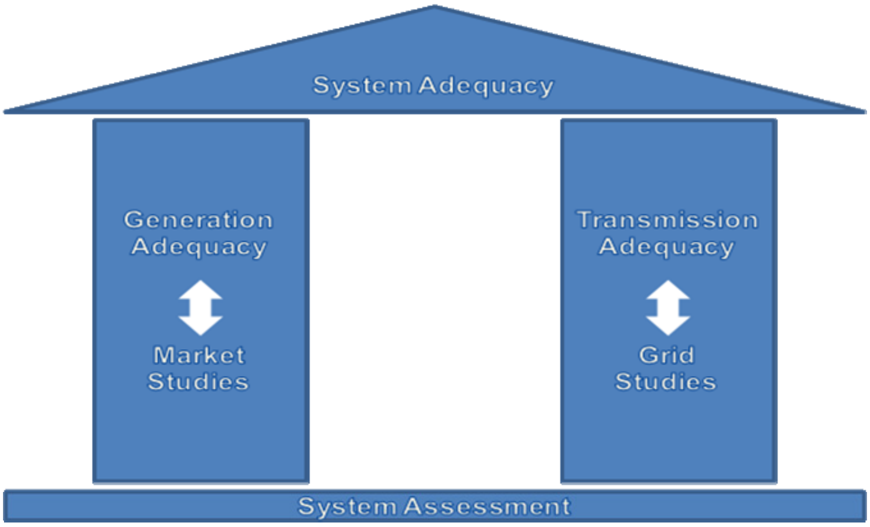

FIG. 60 GENERATION, TRANSMISSION AND SYSTEM ADEQUACY

In this perspective, on the one hand one can consider the pan-European level as the relevant one for the definition of consistent generation and load scenarios (see Chapter 4), both in terms of market trends and in terms of reliability of the network, and to define "base case" pan-European network models. On the other hand, development project studies regard mostly regional stakeholders, and refined cases must reflect local concerns (high/low consumption, and/or high/low wind, and/or dry/wet year, etc. depending on local generation mix features). ENTSO-E will implement the following methodology to perform the abovementioned studies (see Fig. 61).

[41] Pentalateral Energy Forum, associating governments, NRAs, TSOs and other stakeholders of Belgium, France, Germany, Luxembourg, and the Netherlands.

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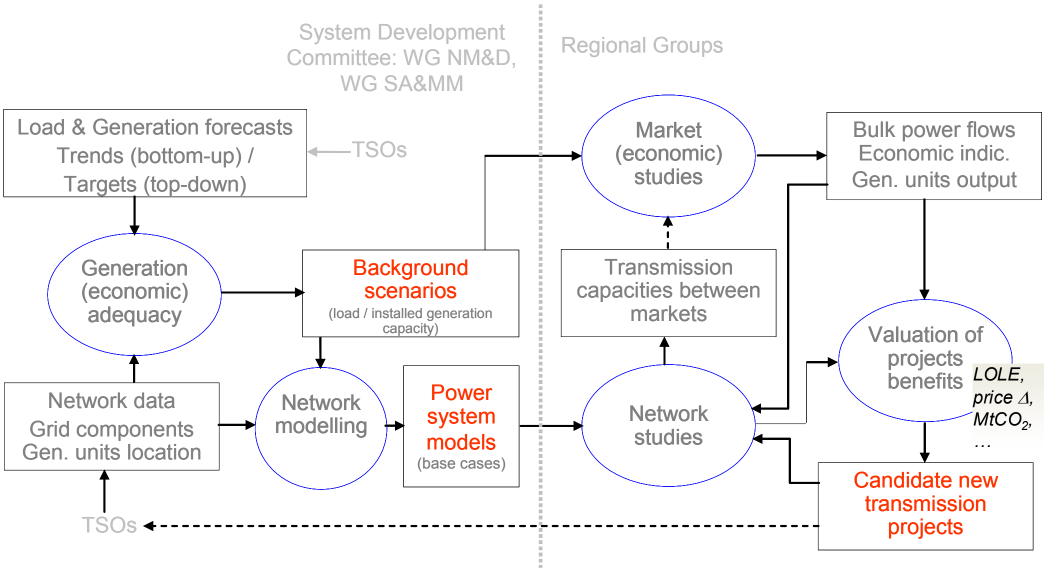

FIG. 61 OVERVIEW OF PROPOSED GENERAL METHODOLOGY

8.4 CONCLUSIONS

This chapter has shown the many parameters that the TSOs need to appreciate in order to accurately assess the socio-economic value of an investment. Today, TSOs in a local or regional level undertake studies that permit this evaluation while putting the focus on different criteria to account for local specificities. A harmonisation of these criteria is necessary in a regional level at least in order to coordinate better the development of the European network in terms of project prioritisation and consistency.

Nevertheless, the most important first step is the realisation of market studies in all European regions in order to have a global view on the investment needs and acquire the necessary input elements for the evaluation of the projects. This work has already been initiated within ENTSO-E.

HIGHLIGHTS:

- Cost-benefit analysis with respect to social welfare is performed for every transmission project, but possibly using different metric from one country to another based on the regulatory regime and the national/regional requirements.
- Large scale market studies are required for a consistent assessment of investment needs and provide basic inputs to project evaluations.
- Common evaluation criteria for projects of European importance will be part of future grid codes and consulted with stakeholders.

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[9] TECHNOLOGIES, OUTLOOK AND PERSPECTIVES

9.1 INTRODUCTION

The European transmission grid is going today through a rapid and significant evolution due to the development of Renewable Energy Sources (RES) and the common European Internal Electricity Market. The transmission grid must provide safe solutions for the injection of new sources of energy and for present and future conventional generation plants without causing congestions. For that reason the capacity of the existing transmission grid needs to be extended either by optimization of the existing grid and by erection of new transmission capacities.

This challenge must be met by use of cost effective solutions and without any disturbance for the whole reliability of the European transmission.

The technologies employed to date in the transmission grids are efficient, reliable, well engineered and are widely available techniques for transferring energy in high-voltage grids.

The ongoing technology progression, predominantly driven by special applications, has led to new techniques that may have the potential to be employed in the future transmission grid.

Of course, it is not possible to give a comprehensive description of all the research done about grid operation and development in the present report. The reader is invited to refer to the ENTSO-E R&D Plan[42]. In this respect, this chapter only presents a brief illustration of the researched fields, to illustrate in which respect transmission projects presented in Chapter 6 indeed take advantage of the best available technologies to meet present and future grid development challenges.

9.2 OVERVIEW OF TECHNOLOGY RESEARCH TODAY

This chapter deals with novel techniques as well as with unconventional techniques i.e. known technologies that have not been widely used for various reasons. Basically technologies can be sorted into four categories depending on their maturity:

- Some are *mature*, even though they might not be largely implemented, i.e. they have already proved their general applicability, have been fully developed, tested, their operation within the existing meshed grid proved reliable and introducing new items is not a technological challenge. DC connections between synchronous and asynchronous areas, EHV underground cables in special circumstances, Phase Shifting Transformers (PSTs) are examples of such mature technologies.
- Some are *in large scale testing phase*, i.e. they have been fully developed (laboratory devices work) but their insertion into the existing meshed grid is still being, or to be, tested, in order to check they can be reliably operated along with other equipments in all likely situations. For instance Flexible Line Management (FLM), low sag conductors and partially underground lines reached this level of maturity.

[42] available at www.entsoe.eu

- Some are *in development phase*, i.e. no feasibility questions remain, but some resources are needed to engineer some still missing brick (e.g. some operating IT, some kind of Flexible AC Transmission System (FACTS)).
- Some are *in research phase*, i.e. some key-issue is not yet solved and hence feasibility is not demonstrated. Typically, distributed storage solutions are today no alternative solution to transmission grid development as their capability, regarding power as energy issues, is about 100 or 1000 times too small compared to transmission grid requirements[43]. Implementation of superconductors and nanotechnologies is also still researched with no practical application yet.

The transmission systems operators are committed to the grid integration of mature and well researched technologies as well as to the research of premature transmission technologies in order to meet the future demands on the transmission system.

This section presents an overview of selected new transmission technologies that have the potential for large scale integration in the transmission grid in Europe in the future. The new technologies in focus may be split in two categories:

- Technologies associated with the improvement of the present infrastructure.
- Technologies associated with grid extension.

9.2.1 Novel and unconventional technologies to make better use of existing assets

The easiest step in order to increase the capacity of an existing grid is partly the optimisation of the present system components. Two kinds of options are illustrated here:

- reallocate power flows on power lines, e.g. with the implementation of FACTs and PSTs;
- increase the capacity of some power OHL corridor, not changing its overall outlook.

9.2.1.1 FACT and PSTs

PSTs and FACTs can help to allocate the flows from high loaded elements in the grid to lower loaded ones and can contribute to the capacity of the existing grid being used in an optimal way. Both technologies are available and well researched. Indeed these devices have an impact on the flow distribution that has to be properly analysed both in the study phase and the real time operation in order to increase the available capacity.

These technologies are complementary to grid expansion since they only add limited transfer capacity through the control of power flows but they do not cancel the need for new transmission lines.

[43] This fact does not prevent these solutions to prove very useful at a smaller scale; or to become an alternative in a much longer run, with the possible development of massive V2G (Vehicle to Grid) solutions, once batteries operation and management issues are solved, etc.

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9.2.1.2 FLEXIBLE LINE MANAGEMENT (FLM) AND HIGH TEMPERATURE - LOW SAG CONDUCTORS

The maximum transmission capacity depends on the rating of the equipment and is deeply impacted by the environmental temperature. Therefore, the relevant standards determine the capacity of the equipment under consideration of climatic conditions.

The equipment predominantly affected by the weather conditions (temperature and wind speed) are mainly overhead lines (OHL). Limits for the operation of OHL's are the minimum distances between the conductors and the earthed parts (i.e. earth surface) and the maximum temperature of the conductors (typically 80°C for conventional cables). For overhead lines, the sag increases with increasing temperature of the conductor and, therefore, increases with load and with rising temperature of the surrounding air. For this reason, the maximum thermal capacity must be linked to the atmospheric temperature in order to avoid mechanical damage of the conductor and in order to maintain a sufficient clearance with the environment. The relevant standards used to calculate the maximum thermal capacity of a line, take into account a limit of the outside temperature for a period of the year.

The outside temperature limit used usually corresponds to the most probable highest temperature of the year for the whole area covered by the TSO. For example: 35°C corresponding to the summer period of central Europe. Because during the winter time the temperature is significantly lower some TSOs prefer to split the year in several periods. For each period, the model takes into account the most probable outside temperature and calculates the maximum thermal capacity of the line.

With the progress of technology, new devices are now available to get and to transmit outside temperature with a better accuracy and reliability. Therefore, the concept of Flexible Line Management (FLM), also called Dynamic Line Rating, may be applied. In this concept the maximum load is dynamically adjusted dependent on the actual environmental conditions and the physical state of the conductors. The EWIS study[44] shows that this technique enables up to 20 % increase above the initial thermal capacity, and possibly 30%-40% for very short periods of time.

The replacement of the existing conductors of an overhead line by conductors with higher ampacity (High Temperature Low Sag conductors - HTLS) offers another option to increase the capacity. New conductors may allow an increase of the transmission capacity of the overhead line. These conductors provide a higher thermal strength and allow operation above 80°C. Under the prerequisite to keep the clearance between the conductors and earthed parts within the permitted values (most often only possible with the reinforcement of the towers) and to operate all components in the relevant circuit within their limits, the system may carry higher load. By this means, the transmission capacity may be increased, for special cases, by up to 50% of the nominal capacity of the line. However its higher impact on transmission losses must be taken into consideration as well as the negative effect on the reactive power balance of the grid.

[44] European Wind Integration Study (EWIS) (funded by EC as TREN/07/FP6EN/S07.70123/038509) available at www.wind-integration.eu.

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9.2.2 NOVEL AND UNCONVENTIONAL TECHNOLOGIES FOR GRID EXTENSION

9.2.2.1 DC TECHNOLOGY

With the development of renewable energy generation and especially with off-shore wind farms installed in the sea, far away from the coasts, TSOs need to find new cost-effective and reliable solutions, in order to transport the energy from the maritime substation to the onshore grid. For sub-marine power lines, alternative current (AC) technologies reach their technical limits in the order of approximately 50-100 km. For longer distances the direct current (DC) technologies become increasingly efficient. The actual breakeven point in distance depends strongly on the specific project parameters and is typically between 80 km and 120 km for offshore submarine cable connections.

Onshore, the economic breakeven point between AC and DC OHL is in the order of 700 km distance between the respective grid connections. AC OHL is the prevailing technology in Europe as it is, in technical, economic, and ecological terms, the most efficient solution for electricity transmission for the encountered distances. However, specific situations (very long distances, underground, subsea, etc.) may create favourable technical and economic circumstances for DC lines.

Presently, DC technology in transmission grid consists of bilateral connections (and back to back facilities) between asynchronous areas. Also within a synchronous area bilateral connections, with parallel operation to AC equipment are appearing.

No multi-terminal DC grid exists[45] due to the unavailability of the main components such as DC circuit breakers and advanced control systems: a simple fault within an eventual DC grid would trigger the tripping of the whole DC system. Building efficiently DC multi-terminal grids would hence first require to solve technical issues and to define appropriate standards, beginning with the voltage level. These issues are addressed by TSOs, manufacturers and other stakeholders, via the ENTSO-E R&D actions in the framework of the EC R&D work-program and the CIGRE WG B4-52 “HVDC Grid Feasibility Study”. First conclusions are expected by 2012.

VSC HVDC technology might be used to build DC multi-terminal networks with greater flexibility compared to LCC HVDC. The first multi-terminal system will probably be the onshore VSC HVDC link between Sweden and Norway. Another example of VSC implementation can be found in Section 2 of Appendix 4.

9.2.2.2 UNDERGROUND CABLES

In general underground cables (AC and DC) are not a novel technology but their characteristics have been and are gradually improving over the recent years. They offer an alternative substitute for OHL in places where the use of overhead lines are not applicable or advisable (for example in urban areas or sensitive environmental areas). This applies also for Gas Isolated Lines (GIL) where the conductor is insulated from the earth potential by an insulation gas.

It must be underlined that the use of these technologies in the transmission grid is limited to projects with specific requirements due to economic reasons (depending on technology and

[45] Yet, some 3-legged DC systems exist in the world. For instance, the SACOI link between Italy and Sardinia, which supplies some power to Corsica via a sub-terminal.

local context, resort to EHV underground cost can be in the range of 5-20 times OHL cost), due to technical reasons (reactive power compensation, resonance, protection issues) and due to reliability and time to repair constraints.

9.2.2.3 HIGHER VOLTAGE LEVELS

A further unconventional transmission technology in Europe is the use of Voltage AC-technology with a voltage range of 500 kV or higher. Such lines are also able to increase the transfer capacity (a couple of GW) over long distances when compared to the conventional technologies applied to day. This technology is in operation for a long time in different countries, for example USA, Canada, Russia and Japan. The equipment is standardized and well available. However, the environmental impact of these lines may even be higher when compared with the transmission systems predominately used to date.

9.3 A WISE USE OF NEW TECHNOLOGIES TO MEET PRESENT AND FUTURE CHALLENGES

9.3.1 NEW TECHNOLOGIES IN TRANSMISSION PROJECTS

New technology is a source of valuable solutions for grid development and operation in an ever demanding context.

Provided the reliability of system operation is ensured or enhanced (see Chapter 7), and economic soundness is demonstrated (see Chapter 8), TSOs indeed take advantage of new technological advances:

- TSOs strive to make the best use of existing assets implementing technologies such as PST, HTLS, FACTS, in order to optimise the grid development or as an interim measure where grid extension cannot be realised in a timely manner;
- When grid extension is needed, proven new technologies are widely resorted to fulfil transmission tasks;
- TSOs also do anticipate future challenges with live-testing of promising new technologies through pilot projects;
- TSOs point out the need of new technology development for long term grid issues and address the questions e.g. to manufacturers (i.e. DC circuit breaker, …).

Chapter 6 and Appendix 1 demonstrate that TSOs are indeed making a wise use of technologies to propose the best long lasting solutions to every investment, without prejudice of the overall consistency of the interconnected system. DC, underground cables, PST projects within a synchronous area will become soon common, notwithstanding the implementation of smart devices on the grid: FLM, etc.[46]

[46] The TYNDP report focuses on HV projects and « Smartgrid » projects are not detailed in this framework.

9.3.2 REQUIREMENTS FOR A WIDESPREAD USAGE OF NEW TECHNOLOGIES

As already mentioned, European TSO's are supporting the development of the above mentioned new technologies by testing new products supplied by manufacturers, testing new technologies, influencing thus the improvement of the most relevant technologies. In fact TSOs are frontrunners in all these advances in new technologies.

Some of the technologies are still in a premature state and a large scale integration of these technologies in the transmission grid is not possible due to reliability constraints. As the TSO's have the responsibility for the whole electrical system in their control zone, precaution is needed with respect to the introduction of new technologies.

For that reason all new candidate technologies for wide-spread use in transmission grid, before being adopted,

- must undergo type testing according to European or International standards whenever applicable;
- should be operationally tested with success in pilot projects by the TSOs;
- must be suitable for being deployed in the whole transmission grid, should not depend on particularities found in special situations, and should fit in the whole system.

  Only the fulfilment of these requirements provides the high security and reliability levels in the European transmission system to date.

HIGHLIGHTS:

- TSOs strive to make the best use of existing assets implementing technologies such as FACTS, PST, HTLS in order to achieve an efficient grid development, or as an interim measure where grid extension cannot be realised in a timely manner.
- When grid extension is needed, proven new technologies are widely resorted to fulfil transmission tasks.
- TSOs also do anticipate future challenges with live-testing of promising new technologies through pilot projects.

[10] SYSTEM STUDIES AND LONGER RUN PERSPECTIVES

After having presented the different projects and studies in progress by European TSOs, this chapter addresses a broader geographic scope and longer run perspectives:

- Study possible enlargements of the interconnected system to enable new power exchanges and mutual support opportunities that can lead to reliability improvements or reduced costs;
- Develop offshore grids both to take advantage of RES off-shore resources and strengthen the interconnection of weakly interconnected sub-systems;
- Consider supergrid concepts to accommodate much wider and more complex interactions over the continent.

Reliability of the synchronous area is the issue of primary consideration and top priority importance when considering new interconnections beyond the existing borders. Secure operation and high quality of electricity delivery in the long-run should not be jeopardized but rather be improved by any new extension.

Besides the technical aspects associated with a new extension/interconnection other non-technical aspects – such as market structure and unbundling in the applicant's country, environmental issues, wind production issues etc – are becoming increasingly important.

10.1 INTERCONNECTIONS OF EXISTING LARGE SYSTEMS

10.1.1 INTERCONNECTION OF THE TURKISH POWER SYSTEM WITH THE CONTINENTAL EUROPE SYNCHRONOUS AREA

As already reported in Chapter 6, one interconnection of existing large systems in the last stages of examination and testing is the possibly synchronous interconnection Turkey to the Continental European synchronous system. After detailed studies of the technical feasibility of this synchronous interconnection and of the concrete measures required in the Turkish system for stable and secure interconnected operations, two island tests and the beginning of a one-year synchronous operation test are planned for 2010. The network expansions planned to this purpose are described hereafter. A detailed description of the interconnection of the Turkish power system with the Continental Europe synchronous area of ENTSO-E can be found in Section 3 of Appendix 4.

As shown in Fig. 62, Turkey is to be connected to the Continental European synchronous area through three 400 kV lines (two to Bulgaria and one to Greece). This task includes the creation of a 400 kV corridor in northern Greece, from Thessaloniki to Turkey, and the reinforcement of the southern part of the Bulgarian 400 kV network.

The corridor in Greece includes a 400 kV line of 266 km from Filippi (GR), through new EHV SS N. Santa, to Babaeski (TR) which will serve directly the connection of Turkey. This corridor will be further enhanced in the future by a second new EHV double circuit transmission line of 110 km from Filippi to the area of Thessaloniki. The project upon completion of all works becomes a “multi – task” project as it will contribute to:

- System extension to Turkey;
- Accommodation of new thermal power plants;
- Accommodation of wind generation in the area.

In addition, the planned interconnection of the Turkish power system created the need of expansion of the 400 kV network in Northern Greece and reinforcement of the 400 kV South-East Bulgarian network.

Reinforcement projects in the South part of the 400 kV Bulgarian network include the construction of three new 400 kV lines: Maritsa East – Plovdiv (257), Maritsa East – Maritsa East 3 (258), and Maritsa East – Burgas (262), as well as one double circuit 220 KV line: Aleko – Plovdiv (260). These four transmission line projects are also "multi-task" since they will contribute to:

- Accommodation of new thermal power plants;
- Enhancement of the interconnections with Turkey and Greece.

The new interconnection line between Greece and Bulgaria foreseen for 2012-2015 (256) will further strengthen the network in the region.

FIG. 62 INTERCONNECTION TO THE TURKISH SYSTEM

10.1.2 A POSSIBLE MEDITERRANEAN RING

The Medring study in 2002 analysed the feasibility of interconnecting all countries around the Mediterranean Sea to improve the systems reliability, and enable power exchanges between countries. This ring would interconnect Europe with the Southern Mediterranean area. Stability analyses and questions of AC vs DC interconnections are of special importance for studies about such a ring.

The Mediterranean ring vision has recently been given new impulses as other initiatives developed, triggered by governments and/or private companies and bodies (Union for the Mediterranean Sea associating EU countries and other countries surrounding the sea, Mediterranean Solar Plan, Desertec initiative, etc.). Developing the ring and interconnection across the sea would enable mutual support, a common EU-Mediterranean energy market, and exploitation of the region's vast solar and wind energy potential.

Morocco-Algeria-Tunisia are already synchronously connected to Spain via subsea cables in the Straits of Gibraltar, and Turkey could soon be synchronously connected to Greece and Bulgaria (see section 10.1.1 just above). In the coming years and decades, a so-called "trans-mediterranean supergrid" could be envisaged, as described in Chapter 6 and Appendix 2.

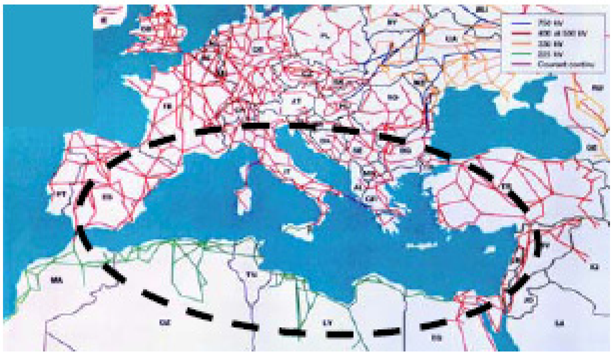

FIG. 63 MEDITERRANEAN ENERGY RING AREA OF INFLUENCE

10.1.3 INTERCONNECTION OF IPS/UPS WITH CONTINENTAL EUROPE

A comprehensive feasibility study[47] of a synchronous interconnection with the IPS/UPS system of Russia, Ukraine, Belorussia, the Baltic and other states was conducted under the umbrella of the former UCTE and IPS/UPS. This study was financially supported by the European Commission in the framework of the TEN-E programme and was concluded in December 2008.

It is worth highlighting that the synchronous system under consideration would be unique in the world, spanning more than 10 time zones and serving more than 700 million people on

[47] Feasibility Study: synchronous interconnection of the IPS/UPS with the UCTE: Summary of Investigations and Conclusions – December 2008.
http://entsoe.eu/fileadmin/user_upload/_library/publications/baltic/system_studies/UCTE-Baltics_sync_interconnection_-_Executive_summary.pdf

two continents with different network structures, load characteristics and various generation patterns.

The main objectives of the study were to investigate the technical, operational, organisational and legal feasibility for an East-West synchronous interconnection of the transmission systems. It was also charged with identifying the necessary measures and associated costs involved in the implementation. The project work was a combination of analyses and power system simulations for two synchronously coupled systems without enforcing regulations and standards of one system on the other. The essential findings of the feasibility study summed up below have been commonly agreed and shared by the study partners. Although the conclusions indicate that a synchronous coupling appears technically viable, it must be considered as a long-term option: dynamic effects appear as the most limiting criteria for system extensions compared to steady-state load flow limitations (see Fig. 64). These are in the first instance of a structural nature that needs both sophisticated countermeasures and further research in this respect.

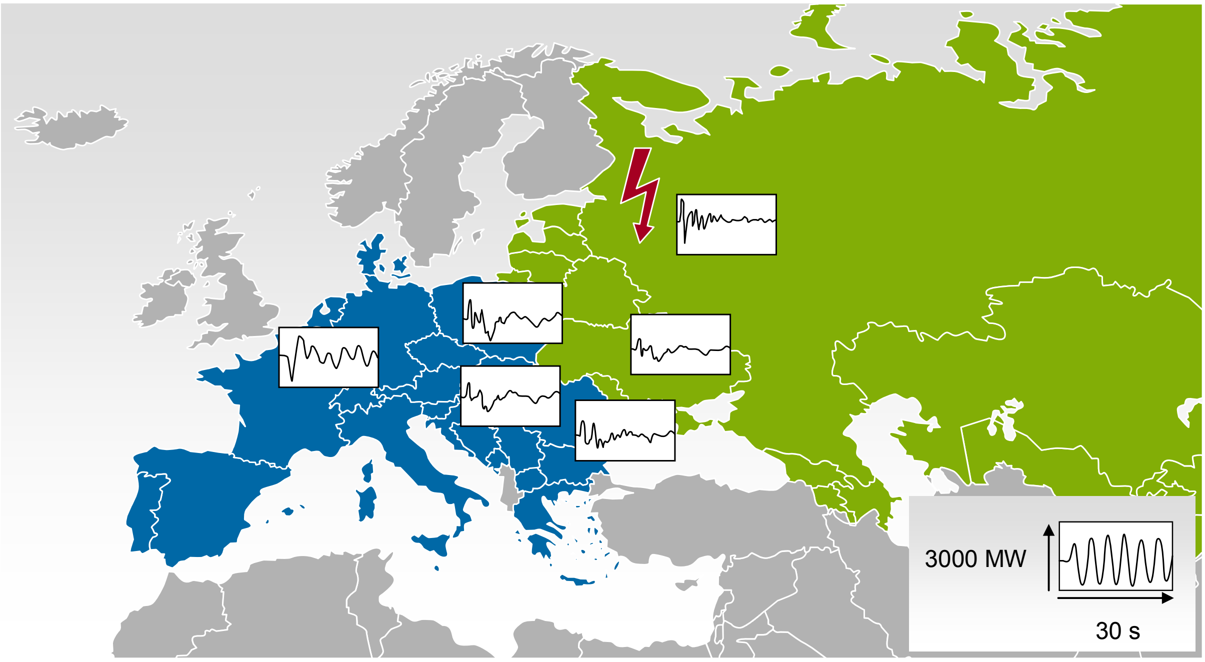

FIG. 64 PROFILES OF WIDE-AREA POWER OSCILLATIONS AFTER A SEVERE DISTURBANCE IN THE IPS/UPS SYSTEM

The construction of High Voltage Direct Current (HVDC) links between the interface countries may be considered as a medium-term alternative. However, this will need separate investigations and decisions by the stakeholders concerned.

The findings underline the overall complexity of a synchronous coupling, firstly in the context of system security and overall reliability, but also from the standpoint of its operability in the underlying electricity markets.

10.1.4 Interconnection of Ukraine and Moldova with Continental Europe

Related to the IPS/UPS project, a new UA/MD project of synchronous interconnection of Ukraine and Moldova system to ENTSO-E's Continental European system is in the launching phase of a feasibility study. Steady state analyses and dynamic calculations as well as power system control analysis will be carried out within working groups under the cooperation of ENTSO-E and UA/MD. This planned interconnection study of UA/MD system should mostly involve TSOs in the RG CCE. Several possible network and substation expansions or reinforcements requirements related to this connection can be depicted in Appendix 1.

10.1.5 Interconnection of the Baltic system with Continental Europe

A study of the Baltic and Polish TSOs on synchronous operation of the Baltic power systems with UCTE was completed at the end of 2007[48]. It showed preliminary conditions for the Baltic countries and a preliminary scope of investments in the Baltic countries for a synchronous connection to the Continental European grid.

After a preliminary assessment of feasible options, a link with a DC back-to-back option is now in the preparatory stage. LitPol Link, a joint company of PSE Operator S.A. and Lietuvus Energija AB, was set up with the objective of preparing the investment for a 400 kV double circuit line Alytus (LT) – Elk (PL) with 2 x 500 MW back-to-back in Alytus. This planned investment is an important part of this ENTSOE TYNDP. The Baltic TSOs have also underlined their strategic objective to become part of the Continental European synchronous area.

A new research study is being launched in the nearest future to evaluate current and planned grid ability and necessary grid technical improvements and extensions for the preparation of the Baltic systems for potential synchronous operation with the Continental European grid. Future releases of the TYNDP will be informed by the study conclusions.

10.2 Development of offshore grids

The development of the "transmediterranean supergrid" described in Section 10.1.2 would aim at strengthening the ties between presently weakly connected countries on different shores of the Mediterranean sea, and also at marginally – at least in a first stage – accommodating offshore RES.

The shallower waters of the Baltic and North Seas are attractive places for the development of large amounts of wind power. Several subsea cables are being planned to both connect these facilities and improve the market integration of countries on the different sides of the Seas.

[48] For more details, see http://entsoe.eu/fileadmin/user_upload/_library/publications/baltic/system_studies/UCTE-Baltics_sync_interconnection_-_Executive_summary.pdf

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In this section first the plans for the Baltic Sea's Kriegers Flak area are described. Next, a section about the roadmap to a North Sea offshore grid describes the barriers that need to be removed in order to avoid mere near-shore point-to-point connections of off-shore wind farms and to create the appropriate technical standards and regulatory framework for the reliable and efficient accommodation of large amounts of offshore wind power.

10.2.1 KRIEGERS FLAK

The Kriegers Flak area in the Baltic Sea is well-suited for offshore wind power plants, and a large number of wind turbines are being considered. In total, 1600 MW of future wind power generation capacity will be built in the German, Swedish and Danish parts of Kriegers Flak. These wind power plants could be connected either in a traditional way by separate, national connections or through a combined grid solution. A combined grid solution is a new and very interesting concept which integrates connection of offshore wind power with additional transmission capacity across the Baltic Sea. A combined solution would in many ways be an offshore grid as the practical solution is expected to be based on the technology envisioned for very large-scale offshore grids and because the fundamental challenges are the same as for e.g. a North Sea offshore grid. TSOs researched the feasibility of a multi-terminal VSC-based HVDC solution with 600 MW of transmission capacity to all three countries.

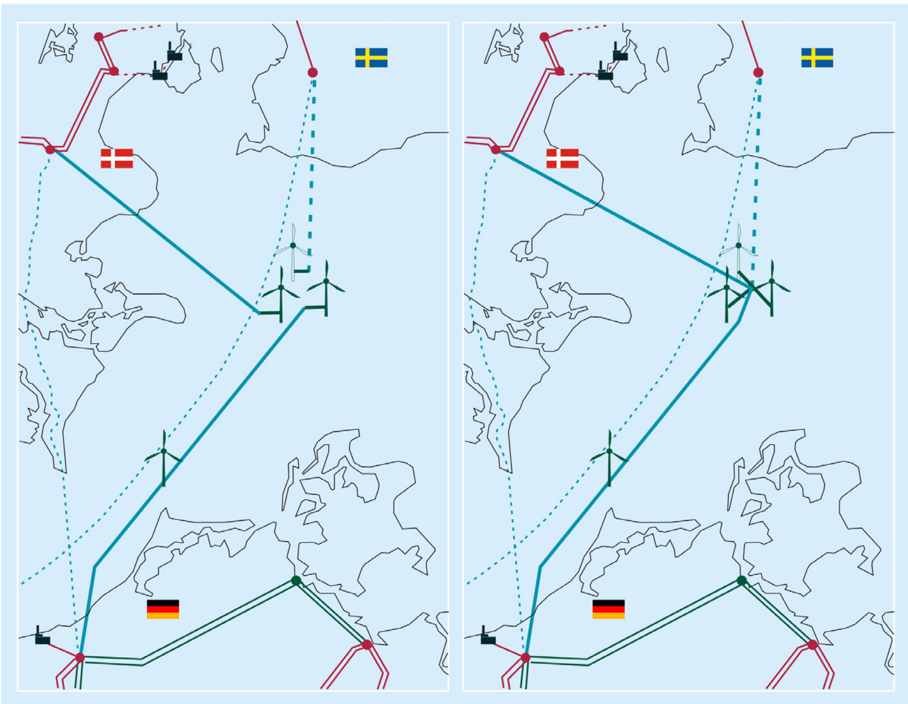

FIG. 65 ALTERNATIVES: INDIVIDUAL CONNECTION AND COMBINED GRID SOLUTION

The three TSOs[49] involved in the project have investigated and developed this new concept. The TSOs are progressing with further analysis and development based on the promising findings of the pre-feasibility study, which was published in May 2009. The joint project

[49] Energinet.dk, Svenska Kraftnät, 50Hertz Transmission

towards a combined grid solution is ambitious and a number of challenges of technical, regulatory, commercial and market-related nature need to be addressed. A successful completion of a cross-border Kriegers Flak project will rely not only on the will and efforts of the involved TSOs, but also of a number of other parties. It is therefore particularly important that the Kriegers Flak project is expected to receive 150 M€ from the European Energy Programme for Recovery. In combination, the financial assistance, the attention and the Member States support will contribute to making this large-scale pilot project possible.

On 11 January 2010, Svenska Kraftnät decided to withdraw from the project, mainly due to uncertainties concerning the construction of wind turbines in the Swedish zone of Kriegers Flak during the foreseeable future. 50Hertz Transmission and Energinet.dk continue the project with the option for a possible link to Sweden at a later stage.

10.2.2 ROADMAP TO A NORTH SEA OFFSHORE GRID

The development of an efficient off-shore grid in the North Sea is fully consistent with ENTSO-E's fundamental objectives to increase reliability of supply, to facilitate sustainable developments and to support the integration of energy markets by greater interconnection. Many stakeholders are involved.

TSOs are very willing to provide solutions. However, in order to prepare suitable solutions, a common understanding on the basic framework conditions is essential. TSOs do strongly believe that in order to make an integrated and internationally coordinated off-shore grid a reality, several barriers need to be removed. If efforts to acknowledge compatible technical standards and harmonise regulatory frameworks were not coordinated, the risk of only limited, near shore development would increase. In that case, nation-specific connections of off-shore wind farms might prevent their swift interconnection and the advantages of a real integrated off-shore grid, i.e. of meeting efficiently both key EU targets of wind farm development and market integration.

Therefore, in November 2009, the ENTSO-E Regional Group North Sea developed a detailed roadmap in this respect:

Barriers regarding offshore grid North Sea	What is recommended
1 No clarity yet concerning responsibility to build off-shore grid. National solutions to EU-requirements differ and now have to be coordinated internationally e.g. rules challenging each other: - open market vs priority of RE, - level and kind of RE-subsidies, - common control and dispatch of RE etc…	On-shore TSOs should be nominated to be responsible for off-shore grids as well. (This means that on-shore- TSOs should have their responsibilities extended off-shore so that the development of interconnectors and off-shore wind connections can be better coordinated). TSOs welcome the creation of the North Seas Countries' Offshore Grid Initiative and are keen to support the tasks, among others, for the identification of responsibilities, regulatory frameworks, market rules and coordination on the off-shore interfaces. National (local) governments must clearly support faster permissions and authorisations processes and ensure international coordination.
2 Lack of incentive mechanisms for TSOs to build the off-shore grid.	Preparation of a common long-term "Region North Seas-Masterplan" agreed by all stakeholders, which is based on socio-economics. System adequacy and grid implications (both on- and off-shore have to be investigated and compared for different solutions. Iteration with whole process-chain (political willingness -> regulatory scheme -> market rules -> technical solutions) will be necessary. The TSO-costs (both for on- and off-shore-grids) should be recovered. Respective international mechanisms to support anticipatory investments of TSOs towards a long-term offshore grid have to be developed.
3 Lack of alignment between permitting procedures and regulatory approval for an on-shore and off-shore grid development	Policymakers (and regulators) to coordinate, smooth and speed-up permitting procedures.
4 To-date there has been a lack of proper long-term planning to cater for the Volatility, Size and Volume of potential off-shore wind developments. International coordination of on-shore- and off-shore grid development is needed – in terms of time, design and adequacy of generation and transmission needs.	The Regional Group North Seas of ENTSO-E to develop an international long term "Region North Seas-Masterplan", agreed by all stakeholders ("PLEF+"), which will allow a modular coordinated construction. This Masterplan will take into account the results of ENTSO-E's valuation concerning a possible European Supergrid. In a first stage standardization concerning regulatory schemes and technical rules is essential to facilitate later inter-connections. ENTSO-E on behalf of TSOs is already taking forecasted WPP into account as inputs into the TYNDP, but consistent generation- (e.g. RE- NAPs) and exchange-scenarios have to be built and agreed by stakeholders before grid planning can be undertaken. Parallel and coordinated work of all stakeholders is necessary.
5 ncompatible Regulatory Frameworks for interconnectors and offshore transmission (Responsibilities to build, own, operate and maintain offshore assets differ as well as grid codes)	Regulators should coordinate and develop interfaces between different schemes. In the short run term a step by step approach leading to harmonisation of the regulatory frameworks in the long run is recommended. Alignment of security/planning standards and connection rules with special focus on off-shore grids is recommended as well.
6 Compatibility / clarity needed concerning: national RE-subsidy schemes which do not allow cross-border RE flows and efficient use of capacity the concept of prioritised grid usage for sustainable generation rules for trading and balancing	**CEER INVOLVED IN DEFINITION OF RULES.** Definition of interfaces or complete harmonisation of prioritised grid access for sustainable generation. TSO's need to be able to re-dispatch generation (including RES production) to maintain system security.
7 Cost-level, cost recovery and allocation of costs	Governments should support proactive investments by TSOs: i.e. efficient, economic, coordinated, and standardized approach. Regulators should proactively allow the recovery of costs related to anticipatory investments based on an agreed long term "Region North Seas Masterplan".

This roadmap will be implemented in the framework of the North Seas Countries Offshore Grid Initiative Political Declaration signed the 7/12/09.

10.3 SUPERGRID ASPECTS

The EU energy policy aims at ambitious goals for 2050, to answer adequately society's desire towards a sustainable, reliable and cost-efficient energy supply system. Depending on the goals ultimately chosen worldwide and their legislative implementation in the EU, the energy supply systems, the primary energy source mix and also especially the transmission infrastructures could be dramatically different in a mere few decades.

Because transmission assets require several years to be built and feature long lifetimes, a long-term vision on grid infrastructure is helpful to guide current and future investments. It is therefore important for ENTSO-E to proactively anticipate the discussions on the subject of a possible European supergrid development and to contribute in creating a realistic view on the possible options, given that it will be ENTSO-E's TSO member companies who would have to plan, finance, build, and operate a supergrid.

Looking beyond the next decade, the ENTSO-E TSOs will investigate main aspects of a possible European supergrid. From the variety of influencing factors and drivers (see below), it is necessary to forecast how the overall setup of electricity supply and the associated electricity transmission requirements will develop.

Fundamental drivers

- Availability and primary energy resources in Europe diminishing and prices increasing.
- Global demand for fossil fuel increasing / Fuel shift (heat pumps, electric vehicles, railway…)
- Economic and population growth driving rising electricity consumption vs. energy efficiency programs
- Technological development: new technological solutions under study, e.g. offshore generation/grid, CCS, energy storage, altering costs for technology

Political developments

- European sustainability objectives (20-20-20 initiative and beyond)
- Development of the European Electricity Market, leading to further intensification of the electricity trade in the European market.
- Environmental criteria for grid projects

Generation and consumption developments

- Considerable growth in the generation of wind power is forecasted for Europe.
- Development of large offshore power stations and offshore grids - ought to be extended on onshore.
- Potential development of solar power in North Africa and South and Middle East.
- Production locations in Europe might be altered. Large-scale offshore wind generation might replace conventional power plants. Closure of nuclear power plants might create a displacement from power generation units from southern to northern Germany.

In order to provide the needed consideration, the ENTSO-E supergrid investigations are to be based on market studies, system adequacy analyses, and grid studies, as well as on a comprehensive study package covering main aspects and issues as shown below.

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Supergrid

Technological issues

- Technical feasibility of existing transmission concepts
- Proper technology;
  - AC, DC (also reliable multi-terminal solutions) and mixed
  - OHL / cables / etc
- Power quality / Level of SoS
- Voltage level / EMF
- Upgrade of existing HV lines to UHV AC/DC
- Technological improvements
- Electricity storage
- Power reserve margin
- Level of reliability

Economical/financial issues

- Different generation and load scenarios
- Cost/benefit (business case) of scenarios
- Electricity prices
- Financial demand per scenario
- Realization and ownership of the Supergrid
- European funding
- Potential investors

Political/sociopolitical issues

- Legal and regulatory framework
- Social acceptance / Public support of the Supergrid
- Permitting processes, harmonization of national rules
- European policy on Demand Side Management
- New areas to be incorporated; e.g. MENA, Russia, Nordic
- Political stability of regions
- Risk of terrorists attacks

The investigation's scope will not be limited to European grid issues but will also consider intercontinental aspects (as described in chapter 10.1 – 10.2 of the TYNDP). Having in mind the very long-term focus, a wide range of scenarios regarding generation and load developments will have to be considered, including the full energy system decarbonisation scenario for 2050 according to current European discussions.

The output of the ENTSO-E investigations is to be a long-term vision on grid-infrastructure necessary to respond adequately to society's desire towards a sustainable, reliable and cost-efficient energy supply system which will likely need to be capable to accommodate massive energy flows over continental or transcontinental distances and to foster a well functioning single Internal Energy Market (IEM) in Europe.

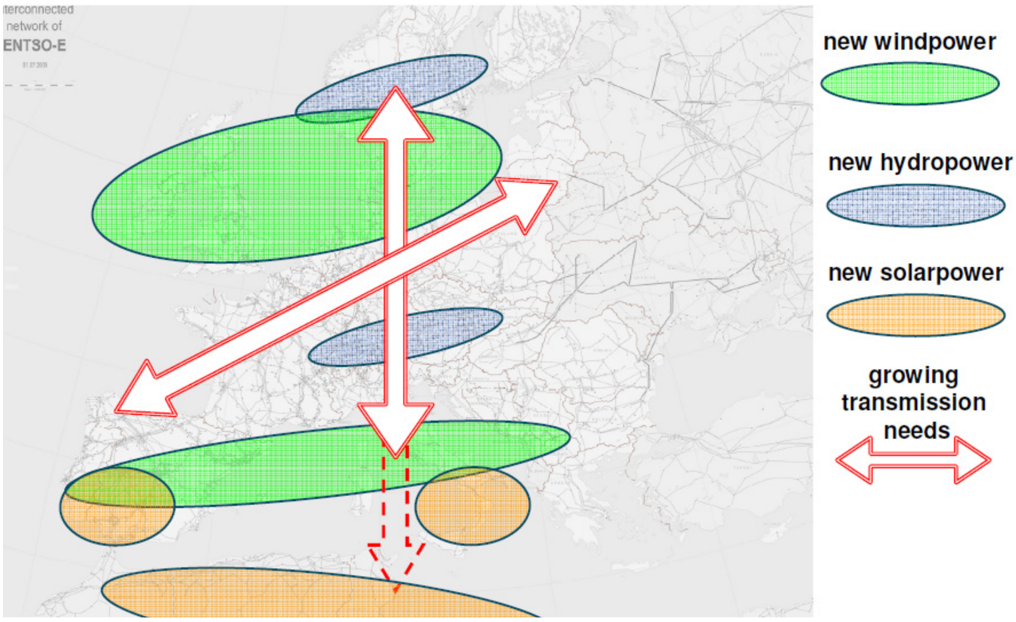

FIG. 66 DEVELOPMENT IN GENERATION AND DEMAND DETERMINE FUTURE TRANSMISSION NEEDS

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The required concepts, scope of work, scenarios etc. regarding supergrid aspects are presently under preparation by ENTSO-E. ENTSO-E also consults and cooperates with relevant stakeholders on these issues.

10.4 CONCLUSION

Although shared and precisely defined scenarios are required to perform a more quantitative analysis, EU targets for RES integration and implementation of an Integral Electricity Market while maintaining the Security of Supply set a clear blueprint. Some visions of the needed future power system can already be sketched. The future European power grid might be connected to neighbouring systems at its Southern and Eastern borders, extending from the polar circle to the Sahara both onshore as today and also offshore. Such an increase in scale, with large amounts of climate dependent RES will require a clear and harmonised regulatory framework and innovations in system planning, operations and also market issues, and will also require reinforcements of existing high voltage networks onshore. Transmission assets will hence continue to play an ever increasing role to connect remote RES to customers and to manage the load-supply balance, along with a more efficient and smarter use of energy by end consumers.

Investments projects proposed in Chapter 6 are consistent with such longer-run perspectives, as appropriate first steps.

HIGHLIGHTS:

- Building on several study projects, a qualitative long-run vision can be sketched, with an ever increased role of the transmission grid, especially to give EU consumers reliable access to RES.
- Coming investment projects support such a perspective.
- Efficient and swift development of offshore grids requires shared technical standards and a consistent harmonised regulatory framework for investors.

[11] CONCLUSION

11.1 A FIRST TEN-YEAR NETWORK DEVELOPMENT PLAN

TSOs decided to set up ENTSO-E on December 19th 2008; the Association has been fully operational since July 1st 2009 and, with the present TYNDP report, releases one of the major deliverables of its ambitious workplan a mere few months after.

This report is considered a *pilot project*, ahead of the enforcement of the 3rd Package and the establishment of ACER in early 2011. It is intended to be a major first step, a tangible basis to start fruitful debates, launch coordinated works involving all stakeholders for the next releases, and solve major concerns for grid development. Most importantly, it is ENTSO-E's response to the urgent needs arising in the European context today, due to the massive development of RES and the impact of the EU Energy policies.

With this early start, ENTSO-E devotes much attention to the *transparency* and care for stakeholders' concerns. Before drafting the report, discussions with stakeholders were conducted to present the goals of the first TYNDP release and possibly adapt its content. The report has been subject to the public scrutiny through an ENTSO-E consultation process in Spring 2010. Constructive *feedback* has been received with respect to the content of the report, and especially proposals for prioritisation of future works.

11.2 DELIVERABLES OF THE FIRST TYNDP

ACER has to measure the deliverables of the ENTSO-E TYNDP against the requirements of the Regulation. This TYNDP pilot project marks progress in fulfil the objectives set forth by the Regulation in the following ways:

- Bottom-up scenarios have been developed by TSOs describing mid-term trends.
- Investment needs and projects derive from coordinated modelling of integrated networks between TSOs, from numerous market and network studies, such as the EWIS study, the PLEF Regional Adequacy Forecast etc.
- A comprehensive assessment of resilience is presented synthetically. Principles are proposed as bases for future, refined and shared procedures for such assessments.
- A consultation of stakeholders has been performed to get feedback about the present report.
- This first release TYNDP will be the basis for seeking consistency with national and regional plans when the 3rd Package is enforced in early 2011.
- The detailed description of projects in Appendix 1 provides the necessary data to enable monitoring of the implementation of the plan as from the second edition.

The transmission investment projects listed in this report is the most accurate and up-to-date reference of the TSOs' continuous efforts to adapt the transmission network and have been the fruit of regional, multilateral or bilateral cooperation.

TABLE 9 LENGTH OF NEW AND REFURBISHED POWER LINES UNTIL 2020 (PROJECTS OF EUROPEAN SIGNIFICANCE)

Project tehcnology	Total Length Km	Length of new connections Km	Length of upgraded connections Km
AC	32500	25700	6900
of which >300kV	*29600*	*23200*	*6400*
DC (mainly subsea)	9600	9600	0
TOTAL	**42100**	**35300**	**6900**
of which in mid-term	*18700*		

The bulk of the new investments concern 400kV AC overhead lines (OHL); about 25% is new DC links (almost all sub-sea or underground cables). New 400 kV AC OHL projects are in technical, economic, and ecological terms the most efficient solution for long distance electricity transmission. Indeed, such reinforcements integrate straightforwardly into the existing grid since this technology has been the standard for a long time. In addition, other solutions are implemented to accommodate specific situations when necessary.

Given that the ENTSO-E transmission network consists of about 300 000 km of lines, it can be deducted from Table 9 that the TSO investment efforts correspond to more than 14% of the existing network in either new (12%) or refurbished (2%) power lines for the next ten years. In Fig. 67, the new or refurbished transmission lines are classified according to their contribution to the EU Energy Policy objectives.

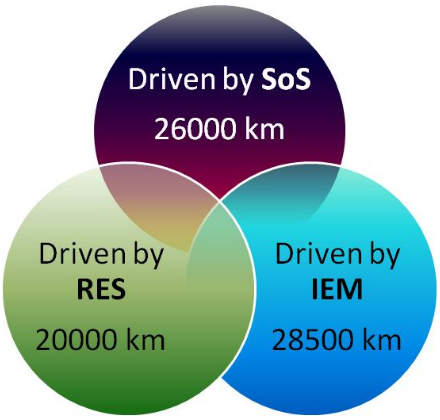

FIG. 67 MAIN DRIVERS FOR INVESTMENT IN NEW OR REFURBISHED POWER LINES (PROJECTS OF EUROPEAN SIGNIFICANCE)

The assets due to be completed within the next five years represent investment costs ranging from 23 to 28 billion €, spread all over Europe, as depicted in Table 10. Although this range represents just a fraction of the total investment efforts of TSOs (i.e. it does not include national or local investments on new/refurbished infrastructure, etc.) it does demonstrate the magnitude of challenges ahead.

TABLE 10 INVESTMENT COSTS OF TRANSMISSION PROJECTS OF EUROPEAN SIGNIFICANCE TO BE COMPLETED WITHIN THE PERIOD 2010-2014

Perimeter	Investments (billion €)
RG North Sea	12 to 14
RG Baltic Sea	11 to 13
RG CCS	11 to 12
RG CCE	8 to 9
RG CSW	6 to 7
RG CSE	4 to 5
Total ENTSO-E	**23 to 28**

For the longer run, a lot of reported projects are still under study and costs are not fully known, or several options (route, technology, etc.) are still open.

11.3 TOWARDS THE FUTURE RELEASES OF THE TYNDP

By its nature as a pilot project, this first release of the TYNDP is the best means for organising the future releases of the TYNDP in a consistent and productive manner in order to meet all stakeholders' expectations as well as the legislation requirements.

Fig. 68 depicts a possible way this is to be accomplished in the future, starting from the pilot TYNDP which is this report. The pilot project is the initialisation step of an iterative process, involving stakeholders, and enabling improvements from one release to the next.

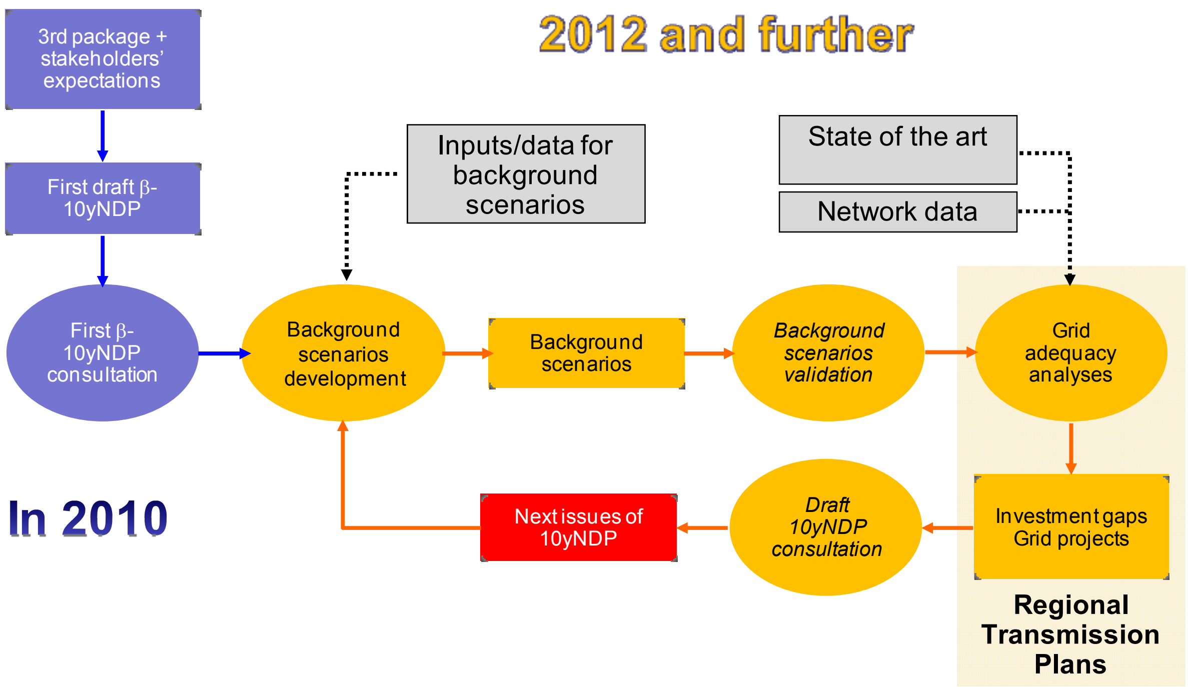

FIG. 68 BUILDING UP PROCESS OF THE TYNDP

With two consultations planned, one on scenarios, the second on the final deliverable, and common studies to perform meanwhile, the loop is actually an extensive two-year process.

In order to meet a future release in June 2012, works for the next issue of the TYNDP must start immediately after the first report is published, in July 2010.

Hence, ENTSO-E already anticipates the next release of the TYNDP. Efforts presently concentrate on the three main concerns:

- To update the present bottom-up scenarios, as well as develop shared, long-run, top down, scenarios, involving stakeholders and especially policy decision-makers. This complex, time consuming matter, will require the commitment and consensus of concerned parties to define at least the 2020 horizon and the completion of the EU 2020 targets based on the NREAPs finalised by June 2010.
- To develop common ENTSO-E European market modelling, reflecting as close as possible the forces which drive the commercial flow of electricity and its translation into physical power flows.
- To further develop a common framework for regional network studies based on an ENTSO-E European integrated network model for mid and long term.

Stakeholders supported strongly these proposed priorities during the consultation process.

Works about other pending issues, especially shared resilience criteria, in whatever respect are also being prepared. These are however long-lasting concerns and the scope of coordinated works must first be carefully defined with stakeholders, ACER and National Regulatory Authorities, before completion deadlines can be proposed. Progress in this respect will enrich the next releases of the TYNDP.

Critical to the above is the availability of data, especially concerning generation investment locations, to ENTSO-E in order to better forecast future needs. A clear framework on how reliable information reaches ENTSO-E needs to be set up and activated well before the second release of the TYNDP.

ENTSO-E intends to enrich the interaction with all stakeholders during the building up of the next releases of the TYNDP (in constructing scenarios, obtaining/providing data, sharing methodologies), or through meetings and workshops. Each release of the TYNDP will be subject of a public consultation. All these layers of exchange between ENTSO-E and stakeholders are meant to lead to the production of consistent, useful, and complete TYNDP reports.

[12] APPENDIX 1: TABLE OF PROJECTS

The following table shows some synthetic information about the projects mentioned in Chapter 6 of the main document. The aim is not to give here a full description of each project, which would go far beyond the scope the present document, but to provide some factual information as well as some overview of the drivers that triggered it and the social benefits that are expected.

The information provided in this appendix is not binding, neither TSOs nor ENTSO-E. It is in particular likely to evolve depending on permitting procedures, possible adaptations of the regulatory framework or for projects still under study.

For each project, the following information is displayed:

- ***Column 1*** of the table, ***"REF",*** shows the label under which the project is referred in the regional maps shown in Chapter 6 and in the pan-European views presented at the end of this Appendix.
- ***Column 2 "RGs"*** mentions the Regional Group(s) concerned by the project.

  NB: the same project may concern several RGs
- ***Columns 3 &4 "Substation 1" & "Substation 2"*** show both ends of the project; when only one substation is concerned (e.g. refurbishment or installation of some device like a new PST or compensation devices) , the two columns are merged. The code of the country concerned is given between brackets.

  NB: In order to make the reading easier, a project involving a whole set of works (e.g. erection of a new 400kV line with construction of a new substation, dismantling of an existing 220 kV one, installation of transformers and some rearrangement of the existing 220 kV grid in the area) is described in only one row of the table.
- ***Column 5 "Project characteristics"*** gives a brief description of the consistency of the project as well as some technical features (e.g. new line/upgrading of existing circuit, underground cable/OHL, double circuit/single circuit, voltage, route length).
- ***Column 6 "Investment need alleviated"*** explains briefly the drivers which triggered the need for these particular projects. These "investment needs" are addressed in Chapter 5 of the present document and displayed on the maps included. Drivers may be demand growth, low transfer capacity (not only cross-border but also internal, i.e; between two areas of the same country), connection of new generation, change of power flows patterns, evacuation of existing generation,…
- ***Column 7 "expected benefits"*** shows what kind of social benefits are expected from the realisation of the project. Typical items are: increase of SoS, increase of NTC, better integration of RES or conventional energy, IEM facilitation, reduction in redispatching costs, mitigation of CO_2 emissions, reduction in annual losses.
- ***Column 8 "present status"*** describes the progress of the project, with respect to the main typical phases of grid projects: under consideration / planned / design & permitting / under construction / completed;

- ***Column 9 "expected commissioning date"*** gives the year by which the project should be commissioned; it should reminded that this date highly depends of the duration of the permitting process, which TSOs do not master; for each project, the date given here is the most likely one, according to present status and to TSO's experience in conducting similar projects; in some cases, it may even be hard to forecast a date, for instance for projects at a very early stage, the consistency of which is still uncertain.
- ***Column 10 "TEN-E"*** shows a cross (x) whenever the project is supported by the EU in the framework of TEN-E programme or the European Energy Programme for Recovery: financial support may concern the project itself or the preliminary studies.
- ***Column 11 "comments"*** displays any additional information that could be of interest.

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Table of projects of European significance

REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
1	CSW	Frades B (PT)	Pedralva 1&2 (PT)	Creation of a new 400kV station in Frades B connected to Pedralva by means of two new 400kV, 40km lines. The realisation of this two connections can take advantage of some already existing 150kV single lines, which will be reconstructed as double circuit lines 400+150kV line and partially sharing towers with those 400kV circuits.	Integration of new hydro power plant in the area.	This project will provide higher RES integration and annual grid losses reduction.	design & permitting	2015		
2	CSW	Pedralva (PT)	Alfena (PT)	New 50km double circuit Pedralva (PT) - Alfena (PT) 400kV OHL (only one circuit installed in a first step).	Integration of new renewable generation units (wind & hydro) and strengthen the Security of Supply to Porto area.	Expected benefits regard RES integration, increase of NTC and improved security of supply.	planned	2016		
3	CSW	Pedralva (PT)	Vila Fria (PT)	New 55km double circuit Pedralva - Vila Fria 400kV OHL (one circuit installed), with needed extension of existing Vila Fria substation to include 400kV facilities.	The project is needed to increase the NTC with Spain, improve the capacity of the grid to receive new renewable energy (wind & hydro) in Northern Portugal and secure the supply to Vila Fria.	Expected benefits regard increased NTC, RES integration and improved security of supply.	design & permitting	2013		
4	CSW	Frades B - Ribeira de Pena - Feira (PT)		New 160km double-circuit 400kV OHL Frades B (PT) - Ribeira de Pena (PT) - Feira (PT) (one circuit operated at 220kV between R. Pena and Feira) with a new 400/60kV substation in Rib. Pena. In a first step, only the 130km section Rib. de Pena (PT) - Feira (PT) will be constructed and operated at 220kV as Vila Pouca Aguiar (PT) - Carrapatelo (PT) - Estarreis (PT) (see project 6). In a second step, one circuit of this line will be operated at 400kV.	Integration of new hydro and wind power plant in Northern Portugal.	The project is expected to help RES integration and provide annual grid losses reduction.	planned	2015		
5	CSW	Macedo de Cavaleiros (PT)	Vila Pouca de Aguiar (PT)	New 75km double circuit 400+220kV OHL (only 220kV circuit installed in the first step) Macedo de Cavaleiros (PT) -Valpaços (PT) - Vila Pouca de Aguiar (PT).	Integration of new renewable generation units and strengthen the Security of Supply to PT.	The project is expected to help RES integration (mainly wind) and improved the security of supply. In addition, an increase of ES-PT NTC is expected, due to reinforced exchange capacity on Douro border.	design & permitting	2010		
6	CSW	V. P. Aguiar - Carrapatelo - Estarreja (PT)		New 400+220kV double circuit OHL (initially only used at 220kV) Vila Pouca Aguiar - (Rib. Pena) - Carrapatelo - Estarreja . Total length of line: 2x(90+49)km.	Integration of new renewable generation units and improving the Security of Supply.	RES integration (mainly wind) and improved security of supply.	design & permitting	2012/2013		
7	CSW	Armamar - Bodiosa - Paraimo (PT)		This 120km double-circuit OHL has been constructed according to 400kV standards but is currently operated at 220kV as Valdigem (PT) - Bodiosa (PT) -Paraimo (PT). The project consists of operating one circuit at 400kV while creating a new 400/220kV substation in Armamar and upgrading the existing Bodiosa substation from 220/60kV to 400/60kV. Total length of line : 120km.	Insufficient capability of existing network to accommodate interior to littoral flows.	The project is expected to help RES integration, increase the NTC and improved the security of supply.	under construction	2010		

Table of projects of European significance

REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
8	CSW	V. Chã B - Arg./Góis - Penela - Paraimo / Batalha (PT)		New double circuit 400+220kV OHL (only 400kV circuit installed in a first step) Vila Chã B-Arganil/Gois-Penela (90km) plus new double circuit 400kV OHL (15km) to connect Penela substation to Paraimo - Batalha line. Two new 400/60kV substations at Vila Chã B and Arg./Góis are needed, as well as the expansion of the existing Penela substation to include 400kV facilities.	Insufficient capacity of the existing network to receive new renewable energy (wind and hydro).	The project is expected to help RES integration, improved the security of supply and reduce the annual grid losses.	planned	2015/2016		
9	CSW	Guarda - Ferro B - (C. Branco) - Falagueira (PT)		New double circuit 400+220kV OHL Guarda (PT) -Ferro B (PT) -'Castelo Branco zone' (PT) (between Guarda and Ferro B only the 400kV circuit will be installed) plus new double circuit 400+150kV OHL 'Castelo Branco zone' (PT) -Falagueira (PT). New 400/60kV substations in Guarda and Ferro B. Total length of line: 135km.	Insufficient capacity of existing network to receive new renewable energy (mainly wind).	The project is expected to help RES integration, improved the security of supply and reduce the annual grid losses.	planned	2013/2014		
10	CSW	Falagueira (PT)	Pego (PT)	New 40km double circuit 400kV OHL (only one circuit installed) substituting for an existing 150kV line.	Insufficient capacity to receive new renewable (wind and hydro) energy and need for alleviating some congestions near Falagueira (PT) substation.	The project is expected to help RES integration, increase the NTC and reduce annual grid losses.	planned	2014		
11	CSW	Batalha-Lavos-Paraimo (PT)		Two new 400kV lines Batalha-Lavos and Lavos-Paraimo, needed to accommodate two new combined cycle power plants (4x435MW) on Littoral Central Region. Total length: 115km.	Needed to receive new CCGT power plants (4x435MW) that are in construction or permitting in Littoral Central Region.	The project is expected to help conventional generation integration, improved the security of supply and reduce annual grid losses.	under construction	2010/2012		
12	CSW	Rio Maior - Alm. Bispo - Fanhões (PT)		New 71km double circuit 400kV OHL feeding Lisbon area from north with creation of a 400/220/60kV substation in Almargem do Bispo. A section of this reinforcement (between Rio Maior and Carvoeira zone) will be finished earlier included on a 400/220kV double circuit line linking Rio Maior and Carregado substations.	The project is needed to improve the security of supply to Lisbon Area.	The project is expected to improve the security & diversity of supply and reduce annual grid losses.	planned	2016/2019		
13	CSW	Palmela - F. Ferro - Fanhões (PT)		Expansion of Fernão Ferro substation to include 400kV facilities and connection to the existent Palmela (PT) - Fanhões (PT) single circuit line by a new 25km double-circuit 400kV OHL.	The project is needed to improve the security of supply on Setúbal Peninsula area.	The project is expected to improve the security & diversity of supply and reduce annual grid losses.	design & permitting	2012		
14	CSW	Marateca - Pegões - Fanhões (PT)		New 90km double-circuit 400kV OHL (one circuit only installed between Pegões and Fanhões). This new line will be connected to already existing line Palmela (PT) - Sines 2 (PT) , so making a direct link Sines-Pegões (PT) - Fanhões (PT) substations.	Congestions on existing network due to north-to-south flows.	Conventional generation integration, improved security of supply and increase of NTC.	design & permitting	2012		

Table of projects of European significance

REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
15	CSW	Falagueira-Estremoz - Divor - Pegões (PT)		New 400/60kV substations in Pegoes and Divor connected by a new 116km Pegoes (PT) - Divor (PT) - Estremoz (PT) single circuit 400kV OHL. In addition, the operating voltage of the existing Estermoz substations and the 93km single circuit Falagueira (PT) -Estremoz (PT) 150kV OHL will be changed to 400kV (were prepared for that).	Special needs for TGV projects and reinforcement to Estremoz and Évora supply.	The project is expected to improve the security of supply, increase the NTC and reduce annual grid losses.	design & permitting	2012		
16	CSW	Aldeadávila (ES)	Lagoaça (PT) - Armamar (PT) - Recarei (PT)	New Duero Interconnection 400kV New 400kV OHL interconnection line Aldeadávila (ES) - Lagoaça (PT) , including new Lagoaça substation (PT). Also associated, the lines Lagoaça-Armamar-Recarei 400kV in PT and the Armamar (PT) 400/220kV substation. On a first phase (2009) a new 400/220kV substation (Lagoaça - PT) will be created with only 220kV level installed, and there will be some rearrangements and reinforcements on the local 220kV network structure. On river crossing a new 220kV double line with separated circuits, firstly Aldeadavila (ES) - Lagoaça (PT) 1 & 2 and changing later to Aldeadavila (ES) - Pocinho (PT) 1 & 2, will substitute the existing two 220kV lines Aldeadavila (ES) – Bemposta (PT) and Aldeadavila (ES)-Pocinho (PT). Total length: 1km (ES)+105km (PT).	Limitations and congestions on the 220kV network in the Douro area where new hydro power stations (~800MW) are in construction or permitting in Portugal, in addition to export/import situations between Portugal and Spain.	Increase of NTC (From today 1100-1500MW up to 1500-2000MW), RES integration and conventional generation integration. Support in Iberian (ES+PT) market integration in MIBEL.	design & permitting for 400kV under construction for Lagoaça substation and 220kV restructuring in Portugal	2009/2010	X	
17	CSW	Guillena (ES)-Puebla de Guzman (ES)	Tavira (PT)-Portimao (PT)	New Southern Interconnection New 400kV OHL double-circuit line between Guillena (ES)-Puebla de Guzman (ES) - Tavira (PT) - Portimão (PT), including new Tavira (PT) and P.Guzman (ES) 400kV substations. On the interconnection section P.Guzmán (ES) –Tavira(PT), initially only one circuit will be placed. Total length: 153km (ES)+110km(PT).	Congestion that occurs on the existing 400kV line Alqueva (PT) -Brovales (ES) at high level of exportation from Portugal to Spain, limiting exchange capability from Portugal to Spain.	The project is expected to increase NTC (up to 3000MW from Portugal to Spain), help RES integration and improved the security of supply. Support in Iberian (ES+PT) market integration in MIBEL.	design & permitting	2011	X	
18	CSW	O Covelo (ES)-Boboras (ES)	Vila Fría (PT)-Vila Conde (PT) - Recarei (PT)	New double circuit 400kV OHL between O Boboras (ES) - O Covelo (ES) - Vila Fria (PT) - Vila do Conde (PT) - Recarei (PT), including new 400kV substations O Covelo (ES), Boboras (ES), Vila Fria (PT) and Vila do Conde (PT). On the section O Covelo (ES) – Vila do Conde (PT), only one circuit will be placed. Total length: 43km (ES)+112km (PT).	Congestion on the existing 400kV line Cartelle (ES) -Lindoso (PT) at high level of exportation from Spain to Portugal. Special needs for High Speed Train projects.	The project is expected to increase NTC (up to 3000MW from Spain to Portugal), help RES integration and improved the security of supply. General Benefit: Market integration in MIBEL.	design & permitting	2014	X	
19	CSW	Vic (ES)	Pierola (ES)	Upgrading (uprating) the existing 75km single circuit Vic-Pierola 400kV line in order to increase its capacity from 1360 MVA to 1710 MVA.	Congestions in the FR-ES border. Necessity of adapting the existing network to the new Eastern interconnection.	Increase of NTC and improved of security of supply.	design & permitting	2010		
20	CSW	Arkale (ES)	Hernani (ES)	Upgrading the existing 12km single circuit Arkale-Hernani n°2 220kV OHL in order to increase its capacity up to 670 MVA.	Overloads in this line in high export situations to France.	Increase of NTC and RES integration.	design & permitting	2011		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
21	CSW	Aldeadavila (ES) JM Oriol (ES)	Villarino (ES) Arenales (ES)	Upgrading the existing 18km Aldeadávila-Villarino 400kV OHL in order to increase its capacity from 1350MVA to 1690MVA. New 220kV JM Oriol-Arenales, and new Arenales substation.	Limitations in the NTC values from Portugal to Spain.	Increase of NTC on ES-PT border, around 2000MW from PT to ES in some peak situations. RES integration and annual re-dispatching cost reduction.	design & permitting	2012/2014		
22	CSW	Boimente (ES)	Ichaso (ES)	North axis Project between Galicia and the Basque Country. Part of the project is considered as the Asturias Ring. New 162km double circuit Boimente-Pesoz- Grado 400kV OHL. Change of voltage level of the existing 50km Soto-Tabiella single circuit from 220kV to 400kV, and connection as input/output in Grado. New 178km single circuit Soto-Penagos 400kV OHL. New 96km double circuit Aguayo/Penagos-Abanto 400kV OHL New 34km double circuit Zierbena-Abanto-Gueñes 400kV OHL. New 120km double circuit Gueñes-Ichaso OHL. New 58km double circuit Gozón-Carrio-Lada -Sama 400kV OHL. It is expected to use the corridors of existing lower voltage lines for some sections. New 124km double circuit Sama-Velilla 400kV OHL. Upgrading (uprating) the 73km single circuit Lada-Robla 400kV OHL in order to increase its capacity by around 300 MVA. It includes new 400kV substations Pesoz, El Palo,Salas, Grado, Gozón, Sama, Carrio, Valle del Nalon, Costa Verde, Penagos, Solorzano, Abanto and Ichaso, with transformers to 220kV.	Congestions in the 400kV lines between the north-western area and the East, because of the attraction of this area as a production site. Congestions in the 220kV network due to the increase of demand in Cantabria, that has today only one 400kV injection from the south. Constraints in the north-to-south direction due to the expected increase of generation in the north-West and north-East areas. Limitations of production of Santurce and Zierbena power plants (high concentration of generation), which sole evacuation line (Santurce-Gueñes) has a slight capacity.	The project is expected to help mainly RES and also conventional generation integration. It will allow to connect regional networks and enhance mutual support. In addition, security and quality of supply in some north Spain areas will be improved.	design & permitting	2010/2015	X	TEN support for studies concerning: Lada-Velilla, Boimente-Narcea, Soto-Penagos, Penagos-Gueñes and Gueñes-Ichaso, Santurce evacuation
23	CSW	Vitoria (ES)	Magallon (ES)	Northern part of the new Cantabric-Mediterranean axis. New 144km double circuit Castejón-Muruarte-Dicastillo-Vitoria 400kV OHL, with new 400kV substations in Muruarte and Dicastillo with 400/220kV transformers New 32km double circuit La Serna-Magallón 400kV OHL.	The project is needed to accommodate geographical unbalances between production (in Northern Spain) and consumption (Mediterranean area) that otherwise would produce congestion in the 400kV corridors of Valladolid/Palencia-Madrid and Aragón/Cataluña-Levante. Need to alleviate congestion on the 220kV network supplying Pamplona. Also need to alleviate congestions on the 400kV and 220kV network between La Serna and Magallón in several production profiles (mainly with high wind power energy) and after contingencies.	The project is expected to improve RES integration, security of supply and reduce annual re-dispatching cost.	design & permitting	2011/2012	X	TEN: La Serna-Magallon

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24	CSW	Fuendetodos (ES)	Eliana Turis (ES)	Southern part of the new Cantabric-Mediterranean axis. New 110km double circuit Fuendetodos-Muniesa-Mezquita-Morella 400kV OHL. New 77km double circuit Teruel-Mudejar-Morella 400kV-OHL. New 78km double circuit La Plana-Morella 400kV OHL substituting to the existing single circuit line. New 63km single circuit La Eliana-La Plana 400kV OHL and upgrading (uprating) the existing line. New 162km double circuit Mezquita-Platea-Turis 400kV OHL. As a first step, in 2012, the new Turis substation will be equipped with a 400/220kV transformer and connected to the existing 400kV lines Cofrentes-La Eliana, and Catadau-Requena 400kV lines. New 400kV substations Mezquita, Platea, Muniesa, and Mudejar with 400/220kV transformer units Upgrading (uprating) the existing 76km Aragón-Peñaflor 400kV OHL	The project is needed to accommodate geographical unbalances between north of Spain and Mediterranean area, that otherwise would produce congestion in 400kV existing corridors. Necessity of integration of wind power energy in an area without enough transmission network. In addition, congestion is expected in Levante area because the low capacity of the existing La Eliana-La Plana 400kV OHL is not sufficient to cope with the high flows coming from the northwest to supply the high increase of demand in Levante.	RES integration, improved security of supply and conventional generation integration.	design & permitting	2011/2014		
25	CSW	Aragón (ES) - Isona (ES) & Escatron (ES) - La Secuita (ES)		New 167km double circuit Aragón/Peñalba-Monzón II-Isona 400kV OHL with new 400kV substations Monzón II and Isona, and a 400/220kV transformer in Monzon II. New 60km single circuit Escatrón-Els Aubals-La Secuita 400kV OHL with a new 400kV substation in Els Aubals with 400/220kV transformer.	Congestion on existing grid due to unbalanced production and consumption between Aragón and Cataluña.	The project is expected to benefit in Annual re-dispatching cost reduction and higher RES & conventional generation integration.	design & permitting	2013/2014		
26	CSW	Catadau (ES)	Benajama (ES)	New 123km double-circuit Catadau-Jijona-Benejama 400kV OHL using the right-of-way of the existing 220kV lines that will be dismantled. A new 400kV substation will be created at Jijona and transformers installed in Jijona and Catadau.	Congestions due to the low capacity of the Benejama-Jijona-Catadau axis, that faces overloads due to high north-to-south flows to supply the Levante demand.	The project should improve the security of supply and reduce the annual grid losses.	design & permitting	2015		
27	CSW	Morvedre (ES)	Santa Ponsa (ES)	Connection of Balearic Islands to Mainland New bipolar 2x200MW HVDC (LCC) 250km connection between Morvedre (mainland) and Santa Ponsa (Mallorca) via 250kV. subsea cable. In addition, Mallorca will be connected to Menorca with a new HVDC 120km link between Santa Ponsa (Mallorca) and Torrente (Menorca). A second connection between Mallorca and Ibiza (60km) will also be constructed.	Need of connecting Balearic Islands (isolated system) to the Continental Europe system through the Spanish mainland.	Expected benefits are an improved security & diversity of supply and connection of isolated areas.	design & permitting	2011	X	
28	CSW	Cofrentes (ES)	Pinilla (ES)	New 82km single circuit Cofrentes-Ayora-Campanario-Pinilla 400kV OHL. This project also includes a new 400kV substation in Campanario.	Necessity of mutual support between two axis of 400kV Cofrentes-Benejama-Rocamora and Romica-Rocamora to avoid overloads in contingencies. Look for a possibility to allow more wind power production in the Peñarrubia area.	Expected benefits regard RES integration, annual re-dispatching cost reduction and CO2 emission mitigation.	design & permitting	2012		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
29	CSW	Cartuja (ES)	Guadame (ES)	New 94km double circuit Cartuja-Arcos de la Frontera-La Roda-Cabra-Cordoba-Guadame 400kV OHL . It includes new 400kV substations Cartuja and Cordoba, with 400/220kV transformers.	The concentration of generation (combined cycle and wind power energy) in the Cadiz and Tajo de la Encantada area causes constraints, in contingency situations, in the 400kV and 220kV network in case of high production profiles.	The project will help RES & conventional generation integration and Improved the security of supply.	design & permitting	2010/2013	X	
30	CSW	Don Rodrigo (ES)	Almaraz (ES)	Two new double circuit 400kV OHL: Guillena-Guadaira-Don Rodrigo and Guillena-Brovales-Arroyo S.Servan-Alcuescar- Almaraz. This project also includes new 400kV substations in Arroyo S.Servan, Alcuescar and Guadaira with 400/220kV transformers. Total length : 383km.	Expected overloads in the existing link between Extremadura and Sevilla in both directions, depending on the future production profile (new generation in both areas, but mainly in the south). Limits to the PT-ES NTC due to overloads in Alvarado-Balboa 220kV line in profiles from Portugal to Spain. Necessity of increase the flows to supply the high demand in Madrid.	The project is expected to improve the security of supply and help conventional, RES generation integration and avoid limits to NTC from Portugal to Spain.	design & permitting	2012/2015		
31	CSW	Caparacena (ES)	La Ribina (ES)	New 177km double circuit Caparacena-Baza-La Ribina 400kV OHL, with two new 400kV substations in Baza and La Ribina (these substations will be also connected to existing El Palmar-Litoral 400kV line). In addition, the existing 173km single circuit Litoral-Tabernas-Hueneja-Caparacena 400kV line will be upgraded (uprated) in order to increase its capacity from 1310 to 1590 MVA.	Necessity of integration of wind and solar power energy in addition to a new pump storage in the area of Baza. It takes the advantage to support the distribution. Need to alleviate the overloads in the 400kV Caparacena-Hueneja in some production profiles.	The project is expected to improve RES (especially wind & solar energy) integration, diversity & security of supply.	design & permitting	2012/2013		
32	CSW	several 400kV lines concerned (ES)		Upgrading several 400kV lines in the area between Aldeadávila, the south of Extremadura, Madrid and the Portuguese border.	Need of alleviating expected overloads in some 400kV lines in contingency situation, due to the new generation projects in Extremadura and south of Madrid.	The project should improve security of supply, conventional generation integration and RES integration.	design & permitting	2008/2011		
33	CSW	Romica (ES)	Brazatortas (ES)	Transmanchega project (total length 255km) New double circuit line Romica-Manzanares-Brazatortas 400kV OHL. New substation Manzanares with a 400/220kV transformer unit. The new 400kV substation Brazatorta will be commissioned in 2012 and connected to the existing line Guadame-Valdecaballeros.	The project is needed for integration of wind energy (insufficient capacity of existing network to transmit the power). In addition, the 220kV network supplying Ciudad Real is close to congestion and would need some support.	The project is expected to provide higher RES integration and improved security of supply.	design & permitting	2013/2015		

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34	CSW	Trives (ES)	Moraleja (ES)	SUMA Project (using part of an existing 220kV corridor) New 201km single circuit Trives-Aparecida-Valparaiso-Tordesillas 400kV OHL. New 130km double circuit Tordesillas-Segovia/Herreros-Galapagar/(El Cereal-SS Reyes) 400kV OHL New 33km double circuit Galapagar-Moraleja 400kV OHL (substituting for the existing line) and new PST in the 400kV line Galapagar-Moraleja. Upgrade of the 21km existing single circuit Loeches-SS Reyes 220kV OHL to 400kV in order to increase its capacity. New 33km double circuit 400kV Mudarra-Tordesillas OHL and upgrade of the existing 25km single-circuit Mudarra-Tordesillas 400kV line in order to increase its capacity. The project includes new 400kV substations in Aparecida and Herreros .	Congestion from the northwest area to the centre of the country due to the attraction of Galicia as a production site (conventional and wind power plants). The new expected generation in north-Western Spain causes overloads on the lines transmitting the power to Madrid. High flows on Madrid ring cause congestion on the existing Galapagar-Moraleja and SS.Reyes-Loeches 400kV lines.	The project is expected to reduce annual re-dispatching cost, improved the security of supply and help RES integration. It will also help conventional energy integration.	design & permitting	2011/2015		
35	CSW	to be determined (ES)	to be determined (ES)	Reinforcements in the 220kV network overall the country, in addition to upgrading of 300km of 220kV network , due to wind power evacuation.	Lack of network capacity to evacuate wind power energy, and congestion in some 220kV lines.	These projects will provide higher RES integration.	design & permitting	2009/2014		
36	CSW CCS North Sea	Sta.Llogaia (ES)	Baixas (FR)	New HVDC (VSC) bipolar interconnection in the Eastern part of the border, via 320kV DC underground cable using existing infrastructures corridors and converters in both ending points. The thermal capacity is expected in the range 2x825-2x1000MW. Total line length: 60km	Limited NTC in both directions and limitations to the integration of wind power energy in the Iberian Peninsula.	The project will provide increased cross-border capacity, up to 2800 MW from FR to ES (today 1400MW), higher RES integration and improved security of supply. The project increases the security of the system in case of major incidents. Close to the diversity of supply benefits, decrease in CO2 emissions is expected.	design & permitting	2014	X	European Coordinator Mr. Mario Monti appointed by DGTREN. There is a political agreement on the proposed solution.
37	CSW	Santa Llogaia (ES)	Bescanó (ES)	New 119km double circuit Sta.Llogaia-Ramis-Bescano-Vic/ Senmenat 400kV OHL (single circuit in some sections) New 400kV substations in Bescano, Ramis and Sta.Llogaia, with 400/220kV transformers in Ramis and Bescano.	Necessity of adapting the existing network to the new Eastern interconnection. Congestions mainly in the 400kV Vic-Baixas line and in Catalonian area in contingencies. Not enough transmission network for the connection of new generation in the Bescano area and support to the security of supply in the Girona area.	The project will provide an increase of NTC, improved the security of supply and support RES integration.	design & permitting	2010/2012	X	
38	CSW CCS North Sea	tbd (ES)	tbd (FR)	New cross-border line - not in the French department "Pyrenees Orientales" nor in the Spanish region of Cataluña.	Limited NTC of the ES- FR border in both directions.	Increase of interconnection capacity, up to 4000MW.	under consideration	long term	X	
39	CSW CCS North Sea	Avelin (FR)	Warande (FR)	Reconductoring (with ACSS) of both circuits of existing 400kV OHL between Avelin, Weppes & Warande. Total length : 85km	Need to alleviate congestion due to generation evacuation in Northern France	The project will reduce annual re-dispatching costs and improve the overall capability of the network to accommodate international power exchanges in the area.	under construction	2010		

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40	CSW CCS North Sea	Avelin (FR) Mastaing (FR)		Installation of a 3rd busbar in Avelin (existing 400-kV substation) & replacement of components to increase the ability to withstand short-circuit power; Connection of Mastaing (existing 400kV substation) to existing 400kV circuit between Avelin (FR) & Lonny (FR)	Need to alleviate congestion due to generation evacuation in Northern France	These projects will help conventional generation integration and improve the security of supply and the overall capability of the network to accommodate international power exchanges in the area.	under construction	2012		
41	CSW CCS North Sea	Fruges, Sud-Aveyron, Marne-Sud, Somme (FR)		New 400-kV substations connected to existing 400-kV network and equipped with transformers to 220 kV or high voltage networks	Need to connect new wind generation	These projects will result in higher RES integration.	design & permitting / under consideration	mid term		
42	CSW CCS North Sea	Lonny (FR)	Vesle (FR)	Reconstruction of the existing 70km single circuit 400kV OHL as double circuit OHL.	Need to alleviate congestion on the grid in Northern France (future generation evacuation + exchanges with Belgium)	The project will result in higher RES and conventional generation integration.	under consideration	long term (>=2019)		
43	CSW CCS North Sea	Mandarins (FR)		Replacement of thyristors in the AC/DC substation (IFA 2000 interconnector, DC voltage 270 kV)	Ageing/obsolescence of Mandarins converters	Reduction of infrastructure vulnerability	design & permitting	2011		
44	CSW CCS North Sea	Havre (FR)	Rougemontier (FR)	Reconductoring (with ACCS) of existing 54km double circuit 400kV line.	Need to integrate future conventional generation	The project will improve conventional generation integration, resulting in at least 2000MW generation evacuation capacity in Le Havre area.	design & permitting	2015		
45	CSW CCS North Sea	Taute (FR)	Oudon (FR)	"Cotentin-Maine "Project : new 163km double circuit 400kV OHL connected to existing network via two new substations in Cotentin and Maine regions.	Need to integrate Flamanville 3 nuclear power plant	The project will result in a generation evacuation capacity of 2100 MW in Cotentin area, for conventional units and RES.	design & permitting	2012		
46	CSW CCS North Sea	Baixas (FR)	Gaudière (FR)	Reconductoring of existing 70km double circuit 400kV OHL to increase its capacity.	Congestion is expected on existing asset due to increased exchanges with the Iberian peninsula	The project will result in increased ability to cope with higher exchanges with the Iberian peninsula.	under consideration	2014		
47	CSW CCS North Sea	Tamareau (FR)	Tavel (FR)	Reconductoring with ACCS of both circuits of existing 92km double circuit 400kV OHL to increase its capacity.	Congestion on existing asset due to high East to West power flows between Fos and Rhone Valley generation areas and South Western France; risk of energy not supplied to consumers in the Herault department.	The project will improve the security of supply of the Herault department and the ability of the network to accommodate generation in South-Eastern France.	under construction	2010		
48	CSW CCS North Sea	Gaudière (FR)	Rueyres (FR)	Reconductoring limiting sections (10 km) of existing single circuit 400kV OHL to increase its capacity.	Congestion on existing asset limiting existing generation evacuation, especially in the context of high international power flows.	The project is expected to result in reduced annual re-dispatching costs and improved overall capability of the network to accommodate international power exchanges in the area.	design & permitting	2012		

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49	CSW CCS North Sea	Cantegrit (FR)	Mouguerre (FR)	Reconductoring (with ACSS) of existing 83km single-circuit 220kV OHL to increase its capacity.	Congestion on existing asset, especially in the context of high flows to Spain on the Western axis of the France-Spain interconnection, resulting in potential risk of energy not supplied to consumers or NTC limitation.	The project will improve the security of supply of Bayonne area and also the overall capability of the network to accommodate different patterns of power flows on the Eastern and Western axes of the French-Spanish interconnection	design & permitting	2011		
50	CSW CCS North Sea	Néoules (FR)	Broc-Carros (FR)	The second circuit (formerly operated at 220kV) of a 197km double-circuit 400kV OHL will be operated at 400kV and 400/225 autotransformers installed in relevant substations.	Congestion due to thermal capacity of existing assets of Provence - Alps-Côte d'Azur (PACA) Region and voltage control problems, resulting in risks of load-shedding in the region.	The project will improve the security of supply of PACA region	under construction	2010		This project is the consequence of the 2006 cancellation of the permit for a new 400 kV OHL between Boutre and Broc-Carros.
51	CSW CCS North Sea	Boutre (FR)	La Bocca (FR)	PACA "Filet de sécurité" project: construction of 3 new 220kV underground cables (Boutre - Trans [72 km], Bianςon - Fréjus [26 km] & Bianςon - La Bocca [16 km]) and installation of reactive power compensation devices in 220 kV Boutre and Trans substations	Congestion due to thermal capacity of existing assets of Provence - Alps-Côte d'Azur (PACA) Region and voltage control problems, resulting in risks of load-shedding in the region	The project will improve the security of supply of PACA region	design & permitting	2015		This project complements Project 50 just above; needs DSM measures and new generation units in order to be fully efficient.
52	CSW CCS North Sea	Feuillane (FR)	Realtor (FR)	Operation at 400 kV of existing 63km double circuit OHL previously operated at 220kV	Limitation to future conventional generation in Fos area.	The project will improve the integration of conventional generation: ability to evacuate up to 1400 MW generation in Fos area	under construction	2011		
53	CSW CCS North Sea	Coulange (FR)	Le Chaffard (FR)	Reconductoring (with ACCS / ACCR) of two existing double circuit 400kV OHL (Coulange - Pivoz-Cordier - Le Chaffard and Coulange - Beaumont-Monteux - Le Chaffard) to increase their capacity. Total length of both lines: 275km	Need to alleviate congestion in the Rhone Valley.	The project is expected to provide annual re-dispatching costs reduction while improving the overall capability of the network to accommodate international power exchanges in the area	design & permitting	2016		
54	CSW CCS North Sea CSE	Cornier (FR)	Piossasco (IT)	Replacement of conductors (by ACCS) on Albertville (FR) - Montagny (FR) - Cornier (FR) and Albertville (FR) - La Coche (FR) - La Praz (FR) - Villarodin (FR) - Venaus (IT) - Piossasco (IT) single circuit 400kV OHLs. In addition, change of conductors and operation at 400kV of an existing single circuit OHL between Grande Ile and Albertville (FR) currently operated at lower voltage, and associated works in Albertville (FR) 400kV substation. (Total length of lines : 257 km)	Need to increase cross-border capacity between France and Italy and, on the French side, improve the quality of supply of Savoie.	This upgrade of the existing assets is expected to provide an increase by about 600 MW of FR-IT NTC, improving the security of supply of the system.	under construction	2012	X	
55	CSW CCS North Sea CSE	Grande Ile (FR)	Piossasco (IT)	"Savoie - Piémont" Project : New 190km HVDC (VSC) interconnection FR-IT via underground cable and converter stations at both ends (two poles, each of them with 500MW capacity). The cables will be laid in the security gallery of the Frejus motorway tunnel and possibly also along the existing motorways' right-of-way.	Need to increase cross-border capacity between France and Italy.	The project will provide an increase of FR-IT NTC by about 1000MW, resulting in higher security of supply for the system.	design & permitting	long term	X	

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56	CSW CCS North Sea CSE	Camporosso (IT)		New 450 MVA PST in Camporosso (IT) 220kV substation on Camporosso (IT) - Menton (FR) - Trinité-Victor (FR) OHL.	Need to increase the security of supply in both French Cote d'Azur and Italian Liguria areas.	The project allows to operate the 220kV link closed, which provides improved security of supply of the area and a small increase of NTC between France and Italy.	under construction	2011	X	
57	CSW CCS North Sea	under consideration (FR)	under consideration (CH)	Reinforcement of the interconnection in the area of Geneva's lake.	Need to increase cross-border capacity of France with Switzerland and Italy.	The aim is to increase cross-border capacity; improved RES integration is also expected.	under consideration	long term		
58	CCS CCE North Sea Baltic Sea	Ensdorf (DE)	St. Avold (FR)	Change of conductors on the German part of this single circuit 220kV line (9 km) and installation of a phase-shifter in Ensdorf (DE) 220kV substation.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Improved security of supply and small increase of NTC	planned	mid term		
59	CSW CCS North Sea	Moulaine (FR)	Aubange (BE)	Installation of a second circuit on the existing 220kV cross-border OHL	Need to increase the cross border capacity on BE-FR border	The NTC will be increased by 300 MW (winter) / 150 MW (summer).	under construction	2010	X	
60	CSW CCS North Sea	under consideration (FR)	under consideration (BE)	to be determined.	Need to increase the cross border capacity on BE-FR border	Increase of NTC.	under consideration	long term		
60a	North Sea	Lillo (BE)	Mercator (BE)	Doubling of the axis Zandvliet-Mercator via Lillo by erecting a new 35km 380kV double circuit OHL with 1500 MVA capacity.	Needed to avoid overloading of the line during certain contingencies as a result of new generation and increasing demand.	Conventional generation integration; improved security of supply; Increase of NTC.	design & permitting	2018		
61	CSW CCS North Sea	Moulaine (FR)	Belval (LU)	Connection of SOTEL (industrial grid in LU) to RTE network by mixed (underground cable & OHL) single circuit 220kV line. Parts of the new line use existing ones.	SOTEL request for connection to RTE grid.	Improved the security of supply of SOTEL's customers connected to Belval substation.	design & permitting	2010		connection of a customer
62	CSW CCS North Sea	under consideration (FR)	under consideration (UK)	New subsea DC link, between GB and FR, possibly with a capacity of 1000MW (still to be determined).	Need for increasing interconnection capacity GB-continent.	Increase of FR-GB NTC by about 1000MW (still to be determined).	under consideration	ca. 2017		
63	CCS	Lienz (AT)	Veneto region (IT)	The project foresees the reconstruction of the existing 220kV-interconnection line as 380kV-line on an optimized route to minimize the environmental impact. Total length should be in the range of 100-150km.	Increase cross border capacity between Italy and Austria complying IEM.	The project is expected to improve the security of supply and increase the NTC.	planned	long term		
64	CCS	Bressanone (IT)	New substation near Innsbruck (AT)	New double circuit 400kV interconnection through the pilot tunnel of the planned Brenner Base Tunnel. Total line length: 65km.	Need to increase the cross-border capacity between Italy and Austria.	The project is expected to increase the NTC and Improved the security of supply.	under consideration	2020/2025	x	
65	CCS	Curon (IT)/ Glorenza (IT)	New substation close to the border in AT	New 380/220kV substation in AT directly located near the border ; erection of a 24km single circuit 220kV-connection via OHL and underground cable till Graun (IT) and upgrade of the existing line Graun (IT) – Glorenza (IT).	Need to increase the cross-border capacity between Italy and Austria.	The project is expected to increase the NTC and Improved the security of supply.	under consideration	long term		

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66	CCS CSE	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 and installing a 110kV/132kV PST in Steinach (AT).	Need to increase the cross-border capacity between Italy and Austria.	The project is expected to increase the NTC and Improved the security of supply.	design & permitting	short term		
67	CCE CCS CSE	Divaca (SI)		Installation of a new 400kV PST to assist control of power flows to Italy on secure level and secure the operation of Slovenian grid enabling full utilisation of regional market.	The project will provide improved security of supply, increased NTC and reduced re-dispatching costs & grid losses.	Improved security of supply, increase of NTC, annual re-dispatching costs reduction and annual losses reduction.	under construction	short term	X	
68	CCE CCS CSE	Okroglo (SI)	Udine (IT)	New 120km double-circuit 400kV OHL with installation of a PST in Okroglo. The thermal rating will be 1500 MVA per circuit.	Need for strengthening the connection between Slovenia and Italy and increasing of power exchange capability.	The project will increase NTC, improved the security of supply and achieve the diversity of supply. The PST in Okroglo substation will secure the operation of Slovenian grid, enabling full utilisation of regional market.	planned	long term	X	Common agreement between IT and SI TSOs
69	CCE CCS CSE	Candia (IT)	Konjsko (HR)	New 1000MW HVDC interconnection line between Italy and Croatia via 280km 500kVDC subsea cable and converters stations at both ending points.	Need to increase the cross border capacity between Croatia (and South East Europe in general) and Italy.	The project is expected to increase the NTC and Improved the security of supply.	Under consideration	long term		
70	CCS CSE	Villanova (IT)	Tivat (ME)	New 1000MW HVDC interconnection line between Italy and Montenegro via 375km 500kV DC subsea cable and converter stations at both ending points.	Increase cross border capacity between South East Europe area and Italy complying IEM.	increase of NTC , improved Security of Supply.	design & permitting	2014/2015	X	
71	CCS CSE	Brindisi (IT)	Babica (AL)	500MW single pole HVDC Merchant Line between Italy and Albania via 290km 400kV DC subsea cable and converter stations at both ends. On the Italian side, the new line will be connected to the existing substation of Brindisi South.	Need to increase the cross border capacity between South East Europe area and Italy.	The project is expected to increase the NTC and Improved the security of supply.	design & permitting	2013/2014		Merchant line
72	CCS CSE	Aetos(GR)	Galatina (IT)	Second 500MW HVDC link between Greece and Italy via 316km 400kVDC subsea cable and converters stations at both ends.	Increase cross border capacity between Balkan area and Italy complying IEM.	Increase of NTC and Improved security of supply.	under consideration	2020/2025		
73	CCS	El Aouaria (TU)	Partanna (IT)	New 350km 500MW HVDC line between Tunisia and Italy via Sicily with 400kV DC subsea cable and converters stations at both ends.	Need to increase the cross border capacity between Italy and North Africa.	The project is expected to increase the NTC, improved the security of supply and allow for integration of different markets.	design & permitting	2015		
74	CCS CSE	Chiaramonte Gulfi (IT)	Sorgente (IT)	Realization of 380kV ring grid, trough the construction of 3 new 380kV line: "Chiaramonte Gulfi - Ciminna", "Sorgente - Ciminna" and "Paternò - Priolo". It will be realized a new 380/150kV substation in Caltanissetta area and the voltage upgrade of the existing Ciminna substation up to 380kV. Total line length: 365km.	Congestion on the existing 220kV Sicily network. Future generation evacuation. Energy transfer from Western to Eastern part of Sicily.	RES integration, annual losses reduction and Improved security of supply.	planned	2015/long term		

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75	CCS CSE	Sorgente (IT)	Rizziconi (IT)	New 90km double circuit 400kV line, partly via subsea cable and partly via OHL. This line is part of a larger project that foresees the creation of the future 400kV ring grid of Sicily.	Need of increasing transport capacity between Sicily and Mainland, improving the security of supply (securing the coverage of energy demand and decreasing the probability of loss of load).	The project will support RES integration (by transmitting wind power from Sicily to mainland), reduce grid losses and Improved the security of supply (by avoiding the risk of Sicily tripping to isolated operation).	under construction	2013		
76	CCS CSE	Partanna (IT)	Ciminna (IT)	New 65km single circuit 400kV OHL in Sicily between existing Partanna and Ciminna substations.	Future generation evacuation.	The project will support RES integration, increase the NTC and reduce the re-dispatching costs.	planned	long term		
77	CCS CSE	Partinico (IT)	Fulgatore (IT)	New 45km single circuit 400kV OHL between Partinico and Fulgatore in Western Sicily.	The project is needed to improve the continuity of service, transmit power from future generation and make possible the interconnection with North Africa. It will also foster the connection of wind power plants foreseen in the area.	The project will support RES integration and reduce grid losses & re-dispatching costs.	planned	2015		
78	CCS CSE	Piana degli Albanesi (IT)		New 220/150kV substation, complying with 400kV standards, connected to the Ciminna substation with a new 400kV line and in & out the existing Bellolampo-Caracoli 400kV line.	Congestion on the 220kV network in the Palermo area.	Improved security of supply and annual losses reduction.	planned	long term		
79	CCS CSE	Agrigento (IT)		New 220/150kV substation, complying with 400kV standards. The new substation will be connected in and out to the existing Partanna-Favara 400kV line .	Congestion on the 150kV network in the Agrigento area.	Improved security of supply and annual losses reduction.	planned	long term		
80	CCS CSE	Noto (IT)		New 220/150kV substation, complying with 400kV standards, connected in and out to the existing Ragusa-Melilli 400kV line.	The project will improve the security of supply and reduce the grid losses.	Improved security of supply and annual losses reduction.	planned	long term		
81	CCS CSE	Trino (IT)	Lacchiarella (IT)	A new 380kV double circuit OHL between the existing 380kV substations of Trino and Lacchiarella in North West Italy area. Total line length: 95km, Voltage upgrade of the existing Magenta 220/132kV substation up to 380kV.	The project is expected to help conventional generation integration, improve the security of supply and reduce grid losses.	Conventional generation integration, improved security of supply and annual losses reduction.	design & permitting	short term		
82	CCS CSE	Chignolo Po (IT)	Maleo (IT)	A new 380kV double circuit OHL between the new 380kV substations of Chignolo Po and Maleo in Lodi area. Restructuring of HV network. Total line length: 22km.	Congestion of the 380kV in north West /north East area due to further increase of generation in Piemonte-Lombardia and the development of the Italian-French interconnection.	Conventional generation integration, improved security of supply and annual losses reduction.	under construction	2012		
83	CCS CSE	Volpago (IT)	North Venezia (IT)	Realization of a new 380kV line between the existing substation of North Venezia and the future 380kV substation of Volpago, connected in and out to the 380kV "Sandrigo - Cordignano" . Total line length: 31km.	Unsatisfactory security and quality of supply in the 380kV grid in the Triveneto area.	Improved security of supply and annual losses reduction.	design & permitting	short term		
84	CCS CSE	Casanova (IT)	Vignole (IT)	Voltage upgrade of the existing 100km Casanova-Vignole 220kV OHL to 400kV and new 400/220/150kV substation in Asti area.	Congestion of the 220kV grid due to further increase of generation in Piemonte and development of the Italian French interconnection.	The project is expected to support conventional generation integration, increase the NTC and reduce grid losses.	planned	2014/long term		

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85	CCS CSE	Voghera (IT)	La Casella (IT)	New 45km double circuit 400kV OHL between the existing substations of La Casella and Voghera.	Congestion of the 380kV in north West /north East area due to further increase of generation in Piemonte-Lombardia and the development of the Italian-French interconnection.	The project is expected to improve security of supply, support conventional generation integration and reduce grid losses.	planned	long term		
86	CCS	Foggia (IT)	Villanova (IT)	New 178km double circuit 400kV OHL between existing Foggia and Villanova 400kV substations, also connected in and out to the Larino and Gissi substations. A PST will be installed on the new 400kV line.	Increase of power exchange capability between south and central south of Italy in order to get over the splitting of the regional market caused by limited transfer capability in both directions.	The project is expected to support conventional generation integration, mitigate CO2 emission, reduce grid losses and help RES integration.	design & permitting	2015		
87	CCS	Feroleto (IT)	Maida (IT)	New 400kV OHL across Calabria between the existing substation of Feroleto and the future substation of Maida, while restructuring the existing grid in North Calabria.	Overcoming the overloads and voltage stability problems limits due to the present production units and the future generation in the area.	Conventional generation integration, CO2 emission mitigation, annual losses reduction and RES Integration.	design & permitting	short term		
88	CCS	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.	Overcoming the overloads and voltage stability problems limits due to the present production units and the future generation in the area.	Conventional generation integration, CO2 emission mitigation, annual losses reduction and RES Integration.	design & permitting	short term		
89	CCS CSE	Fano (IT)	Teramo (IT)	New 200km single circuit 400kV OHL between the existing 400kV substations of Fano and Teramo, providing the connection in and out to the future substation to be built in Macerata area.	Overcoming the congestions between the south and the north market area due to the generation development in the southern Italy.	The project is expected to improve security of supply, support conventional generation integration and reduce grid losses.	planned	2015		
90	CCS	Calenzano (IT)	Colunga (IT)	Voltage upgrade of the existing 80km Calenzano-Colunga 220kV OHL to 400kV, providing in and out connection to the existing 220/150kV substation of S. Benedetto del Querceto (which already complies with 400kV standards).	Increase of power exchange capability between north and central north of Italy in order to avoid with the regional market splitting.	The project is expected to support conventional generation integration and reduce grid losses.	design & permitting	short term		
91	CCS	Foggia (IT)	Benevento II (IT)	Upgrade of the existing 85km Foggia-Benevento II 400kV OHL and installation of a PST on this line.	Increase of power exchange capability due to the renewable generation development in Southern Italy.	The project is expected to support RES & conventional generation integration and Improved the security of supply.	design & permitting	short term		
92	CCS	West Udine (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.	Over coming the constraints in North Eastern area of Italy, especially near Redipuglia 380kV sub station, in case of high import from Slovenia and high production of conventional power plants.	The project is expected to support conventional generation integration, increase the NTC and Improved the security of supply.	design & permitting	short term		
93	CCS	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.	Overcoming the constraints in the Venezia and Padova area, due to production development in the North East of Italy.	The project is expected to improve the security of supply, support conventional generation integration and reduce grid losses.	design & permitting	short term		

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94	CCS	Sermide (IT)	Carpi (IT)	New 35km 400kV OHL between the existing substations of Sermide and Carpi.	Overcoming the constrains congestion between N and CN market zones, caused by limited transfer.	The project is expected to support conventional generation integration and reduce grid losses.	planned	long term		
95	CCS	Mese (IT)		Voltage upgrade of the existing 220/132kV Mese substation up to 400kV.	Overcoming the constrains in operation, due the renewable generation.	The project is expected to support RES integration and reduce grid losses.	planned	short term		
96	CCS	Deliceto (IT)	Bisaccia (IT)	New 30km single circuit 400kV OHL between the future substations of Deliceto and Bisaccia, in the Candela area.	increase of power exchange capability due to the new renewable generation development in the Southern Italy.	The project is expected to support RES & conventional generation integration and reduce grid losses.	design & permitting	short term		
96a	CCS CSE	Several new substation in south of Italy (IT)		It will be realized a group of new 380/150kV substations. The new substation will be connected to the wind farms in order to avoid the congestions on the 150kV network and dispatch the green energy.	Reduce the congestions on the 150kV network between Puglia, Campania and Calabria.	Improved security of supply and reduction of congestion.	under construction	Mid term		
97	CCS	Polpet (IT)		Voltage upgrade of the existing Polpet 150kV/medium voltage substation up to 220kV, complying with 400kV standards. The substation will be connected by two shorts links to the existing Soverzene-Lienz 220kV line.	Overcoming the constrains in operation, due the renewable generation.	The project is expected to support RES integration and reduce grid losses.	planned	long term		
98	CCS	Pordenone (IT)		Voltage upgrade of the existing Pordenone 220kV substation up to 400kV. The substation will be connected in and out to the existing Udine O. – Cordignano 400kV line.	Ensuring the supply in N and N-1 condition.	The project is expected to reduce grid losses and Improved the security of supply.	planned	long term		
99	CCS	Avise (IT)	Chatillon (IT)	Voltage upgrade of the existing 40km Avise-Villeneuve-Chatillon single circuit 220kV OHL up to 400kV.	Low transfer capacity on the tie-lines “Riddes – Avise” and “Riddes – Valpelline”, increase import/export power exchanges.	The project is expected to increase the NTC and reduce grid losses.	design & permitting	short term		
100	CCS	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.	Overcoming the constrains in operation and ensuring the supply in N and N-1 condition in large urban centres.	The project is expected to improve the security of supply and reduce re-dispatching costs & grid losses.	design & permitting	short term		
101	CCS	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. Total length: 63km.	Need to overcome the congestion in operation and ensure the supply to large urban centres under N and N-1 conditions.	The project is expected to improve the security of supply and reduce grid losses.	design & permitting	2012/long term		
102	CCS	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.	Need to overcome the congestion in operation and ensure the supply to large urban centres under N and N-1 conditions.	The project is expected to improve the security of supply and reduce re-dispatching costs & grid losses.	design & permitting	long term		
103	CCS	Brescia (IT)		New 400/132kV substation in South East area of Brescia, connected in and out to the existing Flero-Nave 400kVOHL, while restructuring the 132kV network.	Need to overcome the congestion in operation and ensure the supply to large urban centres under N and N-1 conditions.	The project is expected to improve the security of supply and support conventional generation integration.	planned	2015		

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104	CCS	Rome (IT)		Restructuring of the network in the Rome area. The work consists of : a new 380/150kV substation in south-West area of Rome, connected in and out to the existing 380kV line "Rome West-Rome South", a voltage upgrade of the existing Flaminia substation up to 380kV to be connected in and out to the foreseen 380kV line "Rome West - Rome North" and a restructuring of the 150kV network.	Need to overcome the congestion in operation and ensure the supply to large urban centres under N and N-1 conditions.	The project is expected to improve the security of supply and reduce grid losses.	design & permitting	2013/long term		
105	CCS	Treviso (IT)		New 380/132kV substation in Treviso area, connected in and out to the existing 380kV line “Sandrigo - Cordignano".	Need to improve the security of supply under N and N-1 conditions.	The project is expected to improve the security of supply and reduce grid losses.	design & permitting	long term		
106	CCS	Schio (IT)		New 220/132kV substation in Schio area, providing the connection in and out to the existing 220kV line "Ala-Vicenza Monte Viale”.	Need to improve the security of supply under N and N-1 conditions and overcome HV grid congestion.	The project is expected to improve the security of supply and reduce grid losses.	planned	short term		
107	CCS	Vicenza Industrial (IT)		New 380/132kV substation in the industrial area of Vicenza, connected in and out to the existing Sandrigo-Dugale 400kV line.	Need to improve the security of supply under N and N-1 conditions.	The project is expected to improve the security of supply and reduce grid losses.	planned	short term		
108	CCS	North West Padova (IT)		New 220/132kV substation in North West Padova area, complying with 400kV standards, providing the connection in and out to the existing Dugale-Marghera Substation1 220kV line.	Need to overcome the congestion in operation (also on HV grid) and ensure the supply to large urban centres under N and N-1 conditions.	The project is expected to improve the security of supply and reduce grid losses.	planned	long term		
109	CCS	North Bologna (IT)		New 400/132kV substation in North Bologna area connected in and out to the existing Sermide–Martignone 400kV line.	Need to improve the security of supply under N and N-1 conditions and overcome HV grid congestion.	The project is expected to improve the security of supply and reduce grid losses.	planned	short term		
110	CCS CCE	East Vesuvius (IT)		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".	Need to improve the security of supply under N and N-1 conditions and overcome HV grid congestion.	The project is expected to improve the security of supply and reduce grid losses.	planned	long term		
110a	CCS CSE	Rotonda (IT)	Montecorvino (IT)	Upgrade to 380kV of the 220kV Tuscan-Rotonda line.	Increasing transmission capacity between South and Centre of Italy.	RES integration, conventional generation integration and improved security of supply.	planned	Long term		
111	CCS CSE	Lucca (IT)		New 380/132kV substation in Lucca area connected in and out to the existing 380kV line “La Spezia-Acciaiolo”.	Need to improve the security of supply under N and N-1 conditions.	The project is expected to reduce re-dispatching costs and grid losses.	planned	long term		
112	CCS	Tirano (IT)	Verderio(IT)	New 140km single circuit 400kV OHL between Tirano and Verderio substations connecting also the new 400kV substation Grosio/Piateda.	Need to reduce the congestion and increase internal transfer capacity.	The project is expected to support RES integration, and reduce grid losses.	planned	long term		
113	CCS	Monte S. Savino (IT)		New 400/220/132kV substation in Monte S. Savino area connected to the existing S. Barbara 400kV substation by upgrading an existing 220kV line.	Overcoming the congestions caused by the South-North transits.	The project is expected to improve the security of supply and reduce grid losses.	design & permitting	long term		

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114	CCS	Ittiri (IT)	Codrongianos (IT)	New 18km 400kV OHL between the existing substation of Codrongianos and the future 400kV substation of Ittiri that will be also connected in and out to the existing Fiumesanto-Selargius 400kV line.	Overcoming congestion in the Northern Sardinia due to the existing power plants and development of the interconnection with Mainland.	The project is expected to support conventional generation integration.	under construction	2011		
115	CCS	Fiumesanto (IT)	Latina (IT)	Second pole of HVDC link between Sardinia and mainland Italy via 400kV DC subsea cable (420km). The first pole is in operation since 2009. Total capacity of the bipolar link: 1000MW.	Increase of security of Supply in Sardinia island and overcoming the splitting the regional market caused by limited transfer.	The project is expected to support RES integration, reduce re-dispatching costs and Improved the security of supply.	under construction	2010		
116	CCS	Casellina (IT)	Tavarnuzze (IT)	New 37km 400kV OHL with rearrangement of EHV grid in the area between Casellina and S. Barbara. Voltage upgrade of the existing substations of Casellina400/132kV and S. Barbara400/132kV.	Overcoming the congestions caused by the upgrading of S. Barbara Power Plant and the South-North transits.	The project is expected to support conventional generation integration.	under construction	2010		
117	CCS	Castegnero (IT)		New 220/132kV substation connected in and out to the existing 220kV line “Cittadella – Este” and “Dugale – Stazione 1”, providing a restructuring of HV grid.	Ensuring the security of supply in N and N-1 condition.	The project is expected to improve the security of supply and reduce grid losses.	under construction	2011		
118	CCS	Porto Ferraio (Elba Island)	Cornia (Piombino)	New 40km 132kV connection via subsea cable between the existing substation of Porto Ferraio and the future 400/132kV substation of Cornia that will also be connected in and out to the existing Suvereto-Piombino Termica 400kV line.	Need to strengthen the connection of Elba Island to mainland.	The project is expected to improve security of supply, reduce annual re-dispatching costs and annual losses.	design & permitting	short term		
119	CCS	Capri, Ischia, Procida (IT)		New 150kV subsea connection between the Capri, Ischia and Procida islands to the existing substations of Cuma and Torre Annunziata (mainland Italy). Total length : 95km.	Need to connect the isolated systems of these islands to mainland.	The project is expected to improve the security of supply, mitigate CO2 emissions and reduce grid losses.	design & permitting	short term		
120	CCS CSE	Lavorgo (CH)	Morbegno (IT)	New 400kV tie line between Italy and Switzerland.	Need to increase cross-border capacity between Italy and Switzerland.	The project is expected to increase NTC.	under consideration	>2020		
121	CCS	Bickigen (CH)	Romanel (CH)	Construction of different new 400kV OHL sections and voltage upgrade of existing 225kV lines into 400kV lines. Total length: 250km.	Need to transmit power from existing and future generation.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	design & permitting	2014		
122	CCS	Chippis (CH)	Lavorgo (CH)	Construction of different new 400kV line sections and voltage upgrade of existing 225kV lines into 400kV. Total length: 120km.	Need to transmit power from existing and future generation.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	design & permitting	2014		

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123	CCS	Mettlen (CH)	Ulrichen (CH)	Construction of different new 400kV line sections and voltage upgrade of existing 225kV lines into 400kV lines. Total length: 90km.	Need to transmit power from existing and future generation.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	planned	2015		
124	CCS	Mettlen (CH)	Airolo (CH)	Upgrade of existing 225kV OHL into 400kV. Line length: 90km.	Need to transmit power from existing and future generation.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	under consideration	2020		
125	CCS	Schwanden (CH)	Limmern (CH)	New 400kV double circuit (OHL and underground cable) between Schwanden and Limmern.	Need to transmit power from future generation and pump storage.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	design & permitting	2015		
126	CCS	Golbia (CH)	Robbia (CH)	New 2x 400kV cable connection between Golbia and the Bernina line double circuit.	Need to transmit power from future generation and pump storage.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	under consideration	2020		
127	CCS	Magadino (CH)	Verzasca (CH)	Upgrade of existing 150kV line into 220kV line.	Need to transmit power from future generation and pump storage.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	under consideration	2020		
128	CCS	Bâtiaz (CH)	Nant de Drance (CH)	New 400kV double circuit OHL between Bâtiaz and Châtelard. New 2x 400kV cable connection between Châtelard and Nant de Drance. Total length: 22km.	Need to transmit power from future generation and pump storage.	The project is expected to support hydro power generation and pump storage integration and Improved the security of supply.	design & permitting	2014		
129	CCS	Beznau (CH)	Mettlen (CH)	Upgrade of the existing 65km double circuit 220kV OHL to 400kV.	Need to overcome existing bottleneck limiting both import (from France, Germany & Austria) and generation of Beznau power plant.	The project is expected to increase NTC, improved the security of supply and support conventional generation integration.	design & permitting	2015		
130	CCS	La Punt (CH)	Pradella / Ova Spin (CH)	Installation of the second circuit on existing towers of a double-circuit 400kV OHL (50km).	Need to overcome existing bottleneck limiting import from France, Germany and Austria.	The project is expected to increase NTC.	planned	2015		
131	CCS	Bickigen (CH)		Addition of a second 400/220kV transformer in an existing substation.	Need to overcome existing bottleneck limiting both from France, Germany & Austria.	The project is expected to increase NTC and Improved the security of supply.	design & permitting	2012		
132	CCS	Mühleberg (CH)		Construction of a new 400/220kV substation.	Need to overcome existing bottleneck limiting both from France, Germany & Austria.	The project is expected to increase NTC and Improved the security of supply.	design & permitting	2012		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
133	CCS	Bonaduz (CH)	Mettlen (CH)	Upgrade of the existing 180km double circuit 220kV OHL into 400kV.	Need to improve the connection between the Alps and the urban area.	The project is expected to improve the security of supply.	under consideration	2020		
134	CCS	Bassecourt (CH)	Romanel (CH)	Construction of different new 400kV line sections and voltage upgrade of existing 225kV lines into 400kV lines. Total length: 140km.	Need to overcome existing bottleneck limiting both from France, Germany & Austria.	The project is expected to increase NTC and Improved the security of supply.	design & permitting	2012		
135	CCS	220kV nodes (CH)		Many 220kV reinforcement around the urban areas.	Need of better connection of the urban areas.	These projects will improve the security of supply.	planned	2015		
136	CCS CCE North Sea Baltic Sea	Area of Bodensee (DE, AT, CH)		Construction of new lines, extension of existing ones and erection of 400/220/110kV-substation.	This project will increase the current power exchange capacity between the DE, AT and CH.	The project is expected to increase NTC and Improved the security of supply.	planned	long term		
137	CCS CCE North Sea Baltic Sea	Vitkov (CZ)	Mechlenreuth (DE)	New 400kV single circuit tie-line between new (CZ) substation and existing (DE) substation. Length: 70km.	This project will increase the current power exchange capacity between the Czech Republic and Germany.	Increase of NTC.	under consideration	long term		
138	CCS CCE North Sea Baltic Sea	under consideration (CZ)	South-Eastern part of 50Hertz Transmission control area	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).	The project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the cross-border transmission capacity of the grid.	It is expected that the project will maintain or even Improved the security of supply, and support RES integration and CCE Market development.	under consideration	long term		
139	CCS CCE North Sea Baltic Sea	Vierraden (DE)	Krajnik (PL)	This project is the conversion of existing 220kV double circuit line Krajnik (PSE Operator) - Vierraden (50Hertz Transmission) into a 400kV line together with installation of phase shifting transformers in Krajnik (PSE Operator) and Mikułowa (PSE Operator).	The project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the cross-border transmission capacity and flexibility of the grid.	It is expected that the project will decrease the loop flow from DE to PL and to CZ/SK. It will improve the security of supply, increase the power exchange capacity between PL and DE on PL/DE/CZ/SK synchronous profile (i.e. support CCE market development) and support the RES integration.	design & permitting	before 2013	X	conversion of the existing 220 kV double circuit line Krajnik (PSE Operator) - Vierraden (5 Hertz Transmission) into a 400 kV line is a top priority project according to German act for acceleration of transmission grid extension (EnLAG)
140	CCS CCE North Sea Baltic Sea	Eisenhüttenstadt (DE)	Plewiska (PL)	This project is the 3rd 400kV double circuit OHL interconnection between Poland (Plewiska) and Germany (Eisenhüttenstadt) with reinforcement of the Polish internal grid. Total length is 252km, 242km of which being in Poland.	The project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the cross-border transmission capacity of the grid.	It is expected that the project will support the CCE market development, RES integration and maintain or even Improved security of supply.	planned	long term	X	Top priority project according to German act for acceleration of transmission grid extension (EnLAG); German-Polish project development company is in preparation

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
141	CCS CCE North Sea Baltic Sea	Ishøj/Bjæverskov (DK)	Bentwisch (DE)	The Kriegers Flak project is the new subsea cable multiterminal connection between Denmark, Sweden and Germany used for both grid connection of offshore wind farms Kriegers Flak and interconnection. Technical features still have to be determined.	The project will alleviate mainly the need of 1) grid connection for new off-shore wind farms in the Baltic Sea and 2) additional cross-border transmission capacity of the grid.	RES integration and increase of NTC.	under consideration	2014		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Kriegers+Flak/
142	CCS CCE North Sea Baltic Sea	Tonstad (NO)	tbd (DE)	Nord.Link: A new HVDC connection between Southern Norway and Northern Germany. Estimated subsea cable length: 520 - 600km. Capacity: 700 - 1400MW.	Connecting isolated systems (currently no connection between Germany and Norway).	Increase of NTC (700 - 1400MW), diversity of supply and RES integration.	design & permitting	long term		A similar non-TSO project "NorGer" is also under development
143	CCS CCE North Sea Baltic Sea	Kassö (DK) & Ensted (DE)		Installation of two PSTs. This project is in the framework of step 2 in the Danish-German agreement to upgrade the Jutland-DE transfer capacity; This step includes also planed strengthening of existing 380kV lines in the grid of TPS and Energinet.dk .	The project will increase the power exchange capacity between Germany and Denmark Wets. This will improve the market function and contribute to a better utilization of the increasing amount of wind power.	Increase of NTC (Approximately by 500MW when the whole step 2 will be finished), improved security of supply and annual losses reduction.	under construction	mid term		
144	CCS CCE North Sea Baltic Sea	Audorf (DK)	Kassö (DE)	Step 3 in the Danish-German agreement to upgrade the Jutland-DE transfer capacity. It consists of partially an upgrade of existing 400kV line and partially a new 400kV route in Denmark. In Germany new 400kV line mainly in the trace of a existing 220kV line. The total length of this OHL is 114km.	The project will increase the power exchange capacity between Germany and Denmark Wets. This will improve the market function and contribute to a better utilization of the increasing amount of wind power.	This project will enable an Increase of NTC between the two countries, improved security of supply, reduce annual losses.	under consideration	long term		In parallel with this project there is a proposal for a new merchant line NorGer.
145	CCS CCE North Sea Baltic Sea	Niederrhein (DE)	Doetinchem (NL)	New 400kV line double circuit DE-NL interconnection line. Length:60km.	Overloads due to high North-South power flows through the auctioned frontier between the Netherlands and Germany in peak hours of wind in-feed.	Increase of NTC (1000 - 2000MW), improved security of supply and RES integration.	design & permitting	2013		EnLAG (German Law for new lines)
146	CCS CCE North Sea Baltic Sea	Aachen/Düren region (DE)	Lixhe (BE)	Connection between Germany and Belgium including new 100km underground cable and extension of existing 380kV-substations.	Low cross border capacity.	NTC increase, conventional generation integration and RES integration. The project will facilitate IEM, since presently there is no direct exchange capability between DE and BE.	under consideration	long term	X	
147	CCS CCE North Sea Baltic Sea	Dollern (DE)	Hamburg/Nord (DE)	New 400kV double circuit OHL Dollern - Hamburg/Nord including one new 400/230kV transformer in substation Hamburg/Nord and new 400kV switchgear Kummerfeld. Length:43km.	Increase of the transmission capacity from north to south-West Germany due to the increase of RES in Northern Germany.	RES integration, improved security of supply and annual re-dispatching costs reduction.	design & permitting	1. circuit midterm; 2. circuit long-term	X	EnLAG (German Law for new lines)
148	CCS CCE North Sea Baltic Sea	Audorf (DE)	Hamburg/Nord (DE)	New 400kV double circuit OHL Audorf - Hamburg/Nord including two new 400/230kV transformers in substation Audorf. Length: 65km.	Increase of the transmission capacity from north to south-West Germany, due to the increase of RES in Northern Germany and increase of power exchange capability between Denmark and Germany.	RES integration, improved security of supply and annual re-dispatching costs reduction.	planned	long term	X	Due to the German act "EnLAG"

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
149	CCS CCE North Sea Baltic Sea	Dollern (DE)	Stade (DE)	New 400kV double circuit OHL Dollern - Stade including new 400kV switchgear in Stade. Length:14km.	Connection of new power plants.	Conventional generation integration.	design & permitting	mid term		
150	CCS CCE North Sea Baltic Sea	Conneforde (DE)	Maade (DE)	New 400kV double circuit (underground cable+OHL) Conneforde - Maade including new 400kV switchgear Maade. Length: 37km.	Connection of new power plants.	Conventional generation integration.	design & permitting	long term		
151	CCS CCE North Sea Baltic Sea	Wehrendorf (DE)	Ganderkesee (DE)	New line, extension of existing and erection of substations, erection of 380/110kV-transformers.	Increase of the transmission capacity from north to south-West Germany due to the increase of RES in Northern Germany.	RES integration, improved security of supply and annual re-dispatching costs reduction.	design & permitting	mid term		Due to the German act "EnLAG"
152	CCS CCE North Sea Baltic Sea	Dörpen/West (DE)		New substation for connection of offshore wind farms.	Connection of off-shore wind farms.	RES integration and conventional generation integration.	design & permitting	mid term		
153	CCS CCE North Sea Baltic Sea	Redwitz (DE)	Grafenrheinfeld (DE)	Upgrade of 230kV connection Redwitz - Grafenrheinfeld to 400kV, including new 400kV switchgear Eltmann. Line length: 97km.	Support of RES integration in Germany, maintaining of security of supply and support of the market development.	RES integration, improved security of supply and conventional generation integration.	design & permitting	mid term		Due to the German act "EnLAG"
154	CCS CCE North Sea Baltic Sea	Redwitz (DE)		New 500 MVAr SVC in substation Redwitz.	Voltage stability.	Improved security of supply.	planned	mid term		
155	CCS CCE North Sea Baltic Sea	Raitersaich (DE)		New 500 MVAr SVC in substation Raitersaich.	Voltage stability.	Improved security of supply.	planned	mid term		
156	CCS CCE North Sea Baltic Sea	Niederrhein (DE)	Dörpen/West (DE)	New 400kV double circuit OHL Dörpen - Niederrhein including extension of existing substations. Length: 167km.	Increase of the transmission capacity from north to south-West Germany due to the increase of RES in Northern Germany.	RES integration, improved security of supply and conventional generation integration.	design & permitting	long term		Due to the German act "EnLAG"
157	CCS CCE North Sea Baltic Sea	Wahle (DE)	Mecklar (DE)	New 400kV double circuit OHL Wahle - Mecklar including two new substations. Length: 210km.	Increase of the transmission capacity from north to south-West, due to the increase of RES in Northern Germany.	RES integration, improved security of supply and conventional generation integration.	design & permitting	long term		Due to the German act "EnLAG"
158	CCS CCE North Sea Baltic Sea	Irsching (DE)	Ottenhofen (DE)	Upgrade of 230kV connection Irsching - Ottenhofen to 400kV, including new 400kV switchgear Zolling. Length 76km.	Increase of the transmission capacity from north to south due to increase of transits from North to South Germany.	Improved security of supply, RES integration and conventional generation integration.	planned	long term		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
159	CCS CCE North Sea Baltic Sea	Cluster BorWin1 (DE)	Diele (DE)	New line consisting of underground +subsea cable with a total length of 205km. Line capacity: 400MW.	Connection of new offshore wind farm.	RES integration.	under construction	mid term		
160	CCS CCE North Sea Baltic Sea	Offshore- Wind park Nordergründe (DE)	Inhausen (DE)	New line consisting of underground +subsea cable with a total length of 35km.	Connection of new offshore wind farm.	RES integration.	design & permitting	mid term		
161	CCS CCE North Sea Baltic Sea	Offshore- Wind park GEOFreE (DE)	Göhl (DE)	New line consisting of underground +subsea cable with a total length of 32km.	Connection of new offshore wind farm.	RES integration.	design & permitting	mid term		
163	CCS CCE North Sea Baltic Sea	Cluster HelWin1 (DE)	Büttel (DE)	New line consisting of underground +subsea cable with a total length of 145km. Line capacity: aprox. 860MW. This Project includes also a new substation Büttel and connection of this new substation with the existing OHL Brünsbüttel - Wilster.	Connection of new offshore wind farm.	RES integration.	design & permitting	mid term		
164	CCS CCE North Sea Baltic Sea	Cluster SylWin1 (DE)	Büttel (DE)	New line consisting of underground +subsea cable with a total length of 210km. Line capacity: aprox. 690MW.	Connection of new offshore wind farm.	RES integration.	design & permitting	mid term		
165	CCS CCE North Sea Baltic Sea	Cluster DolWin1 (DE)	Dörpen/West (DE)	New line consisting of underground +subsea cable with a total length of 155km. Line capacity: 400MW.	Connection of new offshore wind farm.	RES integration.	design & permitting	mid term		
166	CCS CCE North Sea Baltic Sea	Offshore Wind park Riffgat (DE)	Emden (DE)	New line consisting of underground +subsea cable with a total length of 80km.	Connection of new offshore wind farm.	RES integration.	design & permitting	mid term		
167	CCS CCE North Sea Baltic Sea	Cluster BorWin2 (DE)	Diele (DE)	New line consisting of underground +subsea cable with a total length of 205km. Line capacity: 400-800MW.	Connection of new offshore wind farm.	RES integration.	design & permitting	mid term		
168	CCS CCE North Sea Baltic Sea	Goldshöfe (DE)	Dellmensigen (DE)	Upgrade the line Goldshöfe - Dellmensigen from 220kV to 380kV . Line length:114km. Included with the project : 3x 380kV substations, 2 transformers.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES Integration, improved security of supply and annual losses reduction.	under construction	2012		
168a	CCS, Baltic Sea, North Sea	Region South-West Bavaria (DE)		Upgrading the existing 220kV OHL to 380kV,length 100km and the extension of existing substations, erection of 380/110kV-transformers.	Upgrading the existing 220 kV OHL to 380 kV, length 100 km and the extension of existing substations, erection of 380/110kV-transformers.	Improved security of supply.	planned	long term		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
169	CCS CCE North Sea Baltic Sea	Großgartach (DE)		Upgrade the substation for a higher short circuit capacity. New installation includes 10 gas insulated bays, 63 kA, 3 bus-bar and 2 transformers.	Increase of short-circuit current needs due to the change of the topology for the grid.	Improved security of supply and RES Integration.	under construction	2010		
170	CCS CCE North Sea Baltic Sea	Großgartach (DE)	Hüffenhardt (DE)	New 380kV OHL. Length: 23km. Included with the project : 1 new 380kV substation, 2 transformers.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES Integration, improved security of supply and annual losses reduction.	under construction	2012		
171	CCS CCE North Sea Baltic Sea	Hüffenhardt (DE)	Neurott (DE)	Upgrade of the line from 220kV to 380kV. Length: 11km. Included with the project : 1 new 380kV substation.	Adjustment of the transmission capacity of the grid.	Improved security of supply and annual losses reduction.	planned	2020		
172	CCS CCE North Sea Baltic Sea	Mühlhausen (DE)	Großgartach (DE)	Upgrading line from 220kV to 380kV. Length:-45km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES Integration, improved security of supply and annual losses reduction.	design & permitting	2014		EnLAG (German Law for new lines)
173	CCS CCE North Sea Baltic Sea	Hoheneck (DE)	Endersbach (DE)	Upgrading line from 220kV to 380kV. Length:20km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES Integration and Improved security of supply.	design & permitting	2014		
174	CCS CCE North Sea Baltic Sea	Bruchsal Kändelweg (DE)	Ubstadt (DE)	A new 380kV OHL. Length:6km.	Adjustment of the transmission capacity of the grid.	Improved security of supply and annual losses reduction.	design & permitting	2014		
175	CCS CCE North Sea Baltic Sea	Birkenfeld (DE)	Ötisheim (DE)	A new 380kV OHL. Length:11km.	Adjustment of the transmission capacity of the grid.	Improved security of supply and annual losses reduction.	planned	2020		
176	CCS CCE North Sea Baltic Sea	Villingen (DE)	Weier (DE)	A new 380kV OHL. Length:75km.	Increase of the transmission capacity from north to south-West of Germany, due to the increase of wind energy in Northern part.	RES Integration and annual re-dispatching costs reduction.	under consideration	2020		EnLAG (German Law for new lines)
177	CCS CCE North Sea Baltic Sea	Goldshöfe (DE)	Bünzwangen (DE)	A new 380kV OHL. Length: 45km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES Integration and annual re-dispatching costs reduction.	under consideration	2020		EnLAG (German Law for new lines)

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
178	CCS CCE North Sea Baltic Sea	Baden-Württemberg, Süden & Nordosten (DE)		Installation of 3x250 MVAr 380kV capacitance banks.	Injection of reactive power.	Voltage stability.	under construction	2014		
179	CCS CCE North Sea Baltic Sea	Rommerskirchen (DE)	Weißenthurm (DE)	New line, extension of existing and erection of substations, erection of 380/110kV-transformers. Total line length: 100km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES integration, improved security of supply and conventional generation integration.	under construction	mid term		EnLAG (German Law for new lines)
180	CCS CCE North Sea Baltic Sea	Mengede (DE)	Kruckel (DE)	Installation of a second circuit 380kV OHL and extension of existing substations. Line length:16km.	Connection of new power plants.	Conventional generation integration.	planned	mid term		
181	CCS CCE North Sea Baltic Sea	Dauerberg (DE)	Limburg (DE)	New 380kV double circuit OHL, extension of existing and erection of substations, erection of 380/110kV-transformers. Total line length: 46km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES integration and Improved security of supply.	under construction	mid term		EnLAG (German Law for new lines)
182	CCS CCE North Sea Baltic Sea	Kriftel (DE)	Eschborn (DE)	On the main distance upgrading line, extension of existing substations.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES Integration and Improved security of supply.	under construction	mid term		EnLAG (German Law for new lines)
183	CCS CCE North Sea Baltic Sea	Wehrendorf (DE)		Installation of 300 MVAr 380kV capacitance banks, extension of existing substations.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	Voltage stability and Improved security of supply.	planned	mid term		
184	CCS CCE North Sea Baltic Sea	Bürstadt (DE)		Installation of 2 x 300 MVAr 380kV capacitance banks, extension of existing substations.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	Voltage stability and Improved security of supply.	planned	mid term		
185	CCS CCE North Sea Baltic Sea	Area of Muensterland and Westfalia (DE)		New lines and installation of additional circuits, extension of existing and erection of several 380/110kV-substations. Total line length: 240km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES integration, improved security of supply and conventional generation integration.	planned	long term		EnLAG (German Law for new lines)
186	CCS CCE North Sea Baltic Sea	Gütersloh (DE)	Bechterdissen (DE)	New lines and installation of additional circuits, extension of existing and erection of 380/110kV-substation. Total line length:27km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES integration and Improved security of supply.	under construction	mid term		EnLAG (German Law for new lines)

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187	CCS CCE North Sea Baltic Sea	Area of West-Rhineland (DE)		New lines and installation of additional circuits, extension of existing and erection of several 380/110kV-substations.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES integration, improved security of supply and conventional generation integration.	under construction	mid term		EnLAG (German Law for new lines)
188	CCS CCE North Sea Baltic Sea	Kruckel (DE)	Dauersberg (DE)	New lines, extension of existing and erection of several 380/110kV-substations. Total line length: 130km.	Increase of the transmission capacity from North to South-West of Germany, due to the increase of wind energy in Northern part.	RES integration, improved security of supply and conventional generation integration.	planned	long term		EnLAG (German Law for new lines)
189	CCS CCE North Sea Baltic Sea	Niederrhein (DE)	Utfort (DE)	New lines and extension of existing 380kV-substations. Total length:31km.		RES integration, improved security of supply and conventional generation integration.	planned	long term		EnLAG (German Law for new lines)
190	CCS CCE North Sea Baltic Sea	Saar-Pfalz-Region (DE)		New lines, extension of existing and erection of several 380/110kV-substations.		Improved security of supply and conventional generation integration.	planned	mid term		
191	CCS CCE North Sea Baltic Sea	Neuenhagen (DE)	Vierraden (DE)	Project of new 380kV double-circuit OHL with 125km length as prerequisite for the planned upgrading of the existing 220kV double-circuit interconnection Krajnik (PL) – Vierraden (DE, 50Hertz Transmission).	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	In particular the project will support RES integration in North Germany/Poland, maintaining the security of supply and support of market development in CCE.	design & permitting	2011	X	Top priority project according to German act for acceleration of transmission grid extension (EnLAG)
192	CCS CCE North Sea Baltic Sea	Hamburg/Krümmel (DE)	Schwerin (DE)	This 380kV double-circuit OHL project will close the missing gap in North-East German grid infrastructure. Only 65km of new line must be constructed, 22km already exist.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES integration in North Germany, maintaining of security of supply and support of market development.	under construction	2010	X	Top priority project according to German act for acceleration of transmission grid extension (EnLAG)
193	CCS CCE North Sea Baltic Sea	Halle/Saale (DE)	Schweinfurt (DE)	New 380kV double-circuit OHL between the substations Lauchstädt-Vieselbach-Altenfeld-Redwitz with 215km length combined with upgrade between Redwitz and Grafenrheinfeld (see project 153).	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES integration in Germany, annual redispatching cost reduction, maintaining of security of supply and support of the market development.	partly completed; design & permitting	mid term	X	Top priority project according to German act for acceleration of transmission grid extension (EnLAG); project is also part of the European Energy Programme for Recovery

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
194	CCS CCE North Sea Baltic Sea	wind farm cluster Baltic Sea East (DE)	Lüdershagen/ Lubmin (DE)	Offshore wind farm connection project (by AC-cables on transmission voltage level) has to be constructed and afterwards also to be operated by the TSO (in this project: 50Hertz Transmission) according to German law.	Project will satisfy the need of grid connection for new off-shore wind farms in the Baltic Sea.	Support of RES integration in German part of the Baltic sea.	Under consideration, design & permitting	2011/2015	X	
195	CCS CCE North Sea Baltic Sea	wind farm cluster Baltic Sea West (DE)	Bentwisch (DE)	Offshore wind farm connection project (by AC-cables on transmission voltage level) has to be constructed and afterwards also to be operated by the TSO (in this project: 50Hertz Transmission) according to German law. This includes an option for an interconnection project between Germany, Denmark and Sweden via offshore wind farms Kriegers Flak (see project 141).	Project will satisfy the need of grid connection for new off-shore wind farms in the Baltic Sea.	Support of RES integration in German part of the Baltic sea. For optional interconnection part, increase of NTC.	Under consideration, design & permitting	2011/2015	X	option for an interconnection project between Germany, Denmark and Sweden via offshore wind farms Kriegers Flak is part of the European Energy Programme for Recovery
196	CCS CCE North Sea Baltic Sea	wind farm Baltic 1 (DE)	Bentwisch (DE)	Offshore wind farm connection of 79km single AC-cable on transmission voltage level has to be constructed and afterwards also to be operated by the TSO (in this project: 50Hertz Transmission) according to German law. There is an extension option for the later grid connection of the offshore wind farm Kriegers Flak 1.	Project will satisfy the need of grid connection for new off-shore wind farms in the Baltic Sea.	Support of RES integration in German part of the Baltic Sea.	under construction	2010	X	
197	CCS CCE North Sea Baltic Sea	Neuenhagen (DE)	Wustermark (DE)	Berlin North Ring: replacement of an existing old 220kV double-circuit OHL by a 380kV double-circuit OHL. Length: 75km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in Germany, maintaining of security of supply and support of market development in CCE.	design & permitting	2020		Top priority project according to German act for acceleration of transmission grid extension (EnLAG)
198	CCS CCE North Sea Baltic Sea	Wuhlheide (DE)	Thyrow (DE)	Berlin South Ring: replacement of an existing old 220kV double-circuit OHL by a 380kV double-circuit OHL. Length: 50km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES integration in Germany, maintaining of security of supply and support of market development.	under consideration	long term		
199	CCS CCE North Sea Baltic Sea	Western Pomerania (DE)	Uckermark North (DE)	Construction of new 380kV double-circuit OHLs in North-Eastern part of VE-T control area and decommissioning of existing old 220kV double-circuit OHLs. Length: 135km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	planned	2015		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
200	CCS CCE North Sea Baltic Sea	Lubmin (DE)	Erfurt area (DE)	New 380kV double-circuit OHL from the Northern part of the 50Hertz Transmission control area to the South-Western part of the 50Hertz Transmission control area with considered further extension to South-Western part of Germany. Length ca. 800km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	planned	long term		Suitable project extension under consideration of ongoing long term system studies.
201	CCS CCE North Sea Baltic Sea	Bärwalde (DE)	Schmölln (DE)	Upgrade of the existing double-circuit 380kV OHL. Project will be realized earlier than originally planned as part of project 203. Line length: 50km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	design & permitting	2013		
202	CCS CCE North Sea Baltic Sea	Reinforcement of the 380kV grid in South-Eastern part of 50Hertz Transmission control area		Upgrading of several existing double-circuit 380kV OHL in the South-Eastern part of the control area of 50Hertz Transmission. Total length: 190km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	planned	long term		
203	CCS CCE North Sea Baltic Sea	380kV grid extension in South-Eastern part of 50Hertz Transmission control area (DE)		New 380kV double-circuit OHL in South-Eastern part of 50Hertz Transmission control area. Total length: 105km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	under consideration	long term		
204	CCS CCE North Sea Baltic Sea	Pulgar (DE)	Vieselbach (DE)	Upgrading of the existing double-circuit 380kV OHL . Length:105km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	planned	2012		
205	CCS CCE North Sea Baltic Sea	Reinforcement of the 380kV grid in Lausitz area (DE)		Upgrading of several existing double-circuit 380kV OHL in the Eastern part of the control area of 50Hertz Transmission. Total length: 150km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	under consideration	long term		
206	CCS CCE North Sea Baltic Sea	380kV grid reinforcement and extension in Saxony (DE)		Upgrade of the existing double-circuit 380kV OHL and also construction of 230km of new 380kV double-circuit OHLs in Saxony (control area of 50Hertz Transmission). Length: 80km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	under consideration	long term		
207	CCS CCE North Sea Baltic Sea	Substations in South-Western part of 50Hertz Transmission control area (DE)		Construction of new reactive power compensation devices.	Project will alleviate the need of additional reactive power.	Support of RES and conventional generation integration in North Germany, maintaining of security of supply and support of market development.	planned	2012		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
208	CCS CCE North Sea Baltic Sea	Substations in South-Western part of 50Hertz Transmission control area (DE)		Construction of new reactive power compensation devices.	Project will alleviate the need of additional reactive power.	Support of RES and conventional generation integration in North Germany, maintain security of supply and support of market development.	under consideration	long term		
209	CCS CCE North Sea Baltic Sea	Substations in 50Hertz Transmission control area		Construction of new 380kV/110kV substation.	Project will alleviate mainly the need to increase the capability of the grid to accommodate additional generation capacity.	Support of RES integration in Germany and maintain of security of supply.	planned	2012		
210	CCS CCE North Sea Baltic Sea	Substations in 50Hertz Transmission control area		Construction of new 380kV/110kV substation.	Project will alleviate mainly the need to increase the capability of the grid to accommodate additional generation capacity.	Support of RES integration in Germany and maintain of security of supply.	under consideration	long term		
211	CCS CCE North Sea Baltic Sea	Further connections of more offshore wind farms (DE)		Further connections in the clusters BorWin, DolWin, SylWin and HelWin.	Connection of new offshore wind farms.	Increase RES integration.	under consideration	long term		
212	CCS CCE North Sea Baltic Sea	Isar (DE)	St. Peter (AT)	New 400kV double circuit OHL Isar - St. Peter including new 400kV switchgears Altheim, Simbach and St. Peter and one new 400/230kV transformer in substation Altheim. Line length: 90km.	This project will increase the current power exchange capacity between Austria and Germany.	Increase of NTC and RES integration.	under consideration	2017		
213	CCE CCS CSE	Wien SO (AT)	Szombathely (HU)	Installation of the 2nd circuit on the existing interconnection from Wien SO (AT, APG) to the border (both circuits have already been installed on the Hungarian side, one is connected to Györ and the 2nd circuit to Szombathely). Line length: 63km.	Necessity for further wind integration and connection to the 380kV-grid, increasement of transport capacities in the Eastern grid area.	Increase of NTC, RES integration and Improved security of supply.	under construction	2010/2011		
214	CCE CCS CSE	Gabcikovo (SK)	Györ/Szombathely (HU) Sarasdorf/Wien (AT)	SEPS and MAVIR are considering a new interconnection between SK and HU (starting from Gabčíkovo substation (SK)) and a connection to the existing 400-kV tie-line Györ/Szombathely (HU) - Vienna/Sarasdorf (AT) at the Hungarian side.	Increasement of (n-1)-security and border capacities in this area.	Improved security of supply, increase of NTC and diversity of supply.	under consideration	2020		
215	CCE CCS	St. Peter (AT)	Salzach neu (AT)	New internal double circuit 380kV-line connecting the substations St. Peter and Salzach neu (replacement of the existing 220kV-line). Length: 46km.	Alleviation of North-to-South congestions, creation of strongly needed enhanced North-to-South transmission capacities.	Improved security of supply, annual re-dispatching costs reduction and annual losses reduction.	under construction	2011	X	
216	CCE CCS	Salzach neu (AT)	Tauern (AT)	New internal double circuit 380kV-line connecting the substations Salzach neu and Tauern and erection of the new 380/220/110kV-substation Pongau (replacement of the existing 220kV-line) . Line length: 115km.	Alleviation of North-to-South congestions, creation of strongly needed enhanced North-to-South transmission capacities.	Improved security of supply, RES integration and annual re-dispatching costs reduction.	planned	2017	X	

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217	CCE CCS	Dürnrohr (AT)	Sarasdorf (AT)	Installation of the 3rd and 4th circuit on the existing line Dürnrohr - Sarasdorf and restructuring in the area of the substation Bisamberg and the 220kV-Weinviertel-line . Total length: 100km.	Increase of (n-1)-security.	Improved security of supply, RES integration and annual losses reduction.	planned	2012/2015		
218	CCE CCS	Obersielach (AT)	Lienz (AT)	The project is concerning new 380kV-lines connecting the substations Lienz (AT) and Obersielach (AT) to close the Austrian 380kV-Ring in the southern grid area. Line length: 190km.	Increase of (n-1)-security and transport capacities in the southern grid area.	Improved security of supply, conventional generation integration and RES integration.	under consideration	2020/2025		
219	CCE CCS	Westtirol (AT)	Zell-Ziller (AT)	Upgrade of the existing 220kV-line Westtirol - Zell-Ziller and erection of additional 220/380kV-Transformers. Line length: 105km.	Increase of (n-1)-security and transport capacities in the Western grid area.	Improved security of supply, conventional generation integration and reduction of infrastructure vulnerability.	under consideration	2012/2020		
220	CCE CCS	Lienz (AT)		Erection of a new 220/220kV- PST in the substation Lienz (AT).	Eliminate congestion management measures and allows the meshed operation of the tie-line Lienz - Soverzene.	Improved security of supply, annual re-dispatching costs reduction and increase of NTC.	design & permitting	2012		
221	CCE CCS	St. Peter (AT)	Ernsthofen (AT)	Upgrade from 220kV-operation to 380kV and erection of a 380kV-Substation in Ernsthofen and St. Peter.	Increase of transport capacities in the East-West direction and necessity for the 380kV-Ring concept.	Improved security of supply, RES integration and conventional generation integration.	planned	2013		
222	CCE CCS	Silz (AT)	Zell-Ziller (AT)	Upgrade of the existing 220kV-double circuit- OHL Zell-Ziller - Silz. Line length: 42km.	Increase of (n-1)-security and transport capacities in the Western grid area.	Improved security of supply, conventional generation integration and reduction of infrastructure vulnerability.	under consideration	2013		
223	CCE CCS CSE	Cirkovce (SI)	Heviz (HU) Zerjavenec (HR)	The existing substation of Cirkovce (SI) will be connected to one circuit of the existing Heviz (HU) -Zerjavinec (HR) double circuit 400kV OHL by erecting a new 80km double circuit 400kV OHL in Slovenia. The project will result in two new cross-border circuits: Heviz (HU) - Cirkovce (SI) and Cirkovce (SI) - Žerjavenec (HR).	Increasing power exchange and need to improve market integration.	The project will increase NTC, allowing higher power exchange between Slovenia and Hungary, improved security and diversity of supply and secure the operation of the Slovenian system.	design & permitting	short term	X	
224	CCE CCS CSE	Krsko (SI)	Bericevo (SI)	New 400kV double circuit OHL. This project will strengthen connection between East and Central part of Slovenia and connect an internal loop. Line length: 80km.	Need to improve the security & quality of supply.	The project should benefit in improved security of supply, grid annual losses & annual re-dispatching costs reduction.	design & permitting	short term	X	
225	CCE CCS CSE	Divaca (SI)	Cirkovce (SI)	Upgrading 220kV lines to 400kV in corridor Divaca-Klece-Bericevo-Podlog-Cirkovce. Line length: 193km.	Need to secure the operation of the Slovenian system.	The project is expected to improve the security of supply and reduce annual losses & re-dispatching costs.	planned	long term		

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226	CCE CCS CSE	Ernestinovo (HR)	Pecs (HU)	New 400kV double circuit interconnection line between existing stations. Line length: 86km.	Need to increase the cross-border capacity and support market integration.	The project is expected to increase transfer capacity, improved the security of supply and reduce grid losses.	under construction	2010	X	
227	CCE CCS CSE	tbd (BA)	tbd (HR)	New 400kV interconnection line between existing stations.	Need to increase the cross-border capacity and support market integration.	The project is expected to improve the security of supply, support conventional generation integration and increase cross-border capacity.	under consideration	tbd		
228	CCE CCS CSE	Trebinje (BA)	Plat (HR)	Re-establishment of previously existing 220kV double circuit interconnection Trebinje(BA)-Plat(HR); Total length 10km.	Need to increase the cross-border capacity and support market integration.	The project is expected to increase the operational security and favour conventional generation integration.	planned	2014		
229	CCE CCS CSE	TPP Plomin (HR)	Melina (HR)	New 90km double circuit OHL, with two connecting substations and a transformer 400/220kV, 400 MVA.	Need to connect a new generator.	The project is expected to favour conventional generation integration and increase the operational security.	under consideration	2016		
230	CCE CCS CSE	TPP Sisak (HR)	Mraclin(HR)/Prijedor(BA)	Connection of new generator on existing line 220kV Mraclin (HR) - Prijedor (BA) via a new double circuit OHL. Line length: 12km.	Need to connect a new generator.	The project is expected to favour conventional generation integration and increase the operational security.	design & permitting	2012		
231	CCE CCS CSE	Konjsko (HR)		Installation of a 150 MVAr reactive power device.	Need to control the voltage on the 400kV grid.	The project will improve the security of supply.	planned	2013		
232	CSE	Visegrad (BA)	Pljevlja (ME)	New 400kV transmission line between existing stations. Line length: 70km.	Market integration, need for new DC cable between ME-IT.	Increase of (n-1) security ; New regional corridor ; Increase NTC.	under consideration	>2015		Support of BA State Regulatory commission, preliminary agreement of TSOs BA, ME and IT
233	CSE	Tirana (AL)	Podgorica (ME)	New 400kV line Tirana (AL)-Podgorica (ME) with length 157km (128.5km on Albanian side, 76km of which with double circuit and 28.5km on the Montenegrin side).	Need to strengthen the sparse structure of the South East Europe network and to increase the grid capability to transmit power from countries with surplus generation (BG, RO) towards Italy.	The project is expected to increase NTC and Improved the security of supply.	under construction	2010		
233a	Cont.SE	Tivat (ME)		A new substation will be connected to the existing line 400kV Podgorica(ME)-Trebinje(BA), with two transformers 2X300MVA 400/110kV, and convertor station for the DC cable Tivat-Villanova (see 70).	market integration. Operation of Montenegrin grid to be improved	RES integration, market integration, increase of NTC.	design & permitting	2014/2015		signed contract between governments of Italy and Montenegro regarding construction of the AC interconnector IT/ME
233b	Cont.SE	Tivat (ME)	Pljevlja (ME)	New transmission line connecting existing substation Pljevlja and new substation Tivat. It is part of the new interconnection project ME/IT	market integration, need for new DC cable between ME-IT. N-1 security	Improved security of supply, market integration (creation of new interface between countries).	design & permitting	2016		signed contract between governments of Italy and Montenegro regarding construction of the AC interconnector IT/ME

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234	CSE	Elbasan (AL)	Tirana(AL)	New 400kV AC OHL. Length: 48km.	Need to strengthen the sparse structure of the South East Europe network and to increase the grid capability to transmit power from countries with surplus generation (BG, RO) towards Italy.	The project is expected to increase NTC and Improved the security of supply.	under construction	2010		
235	CSE	Tirana(AL)	Pristina(RS)	New 238km 400kV OHL; on 78km the circuit will be installed on the same towers as the Tirana-Podgorica OHL currently in construction (see project 233); the rest will be built as single circuit line.	Need to strengthen the sparse structure of the South East Europe network and to increase the grid capability to transmit power from countries with surplus generation (BG, RO) towards Italy.	The project is expected to increase NTC and Improved the security of supply.	under consideration	tbd		
236	CSE	Nis (RS)	Stip (MK)	New 220km 400kV single circuit overhead interconnection between Serbia and FYROM. A new 400/110 substation will be built in Serbia between connection nodes.	Low NTC value between Romania,Serbia and Bulgaria from one side and Greece, Albania and FYROM from other side. Improvement of voltage profile in South Serbia.	The project will increase of NTC and Improved the operational safety & the quality of supply in both countries.	Under construction in RS and design & permitting in MK	2011/2013	X	
237	CSE	TPP Kosovo (RS)	Skopje (MK)	A new 400kV OHL relevant to planning investment of 2000MW of TPP in the area of Kosovo and Metohija. Line length: 85km.	Project will alleviate mainly the need to increase 1) the capability of the grid to accommodate additional generation capacity and 2) the transmission capacity of the grid.	The project is expected to favour conventional generation integration and increase the NTC.	under consideration	long term		
238	CSE CCE	Pancevo (RS)	Resita (RO)	New 150km double circuit (single wired at the beginning) 400kV OHL between existing substations.	Need to alleviate the congestion limiting export from Eastern to Western part of South Eastern Europe. Foreseen wind farms in Serbia and Romania need also to be accommodated.	The project will provide an increase of NTC and favour RES integration.	design & permitting	2015		
239	CSE	Bitola (MK)	Elbasan (AL)	New 200km cross-border single circuit 400kV OHL between existing substations.	Need to strengthen the sparse structure of the South East Europe network and to increase the grid capability to transmit power from countries with surplus generation (BG, RO) towards Italy.	In combination with the recently commissioned 400kV link MK-BG, this project is part of the East-West corridor in South-Eastern Europe. The project will increase the NTC and favour conventional generation integration.	under consideration	long term		
240	CSE	Patras (GR)	400kV Continental System (GR)	New 400kV substation in Patras (GIS Technology) and in&out connection to the existing Axeloos - Distomo 400kV OHL via a new 15km double circuit line, part of which will consist of subsea cable. The project shall constitute the first 400kV corridor to Peloponnese.	Future generation evacuation and demand growth.	The project will improve the security of supply, favour conventional generation &RES integration.	design & permitting	2013	X	
241	CSE	Patras (GR)	Megalopolis (GR)	New 400kV substation in Megalopolis and connection to Patras 400kV substation via a 110km double circuit OHL. 2nd corridor to Peloponnese.	Future generation evacuation and demand growth.	The project will improve the security of supply, favour conventional generation &RES integration.	design & permitting	2013	X	

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242	CSE	Megalopolis (GR)	Korinthos (GR)	Construction of a new 400kV substation in Korinthos (GIS Technology) and connection to the Megalopolis substation via a 110km double circuit 400kV OHL.	Future generation evacuation and demand growth.	The project will improve the security of supply, favour conventional generation &RES integration.	design & permitting	2014	X	
243	CSE	Korinthos (GR)	Koymoyndoyros (GR)	Replacement of the existing 150kV double circuit line by a 87km double circuit 400kV OHL.	Future generation evacuation and demand growth.	The project will improve the security of supply, favour conventional generation &RES integration.	design & permitting	2014	X	
244	CSE	Filippi(GR)	Lagadas (GR)	New 400kV substation in Lagadas in Thessaloniki area and connection to the existing substation of Filippi via a new 110km double circuit 400kV OHL.	Market integration, future RES and conventional generation evacuation and improvement of security of supply.	The project will improve the security of supply, favour conventional generation & RES integration.	design & permitting	2012		
245	CSE	N.Santa (GR)		Construction of the new 400kV S/S N.Santa in North Greece. This S/S will serve as the interface for the new line GR-TR, as well as for the interconnection of new wind farms and conventional generation.	Market integration, future RES and conventional generation evacuation and improvement of security of supply. Future interconnection with Turkey.	Increase of NTC, conventional generation integration and RES integration.	under construction	2012		
246	CSE	Aliveri(GR)	System (GR)	Construction of the new 400kV S/S Aliveri in Eviai area and a new 400kV double circuit line Aliveri-System. Line length: 72km.	Future RES and conventional generation evacuation.	Improved security of supply, conventional generation integration and RES integration.	design & permitting	2011		
247	CSE	Aliveri(GR)	Larimna (GR)	Construction of the new 400kV S/S Aliveri in Eviai area and a new 400kV double circuit line Aliveri-System. Line length: 128km.	Future RES and conventional generation evacuation.	Improved security of supply, conventional generation integration and RES integration.	design & permitting	2014		
248	CSE	Polypotamo (GR)	N. Makri (GR)	New 150kV double circuit subsea cable. Line length:33km.	Radial connection of wind farms.	RES integration.	under construction	2011		
249	CSE	Polypotamo (GR)	N. Evia (GR)	New 150kV double circuit OHL. Line length: 40km. Along the new transmission line, 4 new 150/20kV substation shall be build for the interconnection of new wind farms in Evia island.	Radial connection of wind farms.	RES integration.	design & permitting	2010		
250	CSE	Lavrion (GR)	Syros (GR)	New 150kV subsea cable DC connection. There is also the possibility to use AC if proved technically and economically feasible.	Connection of isolated systems and future RES integration.	Improved security of supply and reduce energy costs.	design & permitting	long term	X	
251	CSE	Syros (GR)	Cyclades (GR)	New 150kV subsea cables and 4x150kV Substations to islands of Paros, Naxos, Mykonos, Evia.	Connection of isolated systems and future RES integration.	Improved security of supply.	design & permitting	long term	X	
252	CSE	Melliti (GR)	Kardia (GR)	New 400kV double circuit OHL. Length:40km.	Improve security of supply, strengthen of North to South corridor.	Increase of security of supply and market integration.	design & permitting	2013		

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253	CSE	Kardia (GR)	Trikala (GR)	New 400kV double circuit OHL. Length:80km.	Improve security of supply, strengthen of North to South corridor.	Increase of security of supply and market integration.	design & permitting	long term		
254	CSE	Larissa(GR)	Trikala (GR)	New 400kV double circuit OHL. Length:57km.	Market integration.	Increase of export capabilities to Italy.	under consideration	long term		
255	CSE	Lamia (GR)		Construction of a new 400kV EHV SS in Lamia and connection to the two circuits of the existing 400kV lines Trikala-Distomo and Larisa-Larymna.	Demand growth and equipment enhancement.	Improved security of supply.	planned	long term		
256	CSE	Maritas East 1 (BG)	N.Santa (GR)	New interconnection line BG-GR by a 130km single circuit 400kV OHL.	Increase of NTC, future generation evacuation and stability enhancement of the future interconnection with Turkey.	Increase the security of the interconnection of BG, GR,TR, help reduce annual losses reduction and increase the transfer limit between GR and BG and BG and Turkey.	under consideration	2012/2015		
257	CSE	Maritas East 1 (BG)	Plovdiv (BG)	New 93km single circuit 400kV OHL in parallel to the existing one.	Need to connect new 2x300MW generators in M.East1.	This project aims to provide a secure connection of the new generators in M.East, increase the transfer limit between GR and BG and BG and Turkey and increase the security of the interconnection of BG, GR,TR.	planned	2013		
258	CSE	Maritas East 1 (BG)	Maritas East 3 (BG)	New 13km single circuit 400kV OHL in parallel to the existing one.	Need to connect new 2x300MW generators in M.East1.	This project aims to provide a secure connection of the new generators in M.East, increase the transfer limit between GR and BG and BG and Turkey and increase the security of the interconnection of BG, GR,TR.	planned	2012		
259	CSE	Plovdiv (BG)	Zlatica (BG)	New 75km single circuit 400kV OHL.	Need to supply the growing demand of the area.	This project aims to increase the security of the Plovdiv region and the Bulgarian system in general.	under construction	2010		
260	CSE	Plovdiv (BG)	Aleko(BG)	Reconstruction of the existing 220kV OHL and the building of a new second one. Line length: 40km.	For some regimes this line gets overloaded. Main bottleneck of Turkey TTC.	Eliminate the bottleneck, increase the thermal limit from 228 MVA to 720 MVA, increase the security of the Plovdiv region and TTC of Turkey .	planned	2012		
261	CSE	Karnobat (BG)	Dobrudja (BG)	This project concerns the reconstruction of the existing 220kV OHL. Line length: 95km.	Demand growth. A very important connection between South East generation region and Middle East region - with a big consumption.	Increase the security of the system.	planned	2013		

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262	CSE	Maritas East 1 (BG)	Burgas (BG)	New 400kV OHL. Line length: 135km.	Increase the security of supply of the Burgas region in the maintenance period.	Increase the security of supply of the Burgas region in the maintenance period, increase the transfer limit between GR and BG and BG and Turkey and increase the security of the interconnection of BG, GR,TR.	planned	mid term		
263	CSE	Krushari (BG)		New 400/110kV substation to accommodate RES generation.	RES penetration.	Wind generation integration.	planned	2020		
264	CSE	**Vidno** (BG)		New 400/110kV substation to accommodate RES generation.	RES penetration.	Wind generation integration.	planned	2020		
265	CSE	**Vidno (**BG)	Krushari (BG)	New 400kV double circuit OHL to accommodate RES generation. Line length: 2x115km.	RES penetration.	Wind generation integration.	planned	2020		
266	CSE	Existing interconnection 400kV line Varna (BG) - Issacea (RO)	Krushari (BG)	New 400kV double circuit OHL to accommodate RES generation. Line length: 2x10km.	RES penetration.	Wind generation integration.	planned	2020		
267	CCE CSE	Suceava (RO)	Baltic (MO)	New 400kV transmission line between existing station in Romania and new substation in Moldavia. Line length: 145km.	Market integration. Creating export opportunities from Ukraine to ENTSO-E countries.	Increase of NTC.	planned	>2020		
268	CCE CSE	Constanta (RO)	Pasakoy (TR)	New DC link (subsea cable) between existing stations in RO and TR. Line length: 400km.	Market integration.	Market.	design & permitting	2020		
269	CCE CSE	Portile de Fier (RO)	Resita (RO)	New 400kV OHL between existing stations. Line length: 121km.	Need to strengthen the grid between West and Central of Romania.	Increase of NTC and RES integration.	design & permitting	2015		
270	CCE CSE	Resita(RO)	Timisoara-Sacalaz-Arad (RO)	Upgrade of an existing 220kV single circuit line to 400kV. Line length: 128km.	Need to strengthen the grid between West and Central of Romania.	Increase of NTC and RES integration.	design & permitting	2019		
271	CCE CSE	IN-OUT in Medgidia on actual 400kV OHL Isaccea-Varna (RO)		New400kV double circuit OHL between existing stations. Line length: 13km.	Need to expand the network for access by new generator.	Conventional generation and RES integration.	design & permitting	2015		
272	CCE CSE	IN-OUT in Medgidia on actual 400kV OHL Isaccea-Dobrudja (RO)		New 400kV double circuit OHL between existing stations. Line length: 10km.	Need to expand the network for access by new generator.	Conventional generation and RES integration.	design & permitting	2014		
273	CCE CSE	Cernavoda (RO)	Stalpu (one line in-out G.Ialomitei - RO)	New 400kV double circuit OHL between existing stations. Line length:171km.	Need to expand the network for access by new generator.	Conventional generation and RES integration.	design & permitting	2017		
274	CCE CSE	Constanta (RO)	Medgidia(RO)	New 400kV double circuit (one circuit wired) OHL between existing stations. Line length:171km.	Market integration.	Increase of NTC, RES integration and increase security of supply.	design & permitting	2016		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
275	CCE CSE	Smardan(RO)	Gutinas(RO)	New 400kV double circuit OHL between existing stations. Line length:140km.	Need to expand the network for access by new generator.	Conventional generation and RES integration.	design & permitting	2016		
276	CCE CSE	Suceava(RO)	Gadalin(RO)	New 400kV OHL between existing stations. Line length: 260km.	Need to strengthen the grid between East and West of Romania.	Increase of NTC and RES integration.	planned	2019		
277	CCE CSE	Heviz (HU)	Szombathely (HU)	New 400kV transmission line between existing stations. Line length: 78km.	In transmission outage situation the underlying distribution network is at risk of overload.	Increased operational security.	under construction	2009		
278	CCE CSE	Gyor / Liter (HU)	Gonyu (HU)	New substation Gonyu (generator connection point) is connected by splitting and extending existing line Gyor-Liter.	Need to expand the network for access by new generator.	Conventional generation integration.	under construction	2010		
279	CCE CSE	Gyor (HU)	Martonvasar (HU)	Upgrade of an existing 220kV single circuit line to 400kV double circuit. Line length:84km.	Need to strengthen the grid between Northwest and Central Hungary.	Increased operational security.	design & permitting	2012		
280	CCE CSE	Gyor / Martonvasar (HU)	Bicske (HU)	New substation Bicske with 2*250 MVA 400/120kV transformation is connected by splitting and extending existing line Gyor-Martonvasar line.	Need to increase transformation capacity towards distribution.	Increased security of supply.	design & permitting	2012		
281	CCE CSE	Albertirsa (HU)	Martonvasar (HU)	Adding second circuit to existing 400kV single circuit OHL. Line length: 45km.	Need to improve coupling between North -East and North - West Hungary 400kV grid areas.	Increased operational security.	design & permitting	2012		
282	CCE CSE	Sajoszoged / God (HU)	Detk (HU)	New substation Detk with 2*250 MVA 400/120kV transformation is connected by splitting and extending existing line Sajoszoged-God.	High 220/120kV transformer's lose. Improve N-1 security. Connection point is needed for new generator.	Increased operational security and conventional generation integration.	design & permitting	2012		
283	CCE CSE	Albertirsa / Bekescsaba (HU)	Szolnok (HU)	New substation Szolnok with 2*250 MVA 400/120kV transformers is connected by splitting and extending existing line Albertirsa-Bekescsaba.	High 220/120kV transformers lose, improve N-1 security of supply.	Increased operational security.	design & permitting	2012		
284	CCE CSE	Martonvasar / Paks (HU)	Dunaujvaros (HU)	New substation Dunaujvaros with 2*250 MVA 400/120kV transformation is connected by splitting and extending existing line Martonvasar-Paks.	High 220/120kV transformers lose, improve N-1 security of supply.	Increased operational security.	design & permitting	2012		
285	CCE CSE	Debrecen (HU)		New substation Debrecen with 2*250 MVA 400/120kV transformation is connected by changing the operating voltage of line Sajoszoged-Debrecen from 220kV to 400kV, this line being already designed for 400kV.	High 220/120kV transformers lose, improve N-1 security of supply.	Increased operational security.	planned	2013		
286	CCE CSE	Martonvasar / Liter (HU)	Szekesfehervar (HU)	New substation Szekesfehervar with 2*250 MVA 400/120kV transformation is connected by splitting and extending existing line Martonvasar-Liter.	Need to increase transformation capacity towards distribution.	Increased operational security.	planned	2014		

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287	CCE CSE	Albertirsa / God (HU)	Godollo (HU)	New substation Godollo with 2*250 MVA 400/120kV transformation is connected by splitting and extending existing line Albertirsa-God.	Need to increase transformation capacity towards distribution.	Increased operational security.	planned	2015		
288	CCE CSE	Albertirsa / Martonvasar (HU)	Szazhalombatta (HU)	New substation Szazhalombatta is connected by splitting and extending existing line Albertirsa-Martonvasar.	Need to expand the network for access by new generator.	Conventional generation integration.	planned	2015		
289	CCE CSE	Felsozsolca (HU)	Sajoivanka (HU)	Reconstruction of line to double circuit, installation of the 2nd transformer in substation Sajoivanka. Line length: 29km.	Need to increase transformation capacity towards distribution.	Increased operational security.	under consideration	2015		
290	CCE CSE	Oroszlany (HU)		New substation Oroszlany with 2*250 MVA 400/120kV transformation is connected by splitting and extending the second circuit of line Martonvasar-Gyor.	Need to build new transformer station as old 220/120kV station will be dismantled.	Increased operational security.	under consideration	2017		
291	CCE CSE	Sajoszoged (HU)		New 400/120kV 250MVA transformer with PST.	High 220/120kV transformers lose, improve N-1 security of supply.	Increased operational security.	under consideration	2017		
292	CCE CSE	Debrecen (HU)		Reconstruction of 750kV substation.	750kV equipment in station Albertirsa reach end of life in 2012, alternative location is considered for improved cost-benefit.	Reduced operating cost.	under consideration	2013		
293	CCE	Voľa (SK)	point of splitting (SK)	Splitting of the existing single 400kV line between Lemešany and Veľké Kapušany substations to connect the new 400kV substation Voľa with transformation 400/110kV (replacing existing 220kV substation). New 400kV double circuit OHL. Length: 23km.	Request of relevant DSO on future demand growth in next 4 years. New generation units are expected in the future in this area as well.	Improved security of supply and secure and reliable power output evacuation .	design & permitting	2013		
294	CCE	Lemešany (SK)	Veľké Kapušany (SK)	Restoration of the old 400kV line between Lemešany and Veľké Kapušany substations by installing a second circuit. Line length:74km.	Ensuring of electricity evacuation from new perspective power plant, reinforcement of eastern part of Slovak power system.	Improved security of supply and secure and reliable power output evacuation.	planned	2018	X	TEN-E funding is designated for environmental impact assessment study.
295	CCE	Lemešany (SK)	Moldava (SK)	New 31km double circuit 400kV line, replacing a 220 kV one. The part of the line from Moldava substation up to switching substation Košice was put into operation in 10/2009.	Ensure electricity supply to an important transmission system consumer, now via Košice (400kV) and no more via Lemešany (220kV). Reinforce the Eastern part of the Slovak power system in north-south direction.	Improved security of supply.	under construction	2011		
296	CCE	Medzibrod (SK)	point of splitting (SK)	Connection of existing 220/110kV Medzibrod substation to the 400kV system by splitting the single 400kV line Sučany - Liptovská Mara. Project includes also the reconstruction of Medzibrod substation from 220kV level to 400kV including transformation 400/110kV. Line length:36km.	Need to enhance electricity supply to Medzibrod nodal area and for an important consumer which is at the same time a significant employer in the concerned region.	Improved security of supply.	design & permitting	2013		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
297	CCE	Križovany (SK)	Horná Ždaňa (SK)	The new substation Bystričany with transformation 400/110kV will be connected to the 400kV system by two new 2x400kV lines from Horná Ždaňa and Križovany substations by splitting only one circuit in Bystričany substation. In the future the substation will be also equipped with a 220kV switchgear. Line length:112km.	The project is linked to the decommissioning of NPP Jaslovské Bohunice V1. Beyond that, there is a need to enhance power withdrawal from new potential generation units, and ensure electricity supply to the industrial area.	Secure and reliable power output evacuation, improved security of supply and internal power system reinforcement.	Planned	2020		Decision regarding funding from BIDSF is expected in following months.
298	CCE	Veľký Ďur (SK)	Gabčíkovo (SK)	Erection of new 2x400kV line between two important substations and erection of new switching station Gabčíkovo next to the existing one. Line length:93km.	Need to enhance power withdrawal from new potential generation units in Western Slovakia.	Secure and reliable power output evacuation and Improved security of supply. There are new generation units expected in concerned area, therefore the effect of this line is expected in this way. The project might improve exchange capacity on the Slovak - Hungarian profile.	Planned	2020		The project is associated to the new Slovak - Hungarian interconnection from Gabčíkovo substation (see project 214).
299	CCE	Krasikov (CZ)	Horni Zivotice (CZ)	New single circuit 400kV OHL, 1385 MVA.	Need to strengthen the grid in the direction North-south of the system.	Improved operational security ; reduction of infrastructure vulnerability.	design & permitting	2014		
300	CCE	Chotejovice (CZ)		New 400/110kV substation equipped with transformers 2x350MVA .	Connection point of a new power unit 660MW.	Conventional generation integration ; reduction of infrastructure vulnerability.	design & permitting	2011		
301	CCE	Vyskov (CZ)	Chotejovice (CZ)	New single circuit 400kV OHL; 1385 MVA.	Connection of new 400kV substation (Chotejovice) into the rest of the network system.	Conventional generation integration.	design & permitting	2011		
302	CCE	Vyskov (CZ)	Cechy stred (CZ)	New second circuit 400kV OHL; 1385 MVA.	Need to strengthen the grid in the central part of CZ through doubling the OHL line. Facilitate flow from West to East.	Enhancing security of supply of CZ grid.	planned	2015		
303	CCE	Babylon (CZ)	Bezdecin (CZ)	New second circuit 400kV OHL; 1385 MVA.	Need to facilitate flow form West to East and enhance security of supply; Facilitate flow from West to East.	Improved security of supply.	planned	2016		
304	CCE	Babylon (CZ)	Vyskov (CZ)	New second circuit 400kV OHL; 1385 MVA.	Need to facilitate flow form West to East and enhance security of supply. Facilitate flow from West to East.	Improved security of supply.	planned	2018		
305	CCE	Kletne (CZ)		New 400/110kV substation equipped with transformers 2x350MVA .	Need to increase transformation capacity to distribution.	Reduction of infrastructure vulnerability.	design & permitting	2011		
306	CCE	Vitkov (CZ)		New 400/110kV substation equipped with transformers 2x350MVA.	Need to facilitate connection of RES power generation from 110kV to 400kV, new 400kV interconnection node to DE.	RES integration.	planned	2015		
307	CCE	Vernerov (CZ)		New 400/110kV substation equipped with transformers 2x350MVA.	Need to facilitate connection of RES power generation from 110kV to 400kV, new 400kV connection node to rest of the network.	RES integration ; reduction of infrastructure vulnerability.	planned	>2015		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
308	CCE	Vernerov (CZ)	Vitkov (CZ)	New 400kV double circuit OHL, 1385 MVA.	Need to facilitate connection of RES in CZ and enhance security of supply; facilitate flow between CZ and DE.	RES integration ; improved security of supply.	under consideration	>2015		Connection of 2 new 400 kV substations and facilitate power flow between CEPS and tsp
309	CCE	Vitkov (CZ)	Prestice (CZ)	New 400kV double circuit OHL, 1385 MVA.	Need to facilitate connection of RES in CZ and enhance security of supply. Facilitate flow between CZ and DE.	RES integration ; improved security of supply.	planned	2020		Connection of 2 new 400 kV substations and facilitate power flow between CEPS and tsp
310	CCE	Vyskov (CZ)	Reporyje (CZ)	New connection between 2 existing substations line single circuit OHL 1385 MVA.	Need to strengthen the grid in the central part of CZ and enhance security of supply.	Improved security of supply.	under consideration	>2015		
311	CCE	Kocin (CZ)		Upgrade of the existing substation 400/110kV; upgrade transformers 2x350MVA.	Future generation evacuation, prevention of high short - circuit current.	Conventional generation integration ; reduction of infrastructure vulnerability.	planned	2015/2020		
312	CCE	Mirovka (CZ)		Upgrade of the existing substation 400/110kV with two transformers 2x250MVA.	Future generation evacuation.	Conventional generation integration ; reduction of infrastructure vulnerability.	planned	2017/2018		
313	CCE	Kocin (CZ)	Mirovka (CZ)	Connection of 2 existing 400kV substations with double circuit OHL having 120.5km length: and a capacity of 2X1385 MVA.	Future generation evacuation.	Conventional generation integration ; reduction of infrastructure vulnerability.	planned	2017/2018		
314	CCE	Mirovka (CZ)	V413 (CZ)	New double circuit OHL with a capacity of 2x1385 MVA and 26.5km length.	Need to strengthen the grid. Facilitate flow from West to East.	Enhancing security of supply of CZ grid.	planned	2018/2019		
315	CCE	Kocin (CZ)	Prestice (CZ)	Adding second circuit to existing single circuit line OHL upgrade in length of 115.8km. Target capacity 2x1385 MVA.	Need to strengthen the grid.	Enhancing security of supply of CZ grid.	planned	2019/2021		
316	CCE	Mirovka (CZ)	Cebin (CZ)	Adding second circuit to existing single circuit line (88.5km, 2x1385 MVA).	Need to strengthen the grid.	Enhancing security of supply of CZ grid.	planned	2019/2021		
317	CCE	Hradec (CZ)	Reporyje (CZ)	Upgrade of existing 400kV single circuit OHL with length of 116.9km. Target capacity 1385 MVA.	Need to facilitate flow form West to East and enhance security of supply.	Enhancing security of supply of CZ grid; RES integration.	design & permitting	2014		
319	CCE Baltic Sea	Skawina (PL)		A new AC 400/110kV substation next to existing 220/110kV substation in Cracow Agglomeration Area with transformation 400/110kV 2x400 MVA. New substation Skawina is connected by splitting and extending of existing 400kV lines Tarnów - Tucznawa and Rzeszów - Tucznawa. Dismantling of existing 220/110kV transformers	Connection to the network of power plants.	Conventional generation integration ; improved security of supply.	design & permitting	2015		
320	CCE Baltic Sea	Dargoleza (PL)		A new AC 400/110kV (400 MVA) substation between existing substations Słupsk and Żarnowiec in Northern Poland. New substation Dargoleza is connected by splitting and extending of existing 400kV line Słupsk - Dargoleza.	Connection to the network of RES.	RES integration ; improved security of supply.	planned	2015		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
321	CCE Baltic Sea	Kromolice (PL)	Pątnów (PL)	New 79km 400kV 1870 MVA OHL interconnection line Kromolice - Pątnów - with one circuit from Plewiska to Koninn temporarily on 220kV after dismantling of 220kV line Plewiska - Konin.	Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	under construction	2015	X	
322	CCE Baltic Sea	Kromolice (PL)		A new AC substation between existing substations Plewiska and Ostrów and Pątnów in Poznań Agglomeration Area with transformation 400/110kV 400 MVA. New substation Kromolice is connected by splitting and extending existing line Ostrów-Plewiska and Pątnów - Plewiska.	Safe operation of the system - increase of the power demand.	Improved security of supply ; increased of NTC.	under construction	2015		
323	CCE Baltic Sea	Warszawa Siekierki (PL)	Piaseczno (PL)	A new AC 220/110kV substation (with transformation 220/110kV 2x275MVA) in Warsaw Agglomeration Area connected by a new 20km 220kV 333 MVA cable/OHL line Warszawa Siekierki - Piaseczno.	Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	design & permitting	2015		
324	CCE Baltic Sea	Dobrzeń (PL)	Wrocław/ Pasikurowice (PL)	New 50km 400kV 2x1870 MVA OHL double circuit line from Dobrzeń to splitted Pasikurowice - Wrocław line.	Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply ; Increased of NTC.	design & permitting	2015		
325	CCE Baltic Sea	Krajnik (PL)	Pomorzany (PL)	A new AC substation in Szczecin Agglomeration Area. New substation Pomorzany is connected by new 24km 220kV 522 MVA line Krajnik - Pomorzany and 220/110kV (275 MVA) transformer to existing 110kV switchgear.	Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	planned	2015		
326	CCE Baltic Sea	Grudziądz (PL)	Gdańsk Przyjaźń (PL)	A new AC 400/110kV substation between existing substation Grudziądz and planned substation Gdańsk Przyjaźń with transformation 400 MVA . New substation Pelplin is connected by new 110km 400kV 2x1870 MVA OHL double circuit lines Grudziądz - Pelplin and Pelplin - Gdańsk Przyjaźń after dismantling of 220kV line Jasiniec - Gdańsk.	Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	planned	2015		
327	CCE Baltic Sea	Kozienice (PL)	Ołtarzew (PL)	New 130km 400kV 2x1870 MVA OHL double circuit line Kozienice - Ołtarzew.	Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	design & permitting	2015		
328	CCE Baltic Sea	Piła Krzewina (PL)	Bydgoszcz Zachód (PL)	New 84km 400kV 1870 MVA OHL interconnection line Piła Krzewina - Bydgoszcz Zachód temporarily on 220kV.	Power output from RES.	RES integration ; improved security of supply.	design & permitting	2015		
329	CCE Baltic Sea	Żydowo (PL)	Słupsk (PL)	A new AC 400/110kV substation next to existing 220/110kV substation in Northern Poland with transformation 400/110kV 400 MVA. New substation Żydowo is connected by new 70km 400kV 2x1870 MVA OHL double circuit lines Żydowo - Słupsk and Żydowo - Gdańsk Przyjaźń. Dismantling of existing 220/110kV. transformers.	Power output from RES.	RES integration ; improved security of supply.	planned	2015		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
330	CCE Baltic Sea	Żydowo (PL)	Gdańsk Przyjaźń (PL)	A new AC substation in Gdańsk Agglomeration Area. New substation Gdańsk Przyjaźń is connected by splitting and extending of one circuit of existing line Żarnowiec - Gdańsk Błonia and new 150km 400kV 2x1870 MVA double circuit OHL line Żydowo - Gdańsk Przyjaźń with one circuit from Żydowo to Gdańsk temporarily on 220kV after dismantling of 220kV line Żydowo - Gdańsk.	Power output from RES.	RES integration ; improved security of supply.	planned	2015		
331	CCE Baltic Sea	Gorzów (PL)	Leśniow (PL)	Upgrading of sag limitations (new capacity 461 MVA).	Power output from RES, upgrading of sag limitations.	RES integration ; improved security of supply; Increase of NTC.	planned	2015		
332	CCE Baltic Sea	Recław (PL)	Glinki (PL)	A new AC substation in Szczecin Agglomeration Area. New substation Recław is connected by new 52km 220kV 522 MVA line Recław - Glinki, existing 110kV single circuit line Morzyczyn - Recław upgraded to 220kV and two 220/110kV (275 MVA) transformer to existing 110kV switchgear. Splitting of existing 220kV line Morzyczyn - Police and expanding to Glinki substation.	Power output from RES.	RES integration ; improved security of supply.	design & permitting	2015		
333	CCE Baltic Sea	Pasikurowice (PL)	Świebodzice (PL)	A new AC substation in Wrocław Agglomeration Area. New substation Wrocław is connected to new 135km (sum) 400kV 1870 MVA lines: Pasikurowice-Wrocław and Świebodzice - Wrocław. New 400kV Wrocław substation with 2x400 MVA, 400/110kV transformation. New 400kV Świebodzice substation with 1x500MVA, 400/220kV transformation and 1x400 MVA, 400/110kV transformation. New 400kV OHL interconnection line Wrocław - Świebodzice after dismantling of 220kV line Świebodzice - Biskupice and new 400kV OHL interconnection line Pasikurowice - Wrocław, including new Wrocław substation	Safe operation of the system - change of the voltage in the network (elimination of the network congestions) and safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	under construction	2015		
334	CCE Baltic Sea	Pątnów (PL)	Grudziądz (PL)	New 174km 400kV 2x1870 MVA double circuit OHL line Pątnów - Grudziądz after dismantling of 220kV line Pątnów - Jasiniec (two parallel lines) and Jasiniec - Grudziądz. One circuit from Pątnów to Grudziądz via Jasiniec temporarily on 220kV.	Safe operation of the system - change of the voltage in the network (elimination of the network congestions).	Improved security of supply; Increase of NTC.	design & permitting	2015	X	
335	CCE Baltic Sea	Ostrołęka (PL)	Olsztyn Mątki (PL)	New 138km 400kV 2x1870 MVA double circuit OHL line Ostrołęka - Olsztyn Mątki after dismantling of 220kV line Ostrołęka - Olsztyn with one circuit from Ostrołęka to Olsztyn temporarily on 220kV.	Safe operation of the system - change of the voltage in the network (elimination of the network congestions).	Improved security of supply.	design & permitting	2015		
336	CCE Baltic Sea	Warszawa Praga (PL)		A new AC substation with 2x275 MVA 220/110kV transformation between existing substations Miłosna and Mory in Warszawa Agglomeration Area, New substation Warszawa Praga is connected by splitting and extending existing line Miłosna-Mory.	Safe operation of the system - increase of the power demand.	Improved security of supply.	planned	2015		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
337	CCE Baltic Sea	Radkowice (PL)	Kielce Piaski (PL)	New 26km 220kV 522 MVA OHL line Radkowice -Kielce Piaski, in Kielce agglomeration area.	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	design & permitting	2015		
338	CCE Baltic Sea	Kozienice (PL)	Mory/ Piaseczno (PL)	Replacement of conductors (high temperature conductors).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	under construction	2015		
339	CCE Baltic Sea	Morzyczyn (PL)		A new AC substation in Szczecin Agglomeration Area with transformation 400/220kV 330 MVA and 400/110kV 330 MVA. New substation Morzyczyn is connected by splitting and extending existing 400kV line Krajnik - Dunowo.	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	under construction	2015		
340	CCE Baltic Sea	Lubocza (PL)		An existing substation in Kraków Agglomeration Area. Existing substation will be upgraded by splitting and extending existing 220kV line Siersza- Klikowa and installing second ATR 220/110kV (160 MVA).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	planned	2015		
341	CCE Baltic Sea	Pątnów (PL)	Włocławek (PL)	Upgrading of sag limitations OHL 220kV (389 MVA).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply; Increase of NTC.	planned	2015		
342	CCE Baltic Sea	Czarna (PL)	Polkowice (PL)	New 400kV OHL interconnection line Czarna -Polkowice (1870 MVA, 22km), including new Polkowice 400kV substation with 500 MVA, 400/220kV transformation.	Safe operation of the system - couplings 220kV with 400kV transmission network (elimination of the network congestions).	Improved security of supply; Increase of NTC.	design & permitting	2015		
343	CCE Baltic Sea	Byczyna (PL)		Upgrading of existing AC 220kV substation Byczyna. A new 400kV AC substation in Silesia Agglomeration Area with transformation 400/220kV 2x 500 MVA. New substation Byczyna is connected by splitting and extending existing line Tarnów - Tucznawa.	Safe operation of the system - couplings 220kV with 400kV transmission network (elimination of the network congestions) and Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	under construction	2015		
344	CCE Baltic Sea	Lublin Systemowa (PL)	Abramowice (PL)	New 220kV cable/OHL interconnection line Lublin Systemowa - Abramowice, in Lublin agglomeration area (522 MVA, 18km).	Safe operation of the system - couplings 220kV with 400kV transmission network (elimination of the network congestions).	Improved security of supply.	design & permitting	2015		
345	CCE Baltic Sea	Łagisza (PL)		A new AC 400kV switchgear in existing substation Łagisza (with transformation 400/220kV 500 MVA and 400/110kV 330 MVA) is connected by splitting and extending of existing 400kV lines Rokitnica - Tucznawa.	Connection to the network of power plants.	Conventional generation integration ; improved security of supply.	under construction	2015		
346	CCE Baltic Sea	Halemba (PL)		Halemba substation is connected by splitting and extending of existing 220kV lines Kopanina - Katowice.	Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	planned	2015		
347	CCE Baltic Sea	Gdańsk I (PL)		A new AC 400kV switchgear in existing substation Gdańsk I is connected by splitting and extending of existing 400kV lines Żarnowiec - Gdańsk Błonia.	Safe operation of the system - couplings 220kV with 400kV transmission network (elimination of the network congestions).	Improved security of supply.	under construction	2015		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
348	CCE Baltic Sea	several substations in PSE O control area		Installation additional and exchange existing transformers (400/110kV and 220/110kV), capacitors and SVC in substations, upgrading of substations.	Safe operation of the system - increase of the power demand and voltage and reactive power control.	Improved security of supply.	planned	2015		
349	CCE Baltic Sea	Puławy (PL)		A new AC 400kV switchgear in existing substation Pulawy (with transformation 400/220kV 500 MVA) will be connected by splitting and extending existing 400kV lines: Kozienice- Lublin Systemowa and Kozienice - Ostrowiec.	Connection to the network of power plants.	Conventional generation integration ; improved security of supply.	planned	2020		
350	CCE Baltic Sea	"East" Power Plant (PL)		A new AC substation "East" Power Plant + Construction of a new 400kV OHL East Power Plant -Siedlce Ujrzanów (2x1870 MVA)+ Construction of a new 400kV OHL East Power Plant -Chełm with single circuit (1870 MVA) + Construction of a new 400kV OHL East Power Plant - Lublin Systemowa (2x1870 MVA). A new AC 400kV switchgear in existing substation Chelm with transformation 400/220kV 500 MVA	Connection to the network of power plants and Power output from generating units connected to the transmission network.	Conventional generation integration ; improved security of supply.	planned	2020		
351	CCE Baltic Sea	Blachownia (PL)		A new AC 400kV switchgear in existing substation Blachownia (with transformation 400/220kV 500 MVA and 400/110kV 400 MVA) will be connected by splitting and extending existing 400kV line Joachimów - Wielopole and 220kV line Kedzierzyn - Groszowice.	Connection to the network of power plants.	Conventional generation integration ; improved security of supply.	planned	2020		
352	CCE Baltic Sea	Dunowo (PL)	Plewiska (PL)	Construction of a new double circuit 400kV OHL Dunowo - Żydowo (2x1870 MVA) partly using existing 220kV line + Construction of a new 400kV OHL Plewiska - Piła Krzewina - Żydowo (2x1870 MVA); single circuit temporarily working as a 220kV + A new AC 400kV switchgear in existing substation Pila Krzewina with transformation 400/220kV 500 MVA.	Power output from RES and connection to the network of RES.	RES integration ; improved security of supply.	design & permitting	2020	X	
353	CCE Baltic Sea	Krajnik (PL)	Baczyna (PL)	Construction of a new double circuit 400kV OHL Krajnik - Baczyna (2x1870 MVA, 91km); single circuit temporarily working at 220kV on Krajnik - Gorzów part + New substation 400kV Baczyna will be connected by splitting and extending existing line Krajnik-Plewiska + Upgrading of limitations line Krajnik - Plewiska.	Power output from RES + Reinforcement of Polish internal grid.	RES integration ; improved security of supply; Increase of NTC.	planned	2020		
354	CCE Baltic Sea	Byczyna (PL)	Podborze (PL)	Double line 400kV Byczyna-Czeczott-Podborze (2x1870 MVA, 155km) will be built in parallel with 220kV line Byczyna-Bieruń-Poręba-Podborze in the same road + New substation 400 and 220kV Podborze (with transformation 400/220kV 500 MVA) will be connected by splitting and extending existing lines Wielopole-Nosovice, Kopanina-Liskovec, Bujaków-Liskovec, Komorowice-Bieruń, Moszczenica-Poręba and new double circuit line 400kV Podborze-Czeczott	Safe operation of the system - change of the voltage in the network (elimination of the network congestions) and safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	design & permitting	2020		
355	CCE Baltic Sea	Mikułowa (PL)	Świebodzice (PL)	Double circuit line 220kV Mikułowa-Świebodzice will be upgraded to 400kV - single circuit temporarily working at 220kV (2x1870 MVA).	Safe operation of the system - change of the voltage in the network (elimination of the network congestions).	Improved security of supply; Increase of NTC.	planned	2020	X	

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356	CCE Baltic Sea	Janów (PL)		New substation 400kV Janów (with transformation 400/110kV 400 MVA) will be connected by splitting and extending existing line Rogowiec-Płock.	Safe operation of the system - increase of the power demand.	Improved security of supply.	planned	2020		
357	CCE Baltic Sea	Joachimów (PL)		Replacement of a transformer 400/220kV (500 MVA).	Safe operation of the system - increase of the power demand.	Improved security of supply.	planned	2020		
358	CCE Baltic Sea	Ostrów (PL)	Kromolice (PL)	Installation of a 2nd 400kV circuit along an already existing line on the same voltage. (1870 MVA, 212km).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply; Increase of NTC.	planned	2020		
359	CCE Baltic Sea	Morzyczyn (PL)	Pomorzany/ Glinki (PL)	New line 220kV (522 MVA).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	planned	2020		
360	CCE Baltic Sea	Miłosna (PL)	Siekierki (PL)	New cable connection 220kV Miłosna - Warszawa Siekierki (333 MVA, 10km).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	planned	2020		
361	CCE Baltic Sea	Ołtarzew (PL)	Mory (PL)	Replacement of conductors (high temperature conductors). (new capacity 461 MVA).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	planned	2020		
362	CCE Baltic Sea	Wielopole (PL)	Moszczenica (PL)	Replacement of conductors (high temperature conductors). (new capacity 461 MVA).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	planned	2020		
363	CCE Baltic Sea	Byczyna (PL)	Siersza (PL)	Replacement of conductors (high temperature conductors). (new capacity 461 MVA).	Safe operation of the system - increase of the reliability (elimination of the network congestions).	Improved security of supply.	planned	2020		
364	CCE Baltic Sea	Czarna (PL)	Polkowice (PL)	New line will be second 400kV circuit to existing line in the same direction. (1870 MVA, 22km).	Safe operation of the system - couplings 220kV with 400kV transmission network (elimination of the network congestions).	Improved security of supply and increase of NTC.	planned	2020		
365	CCE Baltic Sea	Wyszków (PL)		New substation 400kV Wyszków (with transformation 400/110kV 400 MVA) will be connected by splitting and extending line Ostrołęka-Stanisławów.	Safe operation of the system - increase of the power demand.	Improved security of supply.	design & permitting	2020		
366	CCE Baltic Sea	Rzeszów (PL)	Chmielnicka (UA)	Establish existing 750kV interconnection between Poland and Ukraine. Mode of operation on border lines (synchronous/asynchronous) depends on results of future study concerning possibility of synchronous connection of Ukraine and Moldova to continental part of ENTSO-E and bilateral Polish - Ukrainian agreement.	The project is the modernisation and resumption of existing 750kV interconnection between Poland and Ukraine.	Increase of NTC and Improved security of supply.	planned	2020		

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367	CCE Baltic Sea	several substations in PSE O control area		Installation of an additional transformer + replacement of an existing one (400/110kV and 220/110kV) and shunt reactors in substations, upgrading and decommissioning of substations.	Safe operation of the system - increase of the power demand and voltage and reactive power control.	Improved security of supply.	planned	2020		
368	CCE Baltic Sea	Ełk (PL)	PL-LT border (LT)	Construction of a new 400kV OHL Ełk to PL-LT border. (2x1870 MVA, 108km).	Reinforcement in Polish internal grid in connection with project: Elk (PL) - Alytus (LT).	Increase of NTC and Improved security of supply with expected additional 600MW capacity between PL and LT. Interconnection LT-PL allow import/export between Poland and Baltic. Also this interconnection is crucial to make possible a synchronous interconnection of Baltic with other ENTSO-E countries.	design & permitting	2015		
369	CCE Baltic Sea	Siedlce Ujrzanów (PL)	Miłosna (PL)	Construction of a new 400kV OHL Siedlce Ujrzanów - Miłosna (1870 MVA, 84km) + A new AC 400kV switchgear in existing substation Siedlce Ujrzanow with transformation 400/110kV 400 MVA.	Reinforcement in Polish internal grid in connection with project: Elk (PL) - Alytus (LT).	Improved security of supply and increase of NTC.	design & permitting	2015		
370	CCE Baltic Sea	Ełk (PL)	New substation (Rutki)	Construction of a new 400kV double circuit OHL Ełk - Rutki (2x1870 MVA, 95km) + A new AC 400kV switchgear in existing substation Elk (in two stages) + A new AC substation Rutki.	Reinforcement in Polish internal grid in connection with project: Elk (PL) - Alytus (LT).	Improved security of supply and increase of NTC.	design & permitting	2015	X	
371	CCE Baltic Sea	Ostrołęka (PL)	Narew (PL)	Construction of a new 400kV OHL Ostrołęka-New substation (Rutki)-Narew (1870 MVA, 120km) + A new AC 400kV switchgear in existing substation Ostroleka (in two stages) with transformation 400/220kV 500 MVA and with transformation 400/110kV 400 MVA.	Reinforcement in Polish internal grid in connection with project: Elk (PL) - Alytus (LT).	Improved security of supply and increase of NTC.	design & permitting	2015		
372	CCE Baltic Sea	Oltarzew (PL)		A new AC substation with two transformers 400/220kV 2x500 MVA and one 400/110kV 400 MVA will be connected by splitting 400kV line Rogowiec-Miłosna and Miłosna-Płock and 220kV line Mory-Sochaczew and Mory-Janów.	Reinforcement in Polish internal grid in connection with project: Elk (PL) - Alytus (LT).	Improved security of supply and increase of NTC.	under construction	2015		
373	CCE Baltic Sea	Ostrołęka (PL)	Stanisławów (PL)	Single circuit line 220kV Ostrołęka-Miłosna will be partly upgraded to double circuit line 400kV (2x1870 MVA, 106km) with development of Ostrołęka 400kV substation + New substation 400kV Stanisławów will be connected by splitting and extending existing line Miłosna-Narew and Miłosna-Siedlce.	Reinforcement of Polish internal grid to make possible power transfer capacity (between PL and LT) of 1000MW.	Improved security of supply and increase of NTC.	design & permitting	2020		
374	CCE Baltic Sea	Kozienice (PL)	Siedlce Ujrzanów (PL)	Existing single circuit line will be upgraded to 400kV line in the same direction (1870 MVA, 90km).	Reinforcement of Polish internal grid to make possible power transfer capacity (between PL and LT) of 1000MW.	Improved security of supply and increase of NTC.	design & permitting	2020		
375	CCE Baltic Sea	Płock (PL)	Olsztyn Mątki (PL)	New single circuit line 400kV (1870 MVA, 180km) with development of Olsztyn Mątki 400kV substation.	Reinforcement of Polish internal grid to make possible power transfer capacity (between PL and LT) of 1000MW.	Improved security of supply and increase of NTC.	design & permitting	2020		

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376	CCE Baltic Sea	Alytus (LT)	PL-LT border (PL)	Construction of Back-to-Back convertor station near Alytus 330kV substation. Construction of double circuit 400kV OHL between Alytus and PL-LT border. Construction of 330kV AC line Alytus-Kruonis. Length of line: 46km.	Project: Elk (PL) - Alytus (LT).	Currently there are no connections between LT and PL. Increase of NTC and Improved security of supply.	design & permitting	2015		
377	Baltic Sea	Klaipeda (LT)	Telsiai (LT)	New single circuit 330kV OHL (943 MVA, 85km).	The new line is required to take advantage of full capacity of HVDC line to Sweden.	Increase of NTC and Improved security of supply.	design & permitting	2013		
378	Baltic Sea	Panevezys (LT)	Musa (LT)	New single circuit 330kV OHL (1080 MVA, 80km).	The new line is required to take advantage of full capacity of HVDC line to Sweden.	Increase of NTC.	planned	2016		
379	Baltic Sea	Kruonis (LT)	Alytus (LT)	New double circuit 330kV OHL (2x1080 MVA, 53km).	new line is required to take advantage of full capacity of link to Poland.	Increase of NTC and Improved security of supply.	planned	2020		
380	Baltic Sea	Visaginas (LT)	Kruonis (LT)	New single circuit 330kV OHL (1080 MVA, 200km).	new line is required to take advantage of full capacity of link to Poland.	Increase of NTC.	planned	2020		
381	Baltic Sea	Visaginas (LT)	Liksna (LV)	Upgrade single circuit OHL (943 MVA, 50km).	new line is required to take advantage of full capacity of link to Poland.	Increase of NTC.	under consideration	2020		
382	Baltic Sea	Vilnius (LT)	Neris (LT)	New single circuit 330kV OHL (943 MVA, 50km).	Additional line could be required when new Visaginas NPP will be build.	Improved security of supply.	planned	2020		
382a	Baltic Sea	Bitenai (LT)		New 330kV switching station.	Switching station will be build near Kaliningrad district border and will connect existing 330kV OHL Klaipeda-Sovetsk and Jurbarkas-Sovetsk.	Improved security of supply.	under construction	2011		
383	Baltic Sea	Klaipeda (LT)	Nybro (SE)	(NordBalt) A new 300kV HVDC VSC partly subsea and partly underground cable between Lithuania and Sweden. (440km).	Connection between Lithuania and Sweden. 440km long.	Improved the market integration Nordic Baltic. Currently is no connection between LT and Sweden.	design & permitting	2015/2016		necessary documentation is under preparation
384	Baltic Sea	RigaCHP1 (LV)	Imanta (LV)	A new 12.5km AC 330kV cable will be built from RigaCHP1 substation to Imanta substation. Both substations will be reconstructed, according new line connecting. New cable will be underground and one part will be underwater (under Daugava river). Expected capacity: 880MW.	New line will increase transmission capacity in the Riga region. Reliability and security of supply in town Riga and Latvia.	Improved security of supply and increase of NTC.	design & permitting	2012	X	Project is the part of the big project of Latvian grid reinforcement (Kurzeme Ring). This project is strong reinforcement of Riga transmission network, security of supply increasing and start connection point to Kurzeme Ring
385	Baltic Sea	Grobina (LV)	Imanta (LV)	"Kurzeme Ring" is a Latvian grid reinforcement project with new 330kV OHL construction and connection to the Riga node. New 330kV OHL construction mainly instead of the existing 110kV double circuit line route, 110kV line will be renovated at the same time and both will be assembled on the same towers. Upgrade of double circuit 330kV double circuit OHL new 380 330. (Capacity 800MW)	New interconnection lines between Western and Central part of Latvia. New transmission line will increase Security of Supply in Western and Central part of Latvia. Platform for integration of new renewable power generation.	Improved security of supply; RES integration ; Increase of NTC. Mentioned line reinforcement is part of the NordBalt project and planned connection point to Estonian-Latvian third interconnection.	planned	2016	X	

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386	Baltic Sea	EE (Lihula-Sindi)	LT (Ventspils-Dundaga- TEC2)	Latvian-Estonian third interconnection will consist of OHL Harku-Sindi-Lihula in Estonian part, OHL Imanta-Tume-Dundaga-Ventspils in Latvian part, and sea cable between cross-border DC or AC cable. Final interconnection type and final interconnection and transmission line route will be selected in middle of 2010. At present three alternative route variants researched. Final interconnection length, DC voltage and transmission capacity will be selected in feasibility and technical study in the middle of 2010. The connection would be as a new single circuit line mixed (OHL+subsea cable) up to 500kV.	Need to increase the current transfer capacity between Estonia and Latvia. Need to increase Security of Supply in Latvia, Estonia and all Baltic countries. Platform for integration of new renewable power generation in both countries.	Increase of NTC, improved security of supply and RES integration. Increasing security of supply in Baltic. Capacity congestion and number of hours with market division will be reduced. Risk of shortage of energy will be reduced in the Nordic and Baltic power system. Expected NTC 600-1200MW.	under consideration	2020	X	
387	Baltic Sea	Tartu (EE)	Sindi (EE)	A new 162km internal connection will be established on existing route resulting in double circuit line with 2 different voltages (330kV / 110kV).	Depending on market situation the cross-border connection between Latvia and Estonia can be congested. In addition it has positive impact to security of supply in Baltic.	Improved security of supply, RES integration and increase of NTC. New internal connection is for ensuring voltage stability in Western part of Estonia and it is also related to transfer capacity regarding new interconnections between Estonia and Latvia and power exchanges between Nordic and Continental Europe.	design & permitting	2014		
388	Baltic Sea	Harku (EE)	Sindi (EE)	New single circuit 400 ÷ 220 OHL. (Capacity 1200 MVA, 140-160km). Major part of new internal connection will be established on existing right of way on the Western part of Estonian mainland and the line voltage will be 330kV.	Depending on market situation the cross-border connection between Latvia and Estonia can be congested. In addition it has positive impact to Security of Supply in Baltic.	Increase of NTC ; RES integration ; improved security of supply in Baltic. The new internal connection will ensure transfer capacity between Estonia and Latvia and facilitate power exchanges between Nordic and Continental Europe.	planned	2018		
389	Baltic Sea	Eesti (EE)	Püssi (EE)	Reinforcement of existing 57km single circuit 330kV OHL. Expected capacity:1200 MVA.	Depending on market situation the cross-border connection between Finland and Estonia can be congested. In addition it has positive impact to security of supply in Baltic.	Increase of NTC, reduction of infrastructure vulnerability and improved security of supply. New internal connection is for ensuring transfer capacity concerning second interconnection between Estonia and Finland.	under construction	2010		
390	Baltic Sea	Balti (EE)	Püssi (EE)	Reconstruction of 68km single circuit 400-220kV OHL.	Depending on market situation the cross-border connection between Finland and Estonia can be congested. In addition it has positive impact to security of supply in Baltic.	Increase of NTC, reduction of infrastructure vulnerability and improved security of supply. New internal connection is for ensuring transfer capacity concerning second interconnection between Estonia and Finland.	design & permitting	2011		

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391	Baltic Sea	Püssi (EE)	Anttila (FI)	A new HVDC (450kV) connection will be built between Estonia and Finland. On the Finnish side, a 14km DC overhead line will be built to a new substation Anttila where the converter station will be placed. On the Estonian side, a 11km DC cable line will be built to a existing substation Püssi where the converter station will be placed. length of marine cable is 140km. Expected capacity: 650MW.	Depending on market situation the cross-border connection between Finland and Estonia can be congested. In addition it has positive impact to security of supply in Baltic.	Increase of NTC; improved security of supply; RES integration ; 650MW ; Increasing Security of Supply in Baltic. Capacity congestion and number of hours with market division will be reduced. Risk of shortage of energy will be reduced in the Nordic and Baltic power system.	design & permitting	2013		
392	Baltic Sea	Yllikkälä (FI)	Huutokoski (FI)	New 155km single circuit 400kV OHL and renovation of 400kV substations in Yllikkälä and Huutokoski. Expected capacity: 1850 MVA.	High imports from Russia + high local surplus of power.	Increase of NTC and Improved security of supply.	design & permitting	2013		
393	Baltic Sea	Seinäjoki Ulvila Ventusneva Keminmaa (FI)	Tuovila Kristinestad Pyhänselkä (FI)	Four new single circuit 400kV OHL are part of project in upgrading Ostrobothnian 220kV system into 400kV, and strengthening the 400 kV grid in Northern Finland. Commissioning of first section in year 2011, second in 2014 third in ca. 2018 and fourth ca 2020. total length of lines: 520 km. Expected capacity: 1850 MVA.	Integration of new generation + replacement of ageing 220kV system + increased transmission capacity demand.	Increase of NTC, RES integration and Improved security of supply.	under construction	2011/2020		
394	Baltic Sea	Hikiä (FI)	Forssa (FI)	New 80km single circuit 400kV OHL. Expected capacity:1850 MVA.	Changed exchange patterns.	Increase of NTC.	under consideration	2015		
395	Baltic Sea	Rauma (FI)	Finnböle (SE)	A new 500kV HVDC connection will be built in parallel with the existing one between Finland and Sweden. On the Swedish side, a 70km direct current overhead line will be built to a new substation Finnböle where the converter station will be placed. Total length of line: 300km and capacity: 800MW.	Depending on a hydro situation and market situation the cross-border connection between Finland and Sweden can be congested. In addition there is a large generator under construction in the vicinity of the Finnish side of the border.	Increase of NTC, improved security of supply and annual losses reduction. Congestion and number of hours with market division will be reduced. Redispatching of load flow between 400kV interconnectors at North and Fenno-Skan will reduce power losses. Cost of ancillary services can be decreased. Risk of shortage of energy will be reduced in the Nordic power system.	under construction	2011		
396	Baltic Sea	Finland Nord (FI)	Sweden North (SE)	Third single circuit 400kV AC OHL between Sweden and Finland. Expected capacity: 1850 MVA.	New wind power generation + larger units + decommissioning of 220kV interconnector.	New wind power generation + larger units + decommissioning of 220kV interconnector.	under consideration	2018/2020		
397	Baltic Sea North Sea	Varangerbotn (NO)	Pirttikoski or Petäjäskoski (FI)	New single circuit 380 - 400kV OHL (500km).	Enabling RES (wind and small scale hydro power) to connect to the grid (currently limited grid capacity). Enhance the Security of Supply for the Finnmark area, including critical oil and gas installations.	Security of Supply for the Finnmark area. Enabling new demand in critical oil and gas installations. Enabling RES (wind power) in Northern Norway.	under consideration	2020/2025		The project will be part of a future/potential "Arctic Circle", including reinforcements in Finland, Sweden and Norway.

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398	Baltic Sea North Sea	Under consideration (SE)		New series compensation of OHL.	Power flow limited by reactive power issues.	Increased power flow.	under consideration	2016/2020		
399	Baltic Sea	Vasteras (SE)	Lindbaka (SE)	Upgrade/Replacement of existing single circuit 220kV lines to 400kV.	Increase power flow.	Increase of NTC, improved security of supply and annual losses reduction.	under consideration	2016/2020		
400	Baltic Sea	Ekhyddan (SE)	Barkeryd (SE)	New single circuit 400kV OHL.	Increased installed nuclear capacity.	Improved security of supply.	under consideration	2016/2020		
401	Baltic Sea	Västervik (SE)	Gotland (SE)	New AC or DC subsea cable interconnection 400kV (1000 MW).	Integration of new renewable power generation.	RES integration.	under consideration	2016/2020		
402	Baltic Sea North Sea	Hurva/Hallsberg (SE)	Tveiten (NO)	"South West link" consisting of three main parts: 1) New 400kV line between Hallsberg and Barkeryd 2) New double HVDC VSC underground cable line between Barkeryd and Hurva 3) New HVDC VSC line between Barkeryd and Tveiten/Norway. The project also include new substations and converter stations in the connection points line double circuit new OHL Hallsberg - Barkeryd 170km, underground VSC Barkeryd - Hurva 250km and VSC Barkeryd - Tveiten with 103km on the Norwegian side. Expected capacity: 1200MW.	Market integration. Integration of new renewable power generation.	Increase of NTC, improved security of supply and RES integration.	planned	2014		
403	Baltic Sea North Sea	Scandinavia North (NO)	Scandinavia South (SE)	A joint Stattnett & Svenska Kraftnat study north - south reinforcement (AC or VSC), expected length: 400 - 500km under study.	Integration of new renewable power generation / limit to renewable export.	RES integration.	under consideration	long term		
405	Baltic Sea North Sea	Kristiansand (NO)	Rød (NO)	Voltage upgrading of an existing single circuit 300kV OHL and a new section of OHL between Rød and Bamle. Total length: 175km.	New interconnection lines between Southern Norway and Europe. Security of supply for the Oslo region.	Increase of NTC and reduction of infrastructure vulnerability. Voltage upgrading required in the AC grid to enable the increase of cross-border capacities in 142, 425, 426.	design & permitting	2014		Seen as an extension of the new HVDC cables (142, 424, 425, 426).
406	Baltic Sea North Sea	Kristiansand (NO)	Tonstad - Saurdal (NO)	Voltage upgrading of existing single circuit 300kV OHL Kristiansand-Feda-Tonstad-Lyse-Saurdal Seen as an extension of the new HVDC cables.	New interconnection lines between Southern Norway and Europe. Integration of new renewable power generation.	Increase of NTC, RES integration. Voltage upgrading required in the AC grid to enable the increase cross-border capacities in 142, 425, 426.	design & permitting	2013/2016		Seen as an extension of the new HVDC cables (142, 424, 425, 426).
407	Baltic Sea North Sea	Tonstad (NO)	Arendal (NO)	Voltage upgrading of existing single circuit 300kV OHL Tonstad-Solhom-Arendal.	New interconnection lines between Southern Norway and Europe. Integration of new renewable power generation.	Increase of NTC, RES integration. Voltage upgrading required in the AC grid to enable the increase cross-border capacities in 142, 425, 426.	planned	2016/2018		Seen as an extension of the new HVDC cables (142, 424, 425, 426).
408	Baltic Sea North Sea	Kristiansand, Feda (NO)		Reactive compensation due to HVDC links NorNed and Skagerak 4. Reactive power devices in 400kV substations.	Increased market integration. Reactive compensation due to HVDC links NorNed and Skagerak 4.	Improved security of supply and reduction of infrastructure vulnerability.	planned	2011/2014		Seen as an extension of the new HVDC cables (142, 424, 425, 426).

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409	Baltic Sea North Sea	Feda, Tonstad (NO)		Reactive power devices in 400kV substations.	Increased market integration. Reactive compensation due to HVDC links.	Improved security of supply.	planned	2017/2018		Seen as an extension of the new HVDC cables (142, 424, 425, 426).
410	Baltic Sea North Sea	Kristiansand (NO)		Spare transformer for the HVDC Skagerak interconnection transformer.	Increased market integration.	Improved security of supply and reduction of infrastructure vulnerability.	under construction	2010		
411	Baltic Sea North Sea	Rød (NO)	Sylling (NO)	Voltage upgrading of existing single circuit 300kV OHL Rød-Tveiten-Flesaker-Sylling in connection with the new HVDC line to Sweden, the Syd Vest link.	Increased market integration.	Increase of NTC and improved security of supply.	under consideration	2012/2016		
412	Baltic Sea North Sea	Rød (NO) - Sylling (NO) - Flesaker (NO) -	Hasle (NO) Tegneby (NO) Tegneby (NO)	Reinvestment and capacity increase Oslofjord 400kV subsea cables. Three cables: Filtvedt - Brenntangen, Solberg - Brenntangen, and Teigen - Evje.	Enhance the Security of Supply for the Oslo area, increase cross-border capacity.	Improved security of supply and increase of NTC.	design & permitting	2011/2013		
413	Baltic Sea North Sea	Ørskog (NO)	Fardal (NO)	New 300km single circuit 400kV OHL.	Critical situation with security of supply in the Mid-Norway area.	Improved security of supply, RES integration and increase of NTC.	design & permitting	2013/2014		
413a	Baltic Sea North Sea	Sima (NO)	Samnanger (NO)	New 420kV line Sima-Samnanger to ensure security of supply in the region of Hordaland/ Bergen, and to integrate new hydro power.	Enhance the Security of Supply for the Hordaland area. Enabling RES small scale hydro power in Western Norway to connect to the grid (currently limited grid capacity).	Improved security of supply; RES integration.	design & permitting	2013/2014		
414	Baltic Sea North Sea	Fardal (NO)	Aurland (NO)	Voltage upgrading of existing single circuit 300kV OHL Fardal-Aurland Extension of 413 - Ørskog - Fardal.	RES integration.	Improved security of supply, RES integration and increase of NTC.	planned	2015/2017		
415	Baltic Sea North Sea	Namsos (NO)	Klæbu (NO)	Voltage upgrading of existing single circuit 300kV OHL Namsos-Klæbu.	Enabling RES (wind and small scale hydro power) to connect to the grid (currently limited grid capacity).	RES integration.	planned	2013		
416	Baltic Sea North Sea	Klæbu (NO)	Aura/ Viklandet (NO)	Voltage upgrading of existing single circuit 300kV OHL Klæbu-Aura.	Enabling RES (wind and small scale hydro power) to connect to the grid (currently limited grid capacity).	RES integration.	planned	2016		
417	Baltic Sea North Sea	Aura/Viklandet (NO)	Fåberg (NO)	Voltage upgrading of existing single circuit 300kV OHL Aura/Viklandet-Fåberg.	Enabling RES (wind and small scale hydro power) to connect to the grid (currently limited grid capacity).	RES integration.	under consideration	2016/2020		
418	Baltic Sea North Sea	Nedre Røssåga (NO)	Namsos (NO)	Voltage uprating of existing single circuit 300kV Nedre Røssåga-Tunnsjødal-Namsos OHL to 400kV.	Enabling RES (wind and small scale hydro power) to connect to the grid (currently limited grid capacity).	RES integration.	planned	2015		
419	Baltic Sea North Sea	Namsos (NO)	Storheia (NO)	New 119km 800MVA single circuit Namsos-Roan-Storheia OHL to connect new wind power generation at Fosen.	Enabling RES (wind and small scale hydro power) to connect to the grid (currently limited grid capacity).	RES integration.	design & permitting	2013		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
420	Baltic Sea North Sea	Storheia (NO)	Orkdal / Trollheim (NO)	New Storheia-Snillfjord-Orkdal/Trollheim single circuit 400kV line to connect new wind power generation in the Snillfjord area; part of the line will be a subsea cable.	Enabling RES (wind and small scale hydro power) to connect to the grid (currently limited grid capacity).	RES integration.	design & permitting	2015		
421	Baltic Sea North Sea	Ofoten (NO)	Balsfjord (NO)	New 150km single circuit 400kV OHL.	Enabling RES (wind in Northern Norway) to connect to the grid (currently limited grid capacity). Enhance the Security of Supply of the Finnmark area, including critical oil and gas installations.	Improved security of supply; RES integration.	design & permitting	2014/2015		The project will be part of a future/potential "Arctic Circle", including reinforcements in Finland, Sweden and Norway.
422	Baltic Sea North Sea	Balsfjord (NO)	Hammerfest (NO)	New 355km single circuit 400kV OHL.	Enabling RES (wind in Northern Norway) to connect to the grid (currently limited grid capacity). Enhance the Security of Supply for the Finnmark area, including critical oil and gas installations.	Improved security of supply; RES integration.	design & permitting	2016		The project will be part of a future/potential "Arctic Circle", including reinforcements in Finland, Sweden and Norway.
423	Baltic Sea North Sea	Skaidi (NO)	Varangerbotn (NO)	New single circuit 400kV OHL.	Enabling RES (wind in Northern Norway) to connect to the grid (currently limited grid capacity). Enhance the Security of Supply for the Finnmark area, including critical oil and gas installations.	Improved security of supply; RES integration.	planned	2020/2025		The project will be part of a future/potential "Arctic Circle", including reinforcements in Finland, Sweden and Norway.
424	Baltic Sea North Sea	kVilldal (NO)	UK (substation to be determined)	A new 1400MW HVDC bipolar installation connecting Western Norway and the UK via 800km subsea cable; DC voltage is to be determined.	Currently there is no connection between UK and Norway.	1400MW increase of NTC; RES integration; diversity of supply: connection between a hydro and a thermal power system.	under consideration	2017/2020		
424b	North Sea	Triton Knoll (UK)		Establish new 400kV double busbar collector substation.	Provision for additional wind capacity from the North Sea.	RES integration.	under consideration	2018		
424c	North Sea	Triton Knoll (UK)	Bicker Fenn (UK)	New 400kV double circuit.	Limit to renewable export.	Reduce congestion.	under consideration	2018		
424d	North Sea	Near Triton Knoll (UK)		Establish new 400kV double busbar collector substation.	Provision for additional wind capacity from the North Sea.	RES integration.	under consideration	2018		
424e	North Sea	Triton Knoll (UK)	Walpole (UK)	New 400kV double circuit.	Limit to renewable export.	Reduce congestion.	under consideration	2018		
424f	North Sea	Triton Knoll (UK)	Grimsby West (UK)	New 400kV double circuit.	Limit to renewable export.	RES integration.	under consultation	2019		
424g	North Sea	Bicker Fenn (UK)	Near Bainton (UK)	New 400kV double circuit.	Limit to renewable export.	RES integration.	under consideration	2018		
424h	North Sea	Near Bainton (UK)		Establish new 400kV double busbar substation.	Limit to renewable export.	RES integration.	under consideration	2018		
424i	North Sea	Killinghome South (UK)		Establish new 400kV double busbar substation and construct new 400kV double circuit to Grimsby West.	Limit to renewable export.	RES integration.	under consideration	2020		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
424j	North Sea	Bramford (UK)	Twinstead(UK)	New 400kV double circuit.	Limit to renewable and nuclear export.	Reduce congestion.	under consideration	2017		
425	Baltic Sea North Sea	Feda (NO)	to be determined (NL)	NorNed 2: a 2nd HVDC connection between Norway and The Netherlands via 570km 450kV DC subsea cable with 700 - 1400MW capacity.	Need to increase the current transfer capacity between both countries.	700-1400MW increase of NTC; RES integration; diversity of supply: connection between a hydro and a thermal power system.	under consideration	2015/2017		
426	Baltic Sea North Sea	Kristiansand (DK)	Tjele (NO)	Skagerak 4: 4th HVDC connection between Southern Norway and Western Denmark, built in parallel with the existing 3 HVDC cables; new 700MW including 230km 500kV DC subsea cable.	Need to increase the current transfer capacity between both countries.	700 MW increase of NTC ; Diversity of supply: connection between a hydro and a thermal power system. Enabling increased RES integration.	design & permitting	2014	X	http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Skagerrak+4/
427	Baltic Sea North Sea	Endrup (DK)	Eemshaven (NL)	COBRA: New single circuit HVDC connection between Jutland and the Netherlands via 350km subsea cable; the DC voltage will be up to 450kVand the capacity 600-700MW.	Need to increase the current transfer capacity between both countries.	Increase of NTC ; improved security of supply; RES integration ; 600-700MW ; The purpose of the link is to allow for the exchange and integration of wind energy and increase the value of renewable energy into the Dutch and Danish power systems and to increase security of supply.	design & permitting	2016		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cobra+cable/
428	Baltic Sea North Sea	Kassø (DK)	Tjele (DK)	Rebuilding of a 400kV OHL of 173km from a single-circuit to a double-circuit . This increases the transfer capacity with approx 1000 MW.	Need for increased capacity Norway-Jutland-Germany.	1000MW increase of NTC; RES integration.	design & permitting	2012/2014		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Kassø-Tjele/
429	Baltic Sea North Sea	Ferslev (DK)	Vester Hassing (DK)	New 20km single circuit 400kV line via a cable with a capacity of approx 800 MW.	Need for improving the ability to transport Læsø off-shore wind power in N-1 security conditions.	RES integration ; improved security of supply.	Planned	2018		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cable+action+plan/Cable+action+plan.htm
430	Baltic Sea North Sea	Revsing (DK)	Landerupgård (DK)	New 18km single circuit 400kV line via cable with capacity of approx. 1200 MW.	Need for transporting wind power from the West Coast to the consumption centre on the East Coast.	RES integration; improved security of supply.	Planned	2017		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cable+action+plan/Cable+action+plan.htm
431	Baltic Sea North Sea	Tjele (DK)	Trige (DK)	New 46km single circuit 400kV line via cable with capacity of approx. 1200 MW.	Need for transporting wind power from the West Coast to the consumption centre on the East Coast.	RES integration; improved security of supply.	Planned	2017		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cable+action+plan/Cable+action+plan.htm

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
432	Baltic Sea North Sea	Asvæsværket ((DK)	Kyndbyværket (DK)	New 60km single circuit 400kV line via cable with capacity of approx. 1200 MW.	Need for reinforcing and meshing the 400kV grid on Zealand.	Improved security of supply.	Planned	2014		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cable+action+plan/Cable+action+plan.htm
433	Baltic Sea North Sea	Glentegård (DK)	Amagerværket & H.C. Ørstedværket (DK)	New 22km single circuit 400kV line via cable with capacity of approx. 1200MW.	Creating a 400kV ring around Copenhagen.	Improved security of supply.	Planned	2016		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cable+action+plan/Cable+action+plan.htm
434	Baltic Sea North Sea	Fraugde (DK)	Herslev(DK)	New single circuit HVDC-LCC installation including a 56km 450kV DC subsea cable with 600MW capacity.	Need for interconnection between Eastern and Western Denmark to exchange wind power & regulation power.	Improved security of supply; RES integration.	under construction	2010		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Great+Belt/
435	Baltic Sea North Sea	Endrup (DK)	Revsing(DK)	Upgrade of 50km double-circuit 400kV OHL to reach a capacity of approx. 2000MW.	Need to connect COBRA line; improve n-1 security; need to increase transport capacity between West coast to East coast.	RES integration; improved security of supply.	Planned	2017		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cable+action+plan/Cable+action+plan.htm
436	Baltic Sea North Sea	Idomlund (DK)	Tjele (DK)	New 74km single circuit 400kV line via cable with capacity of approx. 1200MW.	Need for a second 400kV connection to Idomlund for security of supply and to evacuate wind power from Western Jutland.	RES integration; improved security of supply.	under consideration	2018/2020		http://www.energinet.dk/en/menu/Transmission/New+projects/New+electricity+transmission+installations/Cable+action+plan/Cable+action+plan.htm
437	North Sea	Grain (UK)	Maasvlakte (NL)	New 1290MW HVDC bipolar installation including 260km of 450kV DC subsea cable.	Currently there is no connection between UK and Netherlands.	Project results in 1000MW NTC between both countries; enhanced diversity and security of supply for both markets open access for all market parties by explicit auction and market coupling increase of interconnection capacity and market transparency.	under construction	2010	X	commissioned in 2010 but commercial operation as from 2011
438	North Sea	Eemshaven (NL)	Diemen (NL)	New 175-200km AC overhead line with capacity of 2x2650 MVA of 380kV.	need for connection from the generation locations in the vicinity of Eemshaven to the Dutch 380kV central ring.	Conventional generation integration; RES integration.	design & permitting	2016		
439	North Sea	Borssele (NL)	Geertruidenberg (NL)	New 100-130km double-circuit 380kV OHL with 2x2650 MVA capacity.	Need for connection from the generation locations in the vicinity of Borssele to the Dutch 380kV central ring.	Conventional generation integration; RES integration.	design & permitting	2014		
440	North Sea	Maasvlakte (NL)	Beverwijk (NL)	New 380 kV double-circuit mixed project (OHL+ underground cable) including approximately 20km of underground cable for 2650 MVA. The cable sections are a pilot project. The total length of cable at 380kV is frozen until more experience is gained.	Need for connection from the generation locations in the vicinity of Rotterdam and Amsterdam to the Dutch 380kV central ring.	Conventional generation integration; feed of load increase; RES integration.	under construction	2013		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
441	North Sea	Zwolle (NL)	Hengelo (NL)	Upgrade of the capacity of the existing 60km double circuit 380kV OHL to reach a capacity of 2x2650 MVA.	Need to increase the capacity of the existing line to avoid overloads due to different flow patterns in the grid.	Improved security of supply; conventional generation integration; RES integration.	under consideration	tbd		
442	North Sea	Krimpen aan de Ijssel (NL)	Maasbracht (NL)	Upgrade of the capacity of the existing 150km double circuit 380kV OHL to reach a capacity of 2x2650 MVA.	Need to increase the capacity of the existing line to avoid overloads due to different flow patterns in the grid.	Improved security of supply; conventional generation integration; RES integration.	under consideration	tbd		
443	North Sea	Richborough (UK)	Zeebrugge (BE)	Nemo project: new DC sea link including 135km of 250kV DC subsea cable with 1000MW capacity.	Currently there is no connection between BE and UK.	Increase of NTC by 1000MW.	planned	2016		
444	North Sea	Zomergem (BE)	Zeebrugge (BE)	New approx 50km double-circuit 380kV 5000MVA OHL line between Zomergem and Zeebrugge to evacuate the locally (offshore) produced power line.	Required to further realise the renewable offshore resources available to Belgium.	RES integration; Increase of NTC.	design & permitting	2014		
445	North Sea	Zandvliet (BE)	Lillo (BE)	Doubling of the axis Zandvliet-Mercator via Lillo by erecting a new 35km 380kV double circuit OHL with 1500 MVA capacity.	Needed to avoid overloading of the line during certain contingencies as a result of new generation and increasing demand.	Conventional generation integration; improved security of supply; Increase of NTC.	design & permitting	2014		
445a	North Sea	Gramme (BE)	Van Eyck (BE)	Doubling of 380kV the axis Gramme-Van Eyck.	Increase of NTC and connection of new generation units.	Market integration and power plants connection.	planned	2014		
446	North Sea	Bascharage (LU)	Aubange (BE)	New interconnection between Creos grid in LU and ELIA grid in BE via a 16km double circuit 225kV underground cable with a capacity of 1000 MVA.	Grid studies promote a new interconnection in the south of the grid line for improving security of supply.	Improved security of supply; Increase of NTC; Diversity of supply; new capacity between LU and BE.	design & permitting	2013		
447	North Sea	Heisdorf (LU)	Berchem (LU)	New 20km double-circuit mixed (underground cable+OHL) 225kV project with 1000 MVA capacity including substations for infeed in lower voltage levels.	Need for increased infeed to lower voltage levels, the project will also close a mesh in the south of the grid.	Improved security of supply; Increase of NTC.	design & permitting	2012/2020		
448	North Sea	Thames estuary (UK)		Double-circuit 400kV line upgrade around the Thames estuary.	Low cross border capacity.	Increase of NTC (investment needed to accommodate additional interconnectors and integrate offshore RES	under construction	2011		
449	North Sea	Richborough (UK)	Canterbury (UK)	New double-circuit 400kV OHL and new 400kV substation in Richborough.	Low cross border capacity.	Increase of NTC (investment needed to accommodate additional interconnectors).	planned	2019		
449a	North Sea	Gravir (UK)	Beauly (UK)	Western Isles link. New 450MW HVDC link, +/- 150kV. Route length 156km (80km subsea, 76km onshore underground cable).	Limit to renewable export.	RES integration & reduced reliance on diesel generation.	design & permitting	2013		
450	North Sea	Sellindge (UK)	Dungeness (UK)	Reconductoring existing double-circuit 400kV OHL.	Low cross border capacity.	Increase of NTC (investment needed to accommodate additional interconnectors).	planned	2019		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
450a	North Sea	Kergord and Caithness (UK)	Blackhillock (UK)	The Moray Firth HVDC development - Shetland and Caithness links with offshore HVDC hub. Three ended HVDC link, 2 x 600MW legs and common 1200MW leg. Total route length 395km.	Limit to renewable export.	RES integration.	design & permitting	2014		EC grant of €74m awarded to SHETL under the European Energy Programme for Recovery. Grant relates to the offshore hub element and rating
451	North Sea	Rowdown (UK)		New 400kV quadboosters.	Low cross border capacity.	Increase of NTC (investment needed to accommodate additional interconnectors).	planned	2019		
451a	North Sea	Dounreay (UK)	Beauly (UK)	String a second 275kV OHL circuit on existing towers.	Limit to renewable export.	RES integration.	design & permitting	2012		
452	North Sea	Deeside (UK)	Hunterston (UK)	New 2000MW HVDC link via 360km 500kV DC subsea cable on the West coast of the UK and new 400kV substation in Deeside - CSC Technology.	Limit to renewable export.	RES integration.	planned	2015		
452a	North Sea	Beauly (UK)	Kintore (UK)	Reconductor existing 275kV overhead line route.	Limit to renewable export.	RES integration.	design & permitting	2014		
453	North Sea	Peterhead (UK)	Hawthorn Pit (UK)	New 1800MW HVDC link via 365km 500kV DC subsea cable on the East coast of the UK and new 400kV substation in Hawthorn Pit - CSC Technology.	Limit to renewable export.	RES integration.	planned	2018		
453a	North Sea	Blackhillock (UK)	Kincardine (UK)	Reinsulate existing 275kV route for 400kV operation and establish three new 400kV substations en-route.	Limit to renewable export.	RES integration.	design & permitting	2015		
454	North Sea	Hawthorn Pit (UK)	Norton (UK)	Upgrade of double circuit OHL from 275 to 400kV.	Limit to renewable export.	RES integration.	planned	2018		
455	North Sea	Beauly (UK)	Denny (UK)	New double circuit 400kV OHL (220km) with new terminal substations and substation extensions en route.	Limit to renewable export.	RES integration.	under construction	2014		
456	North Sea	Harker (UK)	Hutton (UK)	Upgrade to double-circuit Harker - Hutton 400kV OHL.	Limit to renewable export.	RES integration.	planned	2013		
456b	North Sea	Harker(UK)	Quernmore(UK)	New 400kV double circuit.	Limit to renewable and nuclear export .	Reduce congestion.	under consideration	2020		
456c	North Sea	Quernmore(UK)	Padiham(UK)	New 400kV double circuit.	Limit to renewable and nuclear export.	Reduce congestion.	under consideration	2020		
457	North Sea	Harker (UK)	Stella (UK)	New 400kV series compensation at a number of locations across the Anglo-Scottish border.	Limit to renewable export.	RES integration.	planned	2014		
458	North Sea	Hinkley (UK)	Seabank (UK)	New 60km double-circuit 400kV overhead line for renewables off the South West peninsula, replanting of Hinkley Point nuclear power station and further CCGT at Seabank.	Integration of nuclear plant and limit to renewable export.	RES and conventional integration.	design & permitting	2016		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
459	North Sea	New substation (UK)	Ironbridge (UK)	New 400kV substation and 85km line to connect the TAN-08 wind farms in mid Wales.	Limit to renewable export.	RES integration.	design & permitting	2016		
459b	North Sea	Wlyfa (UK)	Central Wales (UK)	New HVDC (VSC) bipolar interconnection.	Limit to renewable export.	RES integration.	under consideration	>2020		
460	North Sea	Pentir (UK)	Trawsfynydd (UK)	Upgrade of existing 48km single circuit 400kV line to double circuit to accommodate new wind generation off Anglesey and nuclear replanting at Wylfa.	Integration of nuclear plant and limit to renewable export.	RES and conventional integration.	under consideration	2015		
460b	North Sea	Wylfa(UK)	Pentir(UK)	New 400kV double circuit to connect offshore wind.	Limit to renewable export.	RES integration.	under consideration	2017		
461	North Sea	Woodland (IE)	Deeside (UK)	A new 260km HVDC (380kV DC) underground and subsea connection between Ireland and Britain with 500MW capacity. On the Irish side, a 45km direct current underground cable will be built to the Woodland substation where the VSC converter station will be placed. The link will consist of two identical circuits.	Future generation import and export to and from Ireland respectively.	RES integration; improved security of supply; diversity of supply. The project will enhance market opportunities and benefit competition.	under construction	2011	X	
462	North Sea	Moyhill (IE)	Turleenan (UK)	A new 80km single circuit 400kV 1500MVA OHL from a new Moyhill 400/220kV substation in Ireland to a new Turleenan 400/275kV substation in Northern Ireland. This project is an integral part of the new interconnection project Moyhill- Wooodland between Ireland and Northern Ireland.	Low cross border capacity.	Increase of NTC up to 1000MW NTC from IE to NI (today <450MW); improved security of supply; improved access for renewable generation.	design & permitting	2012	X	
463	North Sea	IE (substation to be determined)	UK (substation to be determined)	Strengthening of EHV networks (partial uprate and new) into Donegal and West of Northern Ireland and enhanced links between the two systems.	This project needs to be completed to facilitate the development of renewable energy in the North-West and Border Regions.	RES integration; improved security of supply; Annual losses reduction.	under consideration	>2015		
464	North Sea	Moyhill (IE)	Woodland (IE)	A new 60km single circuit 400kV 1500MVA OHL from Woodland station north of Dublin up to a new Moyhill 400/220kV station in Co. Meath. This project together with Moyhill-Turlenaan constitute the new interconnection project between Ireland and Northern Ireland.	Low cross border capacity.	Increase of NTC up to 1000 MW NTC from IE to NI (today <450MW); improved security of supply; improve access for renewable generation.	design & permitting	2012	X	
465	North Sea	Loughteeog (IE)		A new 500 MVA 400/110kV substation connected into the Moneypoint-Dunstown 400kV line and the Athy-Portlaoise 110kV line, and with two 400/110kV 250 MVA transformers. This project also comprises a new 110kV line from Loughteeog to Ballyragget 38kV station and upgrading of Ballyragget station and the Ballyragget-Kilkenny 38kV line from 38kV to 110kV substation.	Demand growth at Kilkenny city and surrounding region.	Improved security of supply for counties Kilkenny, Carlow and Laois; reduce losses.	design & permitting	2014		

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REF on map	RGs	Substation 1	Substation 2	Project characteristics	Investment need alleviated	Expected benefits	Progress status	Expected time of commissioning	TENE	Comments
466	North Sea	Flagford (IE)	Srananagh (IE)	The construction of a new 55km single circuit 220kV line connecting the existing Flagford 220/100kV station to a new Srananagh 220/110kV station.	This development is needed to reinforce the network in the North-West area by supporting the voltage and reducing the risk of loss of supply during the winter peaks and the summer maintenance outages. This project will help alleviate constraints on the network in the South-West Region.	Improved security of supply; RES integration; reduce Losses.	under construction	2011		The 110kV works associated with this project have been completed
467	North Sea	Moneypoint (IE)	Tarbert or Kilpaddoge (IE)	A new 10km single circuit 220kV 500MVA (underground+subsea) cable constructed across the River Shannon Estuary from Moneypoint in Co. Clare to Tarbert or a new Kilpaddoge station in Co. Kerry. A new 400/220kV transformer at Moneypoint station is included in this project.	This project will provide an alternative route to import to or export power from the south West.	Improved security of supply; RES integration; Reduce Losses.	planned	2012		
468	North Sea	South-West Substation tbd (IE)	Mid-West Substation tbd (IE)	Increased capacity between the South-West and the Mid-West regions.	This new circuit is required to facilitate the evacuation of generation from the South-West region. This project will help alleviate constraints on the network in the South-West Region.	RES integration; improved security of supply; Reduce Losses.	under consideration	tbd		
469	North Sea	South-West Substation tbd (IE)	Mid-East Substation tbd (IE)	Increased capacity between the South-West and the Mid-East regions.	This new development is required to facilitate the evacuation of generation from the south-West region. This project will help alleviate constraints on the network in the South-West Region.	RES integration; improved security of supply; Reduce Losses.	under consideration	tbd		
470	North Sea	Mayo Substation tbd (IE)	Mid-East Substation tbd (IE)	The construction of new EHV transmission circuit(s) from north West Mayo to the EHV system.	This circuit(s) will facilitate the evacuation of generation from the North-West Region towards the main load centre in the East.	RES integration; improved security of supply; Reduce Losses.	under consideration	tbd		
471	North Sea	Dunstown (IE)	Woodland (IE)	Uprate of the 62-km single circuit 400-kV line between the Dunstown and Woodland stations for increasing the capacity	Following the construction of this circuit, large quantities of generation can be transferred through the Mid-East Region without having to pass through the Dublin city system.	Improve security of supply; Conventional generation integration; RES integration;	under consideration	tbd		

[13] APPENDIX 2: MAIN REGIONAL GROUPS ACHIEVEMENTS, PRESENT AND FUTURE WORKS

The aim of this appendix is to give an overview of the major achievements of ENTSO-E RGs in the recent period. It must be mentioned that the focus is made here on grid studies, scenarios and market modelling being addressed in Appendix 3 and some major projects in Appendix 4.

13.1 REGIONAL GROUP CONTINENTAL SOUTH WEST

The Continental South West Regional Group (CSW RG) has been created in the second term of 2009 in the ENTSOE framework inheriting the task of the former South West Regional Forum of UCTE, created in 2007. The mission of the group is to promote the coordination in planning issues at the regional level. That means mainly facilitate the information exchange and organize studies of common interest. It is considered also a forum for sharing experiences.

In CSW RG, TSOs have conducted periodic bilateral jointly studies along time from which it has been possible to define a set of procedures and methodologies concerning issues of common interest and/or with reciprocal influence on their respective systems.

In the frame of MIBEL (Iberian Electricity Market), since 2001, Spain and Portugal have organized dedicated working groups in order to study the Iberian system as a whole, and also to try to harmonize as much as possible, some criteria and rules regarding network planning. These working groups have periodic meetings in order to follow the ongoing common studies, each TSO network plans and generation evolution perspectives, and also the evolution stage of reinforcement projects with common interest. Also adequacy evaluation and interconnection capacity studies are done and updated periodically, as well as arrangements are agreed for the execution of other new studies considered with interest.

Until now, a lot of joint studies have been performed, in particular related with load forecast, generation expansion scenarios, interconnection capacities, wind integration, forecast methodologies, network analysis criteria and network access rules.

Interconnection capacity studies are focused on the estimation of TTC and NTC values, in both directions, that with a great probably could be available, in accomplishment of Security Planning Standards including n-1 criteria. These studies normally cover a period of three years, starting two years ahead and are supported by network scenarios based on Spain and Portugal TSOs Network Development Plans.

Methodologically, based on agreed scenarios and concerning its own network, each TSO prepares and exchanges with the other the set of data needed for simulations. Afterwards data is merged and resulting flows are compared and validated, after which each TSO evaluates interconnection capacities taking into account restrictions occurring on its own system, considering also faults in the neighbouring system. For each scenario and in each direction interconnection capacity is the lowest value from the ones obtained by each TSOs.

Other studies, also related with interchange capacities reinforcement, are the analysis of new interconnection points. Taking into account the goals established for the medium-term interconnection capacities common studies are arranged at the regular meetings between Spain and Portugal, in order to identify which network reinforcements should be assumed to achieve those capacity goals. The methodology used on these studies is similar to the one described before. When new network solutions are found and agreed the correspondent new reinforcements are included in national Plans.

Another procedure agreed between Spain and Portugal takes place when there is a connection requested by a new important consumer or power plant, close to the border, which may affect interconnection capacities and/or neighbourhood network. In this case the TSO that received the application informs the other one about it and asks about possible influence on its network.

Other studies are related with wind integration and stability evaluation. Taking into account the high goals for wind generation both for Spain and Portugal, and also considering the weakness of the interconnection link between Spain and France, these studies are of great importance. As a result admissible maximum values of wind generation connected to network are identified, in view of the wind generators technology and facilities (Fault Ride Through Capability yes or no, reactive current injection during faults).

Since the creation of the South West Regional Forum, RTE and REE have also carried out common studies related with NTC calculation in both directions. Lately the maximum NTC, for different situations, has been estimated for horizon 2016, taking into account the new link that is planned through the Eastern part of the border. An intense work has been also done related to this interconnection in support of the permitting process, regarding justification, updating studies, analyzing alternatives, engineering, etc.

In addition, recently, RTE and REE have launched the first mid-term NTC study. In this study maximum NTC will be estimated for years 2011 and 2013.

A Regional Adequacy Forecast has been developed, aiming amongst other at estimating the benefits expected from the planned cross-border project between the three countries. A more detailed description is given in Appendix 3.

Last, besides the specific information exchange and other needs associated with the associations tasks, in the periodical meetings of the group also relevant information and studies related with each TSO system have been shared (Development Plans, particular important network reinforcements, construction difficulties, etc.). On each of these meetings one particular technical topic was treated as best practices, sharing presentations. On these presentations each one of the three TSOs involved in the RG showed the rules and/or practices for its own company. Some of the topics discussed were “Performances required to Producers (voltage control, stability...), and Control of Compliance Before and After Connection”, “Increasing the Capacity of Existing Overhead Lines”, “Costs & Benefits Assessment”, and “Supply to Big Cities”.

13.2 RG Continental Central South

In the following are briefly listed some of the activities developed in past years by Central South Regional Group (AT, CH, DE, FR, IT, SI) under the umbrella of the former UCTE, as well as some bilateral activities.

In addition, new activities have been launched by the Regional Group – now in the new ENTSO – E context- in accordance with the CCS_RG Term of References and beyond.

The main common drivers of the studies are two-fold:

- Need for increased Transmission and Cross Border Capacities through the Alps Region;
- Development of Trans Mediterranean HVDC supergrid.

In February 2008, the first regional transmission plan was completed. The Plan was in-depth survey of the investments (cross-border and internal investments) that Central South Regional Forum TSOs have either approved or are considering. Most of those investments have already been presented in TSOs' respective National Transmission Plans and some of them are already under construction. The main results of the Plan were incorporated in the UCTE Transmission Development Plan issued by June 2008, and updated by April 2009.

The following are the major studies conducted in recent years among member countries listed by region involved.

13.2.1 Cross border capacity

FR-CH

A tripartite study RTE - SWISSGRID - TERNA was launched in 2008 to eliminate current bottlenecks on the French-Swiss border, to evacuate future generation capacity in Switzerland and to increase current power exchange capacity between the three countries.

DE-FR

With regard to the Germany-France tie line “220 kV line-Saint-Avold Ensdorf”, taking into account the permanent opening of the line, it was evaluated as useful the installation of a Phase Shifter (PST) on the line in the 220-kV-substation Ensdorf. Thus, a common study launched in 2008 in order to define the operational schema of this line under normal conditions on the French – German 220kV axis.

AT-DE

The border lines between Germany and Austria are not subject to auctions today. APG and transpower (TPS) increased the capacity of the 220-kV-line St. Peter – Simbach in 2008 by installing high-temperature conductors. Nevertheless, due to high physical flows, the existing 220-kV-lines between the grids of APG and transpower are often heavily loaded near to the (n-1) criterion.

With the increase of wind power generation in Germany and new big pumped storage power plants in Austria, transpower and APG expect a further increase of the power exchange between Austria and Germany.

Therefore APG and transpower consider constructing a 400-kV-line connecting St. Peter (APG) and Isar (transpower).

IT-FR

Reinforcement of the existing network at the French – Italian border

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The purpose of the study (co-financed by the CE, TEN-E 183/04) was to evaluate the interest and feasibility to increase the capacity of the France-Italy interconnection.

The main results consist of:

- Installation a phase shifter in Camporosso substation on the line Broc-Carros (Trinité-Victor) Menton Camporosso 220 kV, the main expected benefit being nevertheless the improvement of the security of supply of the area;
- Removal of the current limitation of the existing grid (Albertville - Montagny - Cornier 400 kV lines and Albertville - La Coche - La Praz - Villarodin – Venaus – Piossaco 400 kV lines) by reconductoring these lines and, on the French side, the upgrade of an existing line between Albertville and Grande-Ile and different arrangement of circuits in Albertville substation in order to get a “Grande Ile – Rondissone” circuit instead of one existing circuit 400 kV “Albertville – Rondissone”.

HVDC LINK “SAVOIE-PIÉMONT”

This new link has been studied at first in synergy with Railways, then with Highways, identifying the latter solution as the best option to be pursued. In both cases, the European Commission gave its support, co-financing the studies.

FRENCH – ITALIAN SYSTEM ADEQUACY STUDY AND MARKET SIMULATION IN THE LONG TERM HORIZON

In 2009 Terna and RTE launched an adequacy study and a market simulation for a better assessment of the benefits from the new interconnection projects.

The methodology for a valuation of the new interconnector is based on the comparison, with and without the new interconnector, of the security of supply and of optimal generation dispatches in the interconnected power system.

IT – CH

MERCHANT LINE INTERCONNECTION PROJECTS

In according to article 7, European Regulation 1228/2003, Switzerland and Italy defined a common procedure to calculate the Net Transfer Capacity increase for the new interconnection projects proposed by private investors (first step in Italy for defining the exemption, Italian Decree 21st October 2005).

The Memorandum of Understanding between the Ministry of Economic Development and the Federal Department of Energy and Communications of the Swiss Confederation was signed on 6 March 2007.

In the last years, two new interconnection projects - Merchant lines - have been analyzed and completed: 380 kV “Cagno (IT) – Mendrisio (CH)” (in operation since June 2008) and 150 kV “Villa di Tirano (IT) – Campocologno (CH)” (in operation since October 2009).

IT- AT

NEW INTERCONNECTIONS IT – AT

In 2001, the common study (supported by European Community in the framework of TEN-ENERGY programme, E136/01) between GRTN (now TERNA) and the Austrian TSO Verbund- Austrian Power Grid AG: “Studies for the construction of a 380 kV Transmission line between Cordignano (Italy) and Lienz (Austria) and the strengthening of interconnection between Italy and the Austrian-Slovenian corridor" was launched.

In addition, TERNA and Verbund-Austrian Power Grid are intending to start a common study in 2010 regarding the analyses of a new interconnection in the Area of "Reschenpass"; the idea of this project bases on the project for a 220 kV tie-line Reschenpass (TERNA, Verbund-APG and TIWAG-Netz AG) already mentioned in the UCTE Transmission Development Plan.

PHASE SHIFTER TRANSFORMER PST LIENZ

In March 2008, preliminary analyses have been started by Terna and Verbund-Austrian Power Grid in order to define the main features of the new phase shifter transformer which is planned to be installed in the substation Lienz. The PST is included in the national transmission development plan

132 KV LINE "PRATI DI VIZZE – STEINACH"

In 2002, the study between Italy (TERNA) and Austria (TIWAG-Netz AG) was launched. The study aimed to investigate the possibility to use the renewed section of the existing line "Prati di Vizze – Brennero", currently operated in medium voltage and to define the main features for the Phase shifter transformer (PST). The project has been included in both national transmission development plans.

NEW INTERCONNECTION LINE IT- AT: BRENNER PASS

In 2002, the study of the new interconnection project IT – AT (Brenner Pass) was launched; the study was supported by European Community in the framework of TEN-ENERGY programme (TEN-E/2002/5.7100/Z/02-006) for analysing both, technical and environmental issues of integrating 400 kV Gas Insulated Transmission Line and Rail Transport in a tunnel between Italy and Austria entitled "Studies for a new 380 kV transmission line between Italy and Austria through the Brenner pass: Integration of Electricity and Rail Transport in Tunnel". The study involved both TSOs (TERNA and TIWAG-Netz AG), the University of Padova and Graz University of Technology.

MERCHANT LINE INTERCONNECTION PROJECTS

In March 2009, the study for the new merchant line 110/132 kV "Tarvisio (IT) – Arnoldstein (AT)" with a phase shifter transformer was completed. The analysis of the NTC increase on the northern Italian border was done with the Pentalateral network model. This Merchant Line received the exemption by Italian Ministry of Economic Development in accordance with Italian Decree 21st October 2005.

In addition, three further Merchant Line Projects on the North-Eastern Border of Italy with connection to the grid of Verbund-APG in Carinthia are requested to TERNA and Verbund-APG.

IT – SI

NEW INTERCONNECTION PROJECT "UDINE OVEST – OKROGLO"

In 2004, a joint working group between TERNA and ELES has been launched; the study was supported by the European Community in the framework of TEN-ENERGY program (TEN E194/04).

The aim of the new project is to increase interconnection capacity in order to facilitate the use and optimization of the European energetic resources and, therefore, to tend to an ideal energy common market situation.

PHASE SHIFTER TRANSFORMER DIVACA

In March 2007, Terna and ELES signed an "Agreement on Coordinated Implementation of Investments for Eliminating Bottleneck in Electrical Power Transmission on the Slovenian-Italian Border".

The aim was to define a common study for increasing the management of the cross- border power flow through the installation of a new PST on the IT- SI border.

After the studies, TSOs agreed that a new Phase Shifter Transformer 400 kV (1200 MVA) will be installed in Divaca substation and come into operation by 2010.

MERCHANT LINE INTERCONNECTION PROJECT

On 8th September 2009, the Terms of Reference for a feasibility study on "cross-border capacity evaluation for commercial lines 110/132 kV on the Slovenia-Italy border" was signed. TERNA and ELES investigated the provisional cross border capacity increase, solving the different approaches of the procedures regarding request for exemption (with reference to article 7, Regulation 1228/2003) adopted in Slovenia and Italy.

13.2.2 TRANS MEDITERRANEAN SUPERGRID

FEASIBILITY STUDY ON A SUBSEA ELECTRICITY INTERCONNECTION TO LINK ITALY AND BALKAN AREA

In 2005, some studies on the possibility to connect Italy and the Balkan area were launched; the studies, involving TERNA and other TSOs, were supported by European Community in the framework of TEN-ENERGY programme.

In particular, the possibility of a new HVDC cable between Italy and Montenegro has been investigated, the main objective of the study being to review current and future development stages of transmission network in South Eastern Europe and to evaluate the feasibility of a new subsea HVDC interconnection between Italy and Montenegro. The project is currently in the design & permitting phase.

MERCHANT LINE INTERCONNECTION PROJECT AL - IT

The new interconnection project proposed by a private investor in Albania region consists in a new HVDC cable between the two substations of Brindisi (IT) and Babica (AL). According to Article 7 of European Regulation 1228/2003, the Net Transfer Capacity increase evaluation was completed by Albanian and Italian TSOs in December 2008.

The project could also allow to export to Italy the new generation capacity from a new wind power plan that the investor has planned in Albania.

FEASIBILITY STUDY OF A SUBSEA ELECTRICITY INTERCONNECTION TO LINK MALTA (MT) AND SICILY (IT)

The project is the connection of the Maltese electricity distribution system to the European transmission grid in Sicily. The project is at present at the feasibility study phase in order to investigate the interconnector's long-term viability, considering both AC and DC solutions for the interconnection. The HVDC-VSC (High Voltage Direct Current - Voltage Sourced Converter) model involves two voltage source converters (VSC) linked together by a DC-link cable, their control systems and interfacing transformers. AC solution considers two alternative voltage levels: 132 kV and 220kV.

FEASIBILITY STUDY OF A SUBSEA ELECTRICITY INTERCONNECTION TO LINK TUNISIA AND SICILY (IT)

Following a bilateral agreement between the Ministries of Industry of Tunisia and Italy (signed on 7th August 2008) and the following agreement for the set up of the new company ElMed Etudes S.A.R.L, union Terna and STEG, a feasibility study on a possible electric interconnection between Tunisia and Italy has been started. Taking into account the long sea crossing, the only possible solution is HVDC. This project is under permitting phase on Italian side, it will contribute to import competitive electric energy from abroad, and so to decrease the average price on the Italian market. The new link will significantly favour the participation of the Maghreb area to the European Energy Market, in the frame of the Agreement Protocol signed by the European Commission and Maghreb countries in December 2003.

FEASIBILITY STUDY ON A SUBSEA ELECTRICITY INTERCONNECTION TO LINK ALGERIA AND SARDINIA (IT)

On behalf of the Italian and Algerian TSOs, the Algeria-Italy feasibility study was launched and completed in June 2004. Two HVDC solutions for a 500 to 1000 MW interconnection were studied: a "direct" line between El Hadjar (Algeria) and central Italy and an "optimized" line between El Hadjar and South Sardinia. The "direct" line reaches the limits of the technical feasibility given by the depth of the sea in the region (2000 m).

FEASIBILITY STUDY ON A SUBSEA ELECTRICITY INTERCONNECTION TO LINK LIBYA AND SICILY (IT)

Following a bilateral agreement between TERNA and GECOL in May 2005, a feasibility study on the possible electric interconnection between Libya and Italy was made. Taking into account the long sea crossing, the only possible solution is HVDC. For Italy/Sicily the new HVDC link will be helpful for the supply of green energy from North Africa towards Italy.

13.2.3 NEXT ACTIVITIES

NEW ITALIAN LAW 99/09: NEW INTERCONNECTION PROJECTS

On August 2009, a new energy Law comes into force in Italy. The new law (n°99/2009) expects that the TSO identifies one or more possible interconnection lines with other countries – in the form of "interconnector" within the meaning of Regulation (EC) N°1228/2003 – and the necessary reinforcements of the national transmission grid, in order to increase the total capacity by 2.000 MW. In order to identify the best possible technical solutions, common studies are going to be launched by TERNA and neighbouring countries.

CONTINENTAL CENTRAL SOUTH REGIONAL GROUP - NEW DELIVERABLES

In accordance with its "Terms of Reference Regional Group Continental Central South" some new activities are listed below:

- The first task concerns the new **Regional Transmission Development Plan**. The Regional Transmission development Plan aims to provide an update on the driver of planning (load and generation expected), and detailed analysis on the main needs of the transmission grid and its development projects. The Regional Plan could give a significant contribution to the definition of further European Ten-Year Network Development Plans.

- **Regional Impact of RES:** In order to fulfil the European and national targets regarding the climate protection, substantial incentives were given by national governments to increase the installed RES power in electricity grids. Considering the ongoing RES development in the Continental Central South Region, an hoc investigation was launched by CCS RG in order to analyze the impact of the new planned RES in the area.
- **"Regional Adequacy Forecast Continental Central South [RAF CCS**]": With the perspective of the coming Regional Transmission Plan, and the assessment of the value of interconnection projects under study (between Italy and France, Switzerland, Austria, Slovenia and Germany respectively), an Ad-hoc study has been launched to perform a Regional Adequacy Forecast study on the Continental Central South system (RAF CCS); the study will be performed utilizing different modelling tools (Antares, Grare/Promed).

13.3 RG CONTINENTAL SOUTH-EAST

The main on-going and foreseen activities for the next period, as decided by the members of the RG Continental South-East (CSE) are outlined below. These activities aim to:

- Contribute to the Ten Year Network Development Plan (TYNDP) of ENTSO-E;
- Provide useful information to participating TSOs;
- Provide a common ground for planning studies.

CONSTRUCTION AND UPDATE OF REGIONAL POWER SYSTEM MODEL

Regional transmission and generation adequacy studies necessitate the utilization of appropriate regional models. These models shall be based on existing ENTSO-E (former UCTE) planning models (2013-2018). The steps foreseen to be followed for their creation include:

- Construction of a simplified equivalent representation of external system;
- Update of the regional models for the time horizons 2015-2020. This update shall cover issues including balances, new generation and transmission equipment, loads etc.;
- Consideration of foreseen renewable generation;
- Modelling of step-up transformers, of generation units;
- Collection of dynamic data;
- Documentation including grid maps, merit order, generation information tables with a link to the models, etc.

13.3.1 REGIONAL TRANSMISSION PLAN

Following the 1st edition (in the framework of former UCTE), RG CSE shall issue a common Regional Transmission Plan every two years. This is foreseen to outline the results of common studies based on the developed regional power system models and according to a commonly accepted planning methodology. Such studies will deal with regional interest issues including:

- Development of scenarios and assessment of transmission capacities that will take into account internal constraints of networks;
- Development of RES and especially wind energy in the area.

RES ISSUES IN SE EUROPE

Increase of RES penetration in the European power system is a major target as well as a challenging task for the involved TSOs. In order to launch a regional collaboration in the relevant issues, a common workshop took place on February 2009. Main issues discussed were the current and foreseen evolution of RES and especially wind energy, the legal framework and connection issues. This information shall be compiled in a common report that is under preparation and will be included as an appendix of the new Regional Transmission Development Plan.

The next step shall be the initiation of common regional grid studies, both static and dynamic, in order to assess the impact of expected wind penetration in the regional power system.

Static studies shall aim to explore export capabilities (capability of the regional network (interconnectors) to export surplus of RES production) and the potential necessity of new transmission projects for RES accommodation. In addition, influence of RES penetration shall be assessed, regarding power flows, losses and voltage profile. These investigations shall be carried out in both maximum and minimum load conditions

Dynamic studies shall aim to explore the influence of wind penetration on SE regional power system dynamics including both transient and small signal stability. In this context, it shall be possible to create a common view on the requirement of wind turbines behaviour during contingencies (fault ride through) as well as future needs for the participation of wind turbines in frequency and voltage control.

REGIONAL CROSS-BORDER TRANSMISSION CAPACITIES EVALUATION

According to the Continental SE Regional Group Terms of Reference, one of the main tasks concerns the common calculation of transfer capacities evolution due to the new or planned transmission projects. In order to proceed with this issue, CSE RG decided to use the classical NTC approach. This approach offers the following advantages:

- Simplicity of calculation;
- Widely accepted terminology;
- Capabilities to explore sensitivities of results;
- Comprehensive indicators, both for system-operators and market participants;

The first approach to complete this task has been undertaken by MEPSO. For the relevant studies, ENTSO-E (former UCTE) winter peak 2013 model has been used. All CSE RG TSOs provided necessary information for the calculations including:

- Source/sink area definition (bi- or multi-lateral – "composite");
- N-1 security rule (outage/monitoring of elements on different voltage level and location in the grid);
- Transmission Reliability Margin (TRM).

In this way, most suitable methods for NTC assessment have been used concerning local network characteristics and already established practice. The relevant report, describing the methodology and the obtained results, has been prepared by MEPSO and is under revision by CSE RG TSOs. The main conclusions reached are summarized in the following:

- Transmission capacities values depend on the methodology applied; source/sink area definition and monitoring/selection of limiting contingencies are the most crucial factors;
- TSOs use both bilateral and multi-lateral ("composite") approach for source/sink area definition, because of the uniqueness of transmission network and power balances in the region;
- Further coordination of calculation procedure on regional level is recommended, in order to find best-practice method;
- TRM value should be further investigated;
- Regional model with balanced generation and demand on national level (to the possible extent) is recommended to be used for this kind of analysis.
- In most of the cases, the limiting elements on transmission capacities are interconnection lines;
- The RG CSE aims at a future network capable to support power transactions and Regional Energy Market development.

This first report on transfer capacities shall be finalized with the contribution of all CSE TSOs regarding their view on the uniqueness of the calculation methodology, network bottlenecks and TRM calculation.

13.4 RG CONTINENTAL CENTRAL EAST

Transmission System operators in the Regional Group Continental Central East (RG CCE) play one of the key roles imposed to the European network of Transmission System Operators for Electricity (ENTSO-E) as regards development of technical and market-related network codes and the coordination of system operation and grid development, with the aim of enhancing security of supply, contributing to a sustainable energy environment and the integration of the European electricity market.

RG CCE, which involves 9 countries with 10 Transmission System Operators (with two new members) is a continuation of the former Central East Regional Forum which was organized and run under the scope of UCTE. The following are the members of this RG CCE: Verbund – APG (Austria), ČEPS (Czech Republic), ELES (Slovenia), HEP (Croatia), MAVIR

(Hungary), PSE Operator S.A. (Poland), SEPS (Slovakia), Transelectrica (Romania), TPS (Germany) and 50Hertz Transmission (Germany).

TSOs in the RG CCE continue to be a guarantee for the continuity in managing system security and reliability as highest priority and to contribute in the most effective way to the ENTSO-E set-up.

RG CCE shares one common understanding regarding the fact that in order to integrate the European market, the development of the grid must be achieved while maximizing security and minimizing the total cost (from generation to retail).

Since the increase of generation capacity is strongly linked to market conditions, it is absolutely unsure whether all the generation projects submitted to the TSOs will be confirmed. This introduces a lot of uncertainties on the locations, on the amounts of future generation units and on the associated transmission needs. Due to the time required to commission new grid equipments all those parameters must be forecasted by the TSOs in order to assess the right and optimal locations of the future congestions and to determine the most robust and flexible developments. Due to the increasing volatility of those parameters the uncertainties raise.

In reflection to the factors mentioned above there is a need for regular monitoring and analysis of the future grid investment requirements and check whether the future transmission system network will be developed to that extent in order to fulfil its objectives. To that purpose, different system network studies have been organized in the region mainly in bilateral or multi-lateral base.

13.4.1 Joint Interconnection Study between 50Hertz Transmission and ČEPS

On 25th of May 2008, ČEPS and 50Hertz Transmission (former Vattenfall Europe Transmission) as neighbouring network operators agreed to intensify their cooperation. According to this agreement, a process was established in order to strengthen the cooperation in the matter of network planning, security of supply (SoS) and communication.

The two companies acknowledge that in the context of a free common European market (“Internal Electricity Market”) and considering the ongoing RES integration while maintaining the level of SoS, an efficient interconnected network constitutes more than ever a major challenge. With this joint study both TSOs are on the way to analyze medium and long term grid requirements so that to propose a feasible, achievable and considerably medium and long-term solution while respecting consistent scenarios of load, generation and exchange flows (Regional System Adequacy Forecast) together with a prospective vision for the future for a reliable, secure, cost-effective and environmentally friendly planning and operation of the two power systems and its neighbours.

The study will focus on the evaluation of the necessity, benefits and possibilities of strengthening of the transmission capacity between the two control areas of ČEPS and 50Hertz Transmission. The study will give an overview of the grid requirements with respect to the power exchange scenarios between the two systems, which will be used to make a proposal of such solution, which will enable, in medium and long-term outlook, reliable and safe operation in this very exposed and centred part of European transmission network system in accordance with obligation accepted by ČEPS and 50Hertz Transmission. These obligations are considered as necessary conditions for participation in the international interconnection and functionality of the integrated European Internal Electricity Market.

The joint interconnection study has the main focus on the evaluation of the necessity and benefits of increase of transmission capacity between the control areas of CEPS and 50Hertz Transmission. This main task has several objectives:

- Investigation of the influence of the planned third tie-line as TEN-E project and any other changes of the cross-border parameters of 50Hertz Transmission and ČEPS;
- Assessment of the interaction and harmonization of the increase of wind generation on the north part of Germany with the reinforcement plans of the internal north-south corridor of Germany and its influence on the ČEPS system;
- Analyzing of future bottleneck characteristic on the common profile and also in first grid periphery of both control areas;
- Analyzing of efficient grid options (new capacities) for sustainable improvement of the identified bottleneck characteristic including evaluation of the benefits for the market;
- Developing a prospective vision for the future.

13.4.2 Joint Interconnection Study Between 50Hertz Transmission and PSE Operator S.A.

In February 2007 the boards of directors of PSE Operator S.A. (PSE O) and 50Hertz Transmission (50HzT) met to intensify the traditional cooperation between both neighbouring network operators. As a result of this bilateral conversation a common steering committee was established in order to strengthen the cooperation in three areas: communication, network planning and security of supply.

Meanwhile this common initiative has shown first results and in the established Working Group “Coordination of Network Investment Planning” the grid planning experts of both companies started to focus on new opportunities and mutually exchanged information for the coordination of transmission grid development. Based on these activities the technical effects on the Polish – German interface caused by the planned network reinforcements on both sides, with special view of upgrading the OHL Krajnik – Vierraden line from 220 kV to 400 kV voltage level, were investigated. During the working process calculations were made of the total transfer capacity based on the exchanged data for 2010/2012 and 2015/2017 (PSE O/50HzT) during 2007, 2008 and 2009. The common study was finalized in July 2009.

The joint system study on new opportunities by coordinated network investment planning has several objectives:

- technical investigation of effects on the Polish – German interface depending on variants of balances and wind scenarios in scope of load flow in both directions with (n-1) security check,
- investigation of the effects of reinforcement of the line Krajnik (PL) – Vierraden (DE) on increasing the exchange capability,
- identification of bottlenecks, evaluation of results and further investigations,

- extraction and wording of conclusions and developing a prospective vision for the future.

According to the results of the study both TSOs decide to reinforce the 220 kV Krajnik – Vierraden line to 400 kV together with installing of PSTs in Krajnik and Mikulowa substations on both 400 kV German – Polish tie lines (Krajnik – Vierraden and Mikulowa – Hagenwerder).

Based on the positive results of the current study both sides decided among others that the planned new investments (including reinforcement of existing elements) in both Polish and German networks as well as the new 3rd interconnector between Germany and Poland (TEN-E priority project) have to be considered in a follow-up study.

13.4.3 CCE RES PROGNOSIS

In order to fulfil the European and national targets regarding the climate protection, substantial incentives were given by national governments to increase the installed RES power in electricity grids. Considering the ongoing RES and especially massive wind power development in the German control areas of 50Hertz Transmission and transpower and also the starting activities in other parts of the Central East region, members of the former Central East Regional Forum under the scope of UCTE (CEE) – now CCE RG in 2007 agreed to carry out a CEE wide RES prognosis and mapping project. The outcome of this project aimed to give a quantitative overview of that time’s and a prognosis of the future RES situation within CEE.

13.4.3.1 FRAMEWORK

An effort was made to reach a significant and an acceptable level of coordination starting by collecting data which will give an overview of the planned RES projects in the region in order for TSOs to be in a position to evaluate grid requirements and thereafter prepare their grids for large-scale RES integration to contribute to the European climate protection targets. This RES prognosis which includes also the RES developments in the subordinated (distribution) grids turns out to be an essential input for the Transmission Plan of CCE region. The RES prognosis will be updated and extended to the control areas of Romania and Croatia in order to be in accordance with the new structure of CCE.

13.5 RG BALTIC SEA

In addition to the Nordic Grid Master Plan[50] (2008), already described in Appendix 2, one of the major achievements of the RG Baltic Sea is the Multiregional planning project[51] (2009).

The transmission system operators in Baltic Sea region from Nordel, UCTE and BALTSO signed a mutual Memorandum of Understanding, the “Coordination of Multi-Regional System Planning in The Baltic Sea Region between BALTSO, Nordel and PSE Operator S.A." in the end of 2007. The aim and purpose of this cooperation was to set mutual understanding and principles for system planning cooperation between the parties around the Baltic Sea. The

[50] Joint study by Finnish, Swedish, Norwegian and Danish Transmission System Operators

[51] Joint study by Polish, Lithuanian, Latvian, Estonian, Finnish and Swedish, Transmission System Operators

practical value of the co-operation included the development of a coordinated extension plan of interconnections from the Baltic States to Poland and to the Nordel area in order to satisfy transmission needs between areas.

This study was executed by the following transmission system operators:

- PSE Operator S.A. (Polish TSO, UCTE)
- Svenska Kraftnät (Nordel)
- Fingrid Oyj (Nordel)
- Lietuvos Energija AB (Baltso)
- AS Augstsprieguma Tīkls (Baltso)
- OÜ Põhivõrk (Baltso)

The objective of this study was to evaluate the socioeconomic profitability of the following new interconnections to whole Baltic Sea region:

- Estonia-Finland (650 MW)
- Lithuania – Poland (500/1000 MW)
- Baltics - Sweden (700 MW)

The same methodology, market model and scenarios were used in this study as in the Nordel study above. However, security of supply issues were not explicitly included in the Multiregional study.

The complete report with conclusions can be downloaded at: http://www.entsoe.eu/fileadmin/user_upload/_library/publications/nordic/planning/090210_entsoe_nordic_MultiregionalPlanningProjectReport.pdf

13.6 RG North Sea

ENTSO-E's Regional Group North Sea comprises the TSOs of all countries bordering North Sea, plus LU and RoI. AT is a corresponding member. In particular, the scope of this RG is to deal with both North Sea on- and offshore grid development.

The results obtained so far by the RG based on the analyses regarding the 'old' CWE region are two-fold: 1) the NTC-based bottleneck identification was realized and 2) the translation of the market simulations output into grid model input, leading to common grid calculations, was established.

CWE TSOs performed a NTC-based analysis by comparing the forecasted exchanges with the actual NTC values per border. The method already revealed some pro's and contra's of different approaches using predicted market flows and flows calculated based on a PTDF method from obtained balances per country. Overall, these analyses lead to several indicators such as a frequency of congestion, an estimation of the non-exchangeable energy and the loss of surplus (out of non-exchangeable energy). As a matter of fact, a load flow analysis is complementary to this study.

Next to this, the main efforts have been made on the Grid Calculations. First of all, this challenging analysis definitely increased the collaboration between the different TSOs in the CWE region, leading to a better understanding of each other's grid and the operation of the grid of each member. Exchanges on these topics were, are and will be crucial in order to enhance the quality of the bottleneck identification.

In fact, despite a pragmatic set of translation rules to convert the Market Simulation Snapshots into Grid Situations, it became clear that the complexity due to the level of detail which is necessary to accurately identify the bottlenecks was higher than initially expected.

Approximations and assumptions (e.g. modelling of exchanges with countries out of CWE-GB region, location of future generation units,…) lead to unexpected results. A fine tuning and extension towards the full North Sea Region of the relevant rules and/or models is necessary. Further on, AC load flow convergence was not easily achievable since additional data were needed. On the one hand market simulations only predict active production and definition of reactive production has to be made, on the other hand each TSO has its own model for voltage regulation (and hence specific data and tools to cope this issue) which influences the results.

Progress was made in performing common grid calculations on a regional scale. Now further extension is required to broaden the analysis towards the full North Sea Region (mostly bilateral studies).

On the island of Ireland, the transfer capability between the Republic of Ireland and Northern Ireland systems is currently limited to less than 400 MW. The implementation in November 2007 of the all island Single Electricity Market has led to market scheduled exchanges far in excess of this figure. Forecasts based on market modelling carried out by the two TSOs indicate that the market requirement for transfers will increase to as high as 1500MW by 2020. EirGrid, SONI and NIE (the asset owner with responsibility for transmission planning in Northern Ireland) have carried out numerous studies that have resulted in the selection of a 400 kV interconnection project from Woodland station near Dublin to Turleenan station in Co. Tyrone in Northern Ireland. In addition, further studies are ongoing which are aimed at integrating large amounts of Renewable Energy Schemes (RES) into both systems. One of these studies, the RIDP project is a joint cross-jurisdictional study to integrate RES in the northern part of the island in an optimum way. Results to-date highlight the need for expansion of the EHV networks of both systems into the North-West corner of the island.

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[14] APPENDIX 3: FROM SCENARIOS TO MARKET & NETWORK STUDIES: EXAMPLES FROM REGIONAL ACTIVITIES

The present appendix addresses the first phases of study that may be conducted before detailed network studies can start. Definition of scenarios, market modelling and link towards network studies will be successively considered and illustrated by studies recently performed by some RGs.

14.1 NORDIC GRID MASTER PLAN 2008 (RG BALTIC SEA)

Among all regional studies have been performed in the Baltic Sea area, a particular outlook is given to the Nordic Grid Master Plan[52] issued in 2008. Another recent achievement, the Multiregional planning project (2009) is addressed in Appendix 2.

14.1.1 SUMMARY OF APPROACH TAKEN IN THE NORDIC GRID MASTER PLAN 2008

The purpose of the Nordic Grid Master Plan 2008 was to identify Nordic grid reinforcements with positive cost-benefit value, according to prerequisites for 2015 and 2025.

Prospective for the consumption and production of electricity were set up in scenarios for 2015 and 2025. The scenarios were developed by Nordel to illustrate different possible pathways for power infrastructure requirements. The scenarios made were a business-as-usual reference for 2015 (BAU 2015) and alternative scenarios for 2025. The alternatives were a business-as-usual scenario with two levels of production, a scenario with focus on climate and international cooperation (Climate & Integration) and a scenario with focus on national solutions (National focus).

An adequate list of potential power infrastructure reinforcements was set up, which contained both Nordel internal reinforcements and interconnectors to the Continent. Costs and benefits for all potential reinforcements were calculated and analysed. It was assumed that all five previously prioritised reinforcements (Fenno-Skan 2, Great Belt, Nea – Järpströmmen, South link and Skagerrak 4) would be in operation in 2015.

The analysis included calculation of benefits from improved market efficiency, improved security of supply and reduced electrical losses. Furthermore, market power was generally discussed but was not included in the evaluation.

[52] Joint study by Finnish, Swedish, Norwegian and Danish Transmission System Operators

14.1.2 NORDEL SCENARIOS REPRESENTING THE FUTURE DEVELOPMENT

14.1.2.1 DEFINITION OF THE SCENARIOS

Investments in infrastructure have a typical lifetime of 30 years or more. The benefit of the investments depends on the future development in fuel prices, production capacity and consumption in the different countries.

The focus on environment and the level of international cooperation are some of the most significant driving forces in the development of the power system. Nordel developed scenarios for the future electricity market, defined in the framework of these parameters, in order to analyse the cost-benefit of investments given different future pathways. These scenarios were defined as a business-as-usual scenario in 2015 and three alternative paths for development until 2025: Climate & Integration, National Focus and the reference scenario Business as usual. The Business-as-usual scenario was divided into one scenario with small increase in production capacity (BAU2025-) and another scenario with large increase in production capacity (BAU2025+).

14.1.2.2 THE "BUSINESS-AS-USUAL" (2015 AND 2025) SCENARIO

This scenario was a projection of the current trends. A moderate focus was expected, both on the climate and on the market integration between the countries. The fuel prices were at a level corresponding to the IEA 2006 prognosis, and the CO_2 prices at a medium level. The economic growth was expected to be at a medium level as well.

In the BAU scenario, significant investments in production capacity were assumed. The production capacity increases in all Nordic countries, and consumption was also expected to increase.

14.1.2.3 THE NATIONAL FOCUS 2025 SCENARIO

In this scenario, the focus was on national solutions with a low level of integration between the EU countries. The economic growth was relatively low, as well as the fuel prices (20% below IEA estimated level). The CO_2 price was set to €10/ton. This scenario led to less price difference between the hydro-dominated area and the thermal-dominated area, due to the low fuel prices. New lines from the Nordic countries to the Continent were therefore less beneficial compared to the BAU scenario.

14.1.2.4 THE CLIMATE & INTEGRATION (2025) SCENARIO

In this scenario there was high focus on climate with a strong international agreement on emission reductions. CO_2 prices were at a relatively high level (€ 35/ton), and fuel prices were at a level corresponding to $ 70/barrel of oil.

In this scenario, wind power was competitive with fossil fuel-based electricity production at good locations. In general, more wind and hydro power and less CHP were installed in this scenario.

Most of the new wind power was situated in the northern parts of Norway and Sweden. The large investments in renewable production capacity led to a stronger energy balance compared to BAU. There were also a larger price difference between the hydro- and winddominated Nordic area and the Continental thermal-dominated area. New lines from the Nordic area to the Continent were therefore more beneficial in this scenario. Internal lines from the northern area to the southern area of Nordel were also more beneficial, due to the increased wind power capacity in the north.

14.1.3 Analysis methods

14.1.3.1 General

The analysis was based on an economic analysis of the costs and benefits of the potential new grid investments.

The future demand on the infrastructure was estimated on the basis of the Nordel scenarios for 2015 and 2025. A list of possible reinforcements was set up based on input from the countries.

Analyses of benefits for the reinforcements were estimated with the Samlast model and MAPS model. The investment and operating costs of the new or reinforced lines were estimated. The costs and benefits were summarised, and a cost-benefit ratio was set up for all reinforcements.

14.1.3.2 Elements in the cost-benefit approach

Benefits included in the analysis

The benefits were in accordance with the criteria set up in September 2002 by Nordel given as:

- Market value from production optimisation and energy turnover
- Reduced risk of power shortage
- Reduced electrical losses
- Reduced risk of energy rationing
- Trade in regulating power and ancillary services
- Value of reduced market power

The market value from production optimisation reduced electrical losses and reduced risk of energy rationing have been calculated in the Samlast model developed by Sintef. Samlast is a fundamental model which integrates market simulations with load flow analysis. The model has detailed data for the production system (hydropower), main transmission grid and the power market in the Nordic countries.

The reduced risk of power shortage was calculated in the MAPS model. The MAPS model calculates the loss of load probability (LOLP), expected unserved energy (EUE) and expected power not served (EPNS).

Trade in regulating power and ancillary services and the value of reduced market power were not analysed specifically. The influence on the benefit from the elements was only estimated.

The economic benefits were calculated both for the Nordic area and the Continental area. The results were not divided between the countries, but based on the total benefit and the total cost for the Nordic countries.

COSTS INCLUDED IN THE ANALYSIS

The calculated investment costs included:

- Investments in a given transmission line and auxiliary parts
- Operation and maintenance of the line

Necessary reinforcements of the internal grid as a result of the possible new interconnectors were not included in the investment costs. The total costs of the reinforcements are therefore higher than estimated in the analysis, and the resulting cost-benefit lower. This aspect must be investigated more thoroughly for the suggested reinforcements, and is of special interest when it comes to external Nordic reinforcements, as there may be limiting intersections within the other countries.

NET PRESENT VALUE OF POSSIBLE REINFORCEMENTS

The costs and benefits were analysed for a total lifetime of 30 years. The net present values were calculated by using a 5% rate of interest.

The cost-benefit of reinforcement was calculated as:

Benefit of reinforcements = Total benefits - Total costs.

14.1.4 TRANSMISSION LINES INCLUDED IN THE ANALYSIS

All interconnecting transmission lines that could be beneficial were included in the analysis. The lines which were analysed in the study are shown in Fig. 69.

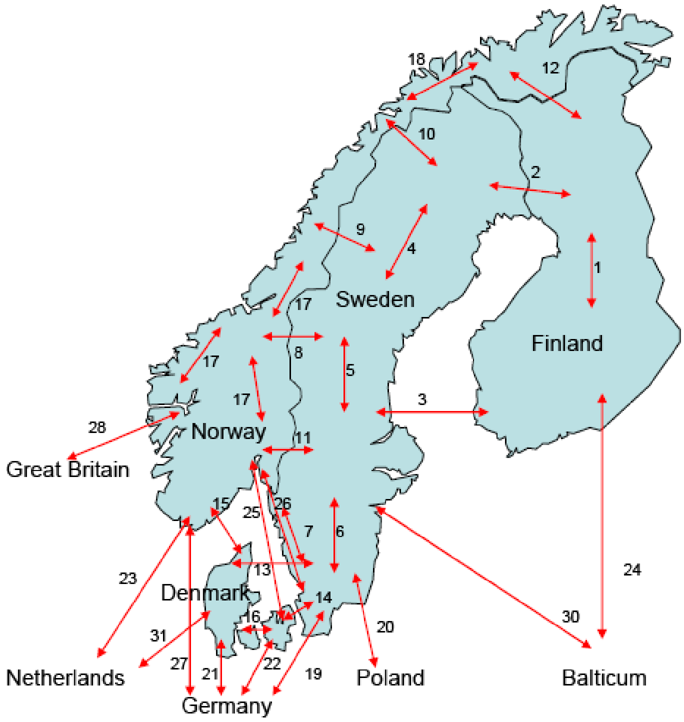

FIG. 69 ANALYSED REINFORCEMENTS

The complete report with conclusions can be downloaded at: http://www.entsoe.eu/fileadmin/user_upload/_library/publications/nordic/planning/080300_entsoe_nordic_NordicGridMasterPlan2008.pdf

14.2 REGIONAL ADEQUACY FORECAST (RG CONTINENTAL SOUTH WEST)

14.2.1 – PRESENTATION

REN (Portugal), REE (Spain) and RTE (France) decided to carry out a joint study of the overall system performance expected till 2018. It was agreed to tackle two main topics:

- The Security of Supply (SoS), appreciated through a number of adequacy indicators (Loss of Load Probability – LOLP, Loss of Load Expectation – LOLE, Expected Energy not Served –EENS) enlightened by an assessment of operational security margins;
- The System Efficiency, appreciated through a number of economic variables (amounts of energy generated from the different types of fuels and renewable sources, levels of cross-border exchanges, net national import/export balances, amounts of generation rescheduled due to transmission congestion); RES integration and amount of CO2 emissions are also considered.

In addition to coming to a joint assessment of the system performance in a number of scenarios (minimal[53], best estimate[54]) and time horizons (2007, 2013, 2018), a special focus was made on the benefit expected from the planned development of interconnections between the three countries, for the time horizon 2018.

TSOs took also the opportunity of this study to exchange on methodologies and tools, starting a process of further collaboration on these issues.

Therefore, the study was divided into two phases:

- Phase I: System Adequacy and Efficiency, based on the use of ANTARES simulation tool developed by RTE,
- Phase II: System Security of Supply, based on the use of RESERVAS simulation tool developed jointly by REE and REN.

Phase I is now finished and Phase II is in progress, with results expected in the beginning of 2010. Nevertheless, the three TSOs involved consider results of Phase I robust enough for conclusions of interest to be drawn.

It is worth mentioning that this is a rather innovative approach that is not very widely used in European TSOs' usual studies.

The following paragraphs give an outlook of the main principles of the methodology (section 14.2.2), hypotheses (section 14.2.3) and results (section 14.2.4).

14.2.2 FOCUS ON METHODOLOGY

Many aspects of the method could be taken from a similar approach already conducted by the CWE Forum for the Regional Adequacy Forecast they issued in December 2008. It should be nevertheless mentioned that this yearly advanced probabilistic approach goes far beyond what TSOs generally do when assessing the expected system performance at Regional or European level.

14.2.2.1 MAIN PRINCIPLES

INTERCONNECTED REGIONAL SYSTEM

The model of the regional power system is made from nodes with generation and demand assets, which are interconnected through transmission capacity. Improved regional system adequacy forecast models the actual synchronous behaviour of the system including the limitation of transmission capacity between countries.

The detailed network with its spatial dimension is not modelled. Therefore, in the general case, the power transfers between nodes are to be understood as possible commercial exchanges, not as real power flows through the border.

NB: Due to the particular configuration of France, Spain and Portugal, the algebraic sum of the physical flows through each border coincides with the algebraic sum of commercial exchanges through this border.

53 i.e. considering only new units the construction of which has already started.

54 i.e. including generation projects that can be considered as reasonably feasible.

EXTENDED FULL YEAR FORECAST

The operation of the regional power system is simulated on whole years and not only on few characteristic snapshots like synchronous winter and summer peak-load in classical regional analyses. Improved regional system adequacy forecast is therefore not deciding which period to analyse but actually detecting when system operation could be difficult. Full year modelling is also the key to better system economic efficiency assessment (especially when flexibility of plants, chronological events and economics are involved) and hence to more comprehensive and sounder conclusions.

ADVANCED PROBABILISTIC MODELLING

The methodology for the improved regional system adequacy forecast is based on a probabilistic modelling approach. Thus, the improved methodology analyses not only the average situation but also the impact of potential variations of generation and demand. Power balance is then computed for a large sample of possible combinations (Monte-Carlo simulation).

VALUABLE POWER BALANCE

A first field of analysis, called “Adequacy” analysis, is based on the usual power balance of generation and demand, which aims at forecasting the behaviour of the system should security of supply be at risk. The advanced modelling mentioned before gives highly valuable information without much complexity. Its main results are the potential power shortages, their frequency, duration and depth in the coming years.

MERIT ORDER SIMULATION

A second field of analysis, called “Economic Efficiency” analysis or ‘perfect market’ analysis, adds the detailed modelling of the merit order of generation assets to previous power balance. The main output is the regional optimisation of the use of generation assets and the related commercial exchanges.

14.2.2.2 SOME FEATURES FOR IMPLEMENTATION

DETERMINISTIC SCENARIOS VERSUS PROBABILISTIC SIMULATIONS

As already mentioned, system adequacy & efficiency assessment relies heavily on probabilistic approaches. Still, there are a significant number of elements for which it makes much more sense to adopt a deterministic standpoint rather than a probabilistic one.

Deterministic forecasts address every uncertainty related to the consistency of the assets to consider (generation mix, transmission capacities), deriving from policies, investment decisions and long-run trends (fuel costs).

Probabilistic modelling addresses every uncertainty related to random factors which can affect the electrical system within a year and must be accommodated with the definite set of assets: climatic variations (temperature, rainfalls, wind inflows), power plants outages, etc.

SCOPE OF DETERMINISTIC FORECASTS

Using deterministic forecasts instead of random draws does not mean that the future is considered as fully predictable: it only means that some aspects of the future are better described by a set of "bounding" scenarios, without reference to probabilities that are largely unknown or even meaningless. This is, basically, the case for all matters in which the uncertainties stem more from human behaviour (e.g. decision to build or not to build such or such plant) rather than from technical or meteorological phenomena (plants outages, cold spells, etc.)

A scenario-based deterministic approach is therefore used for the following categories of data:

- List and technical description of the power plants of every kind;
- Interconnection capacities (seen either as transfer or as transmission capacities);
- Load curve expected for "standard" meteorological conditions.

Each scenario considered gives a set of input data to the advanced probabilistic simulations for each configuration under investigation.

SCOPE OF RANDOM DRAWS

System performance, especially adequacy, assessment, is a topic in which the influence of technical and meteorological uncertainties is very important. It can even be said that the better the adequacy level is, the more sensitive it gets to these uncertainties. This is due to the fact that power systems show usually very low risks of load shedding as long as the operation conditions qualify as regular. The frequency and seriousness of curtailments is therefore entirely dependent on how often abnormal conditions are expected and on how bad they can get to be.

Whatever the method chosen to investigate at best the field of potentially adverse situations that may result from the combined influence of these phenomena (Monte-Carlo methods for instance), the following uncertainties must be taken into account for the assessment of system adequacy levels:

- Outages (planned /unplanned) of generating or transmission facilities;
- Temperature deviations (influencing load mostly);
- Rainfall amounts (influencing hydro generation);
- Wind speeds (influencing the power generated by wind farms).

A very accurate system adequacy assessment would therefore require not only a very accurate technical simulation but also a very accurate meteorological simulation. Depending on the quality of the simulators at hand, bounding scenarios may again be built for each dimension of the problem. Doing that, one should not forget that a complex set of relationships between the uncertainties listed above exist and must be taken into account as far as possible.

The Fig. 70 hereafter gives a comprehensive view of the uncertainties to model and of their potential relationships for a two-zone system.

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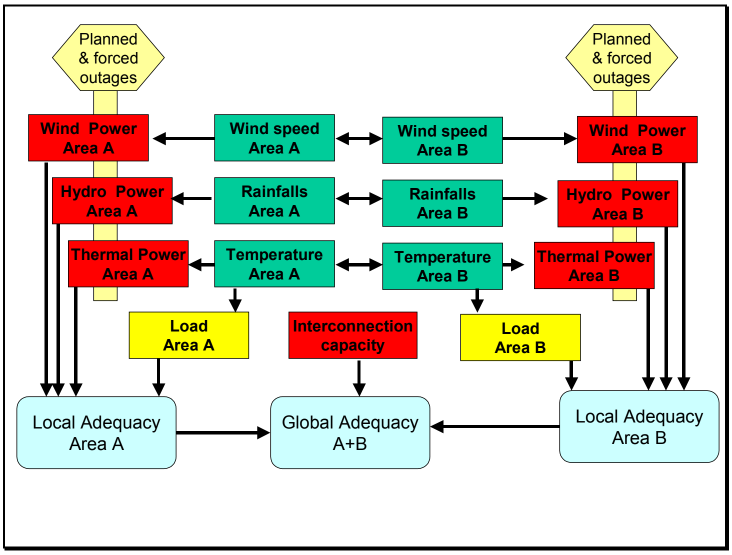


FIG. 70 TWO-ZONE SYSTEM ADEQUACY RELATIONSHIP

For practical purposes, it is obvious that the representation of the phenomena at work makes it necessary to simplify this graph. Still, over-simplifications should be avoided as much as possible, especially as concerns inter-area correlations: for instance the fact that extreme temperatures or winds tend (or do not tend) to be observed simultaneously in the two areas may have a decisive influence on the overall adequacy level of the system.

A thorough estimation of the correlations between the different uncertainties affecting the global system (wind, hydro, temperature) is the key to an accurate estimation out of the "Adequacy" analysis and a pre-requisite to carry out "Economic Efficiency" analyses.

COST MODEL

"Economic Efficiency" analysis requires an economic modelling of the system, with two different goals:

- Assessment of the merit-order of the different units;
- Assessment of the variations of the overall generation operating costs of any system when comparing simulations cases.

The cost model is based on detailed modelling of dispatchable thermal power plants (including fuel and CO2 emission costs, start-up costs and operation & maintenance). Non-dispatchable power plants (e.g. Combined Heat & Power, wind, run-of -river) are considered as must-run units. Hydro storage is modelled as "cost-free" generation schedules, governed by the model in order to minimise the overall (thermal) generation costs taking into account time-series of available inflows.

In order to ensure a sound modelling of the regional system, all countries must share the same common reference for all fuel and market prices.

SIMPLIFIED OUTER RING

The connection of the regional system to the rest of the interconnected system, called "Outer Ring", is to be considered as the limit of the model (see Fig. 71 below).

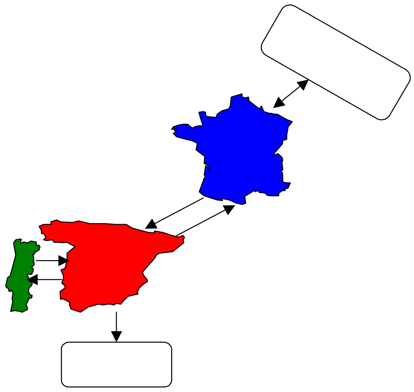


FIG. 71 MODEL OF THE SYSTEM FOR REGIONAL ADEQUACY FORECAST STUDIES

Some simplifications are introduced when modelling the Outer Ring:

- For "Adequacy" studies, modelling of the behaviour of the system in emergency situation, an assessment of the mutual assistance each node can count on from its neighbouring systems in the Outer Ring is adequate;
- For "Economic Efficiency" studies, modelling of the economic behaviour of the system, an assessment of the commercial exchanges each node has with its neighbouring systems in the Outer Ring is required.

14.2.2.3 GENERAL CONCLUSION ON METHODOLOGY

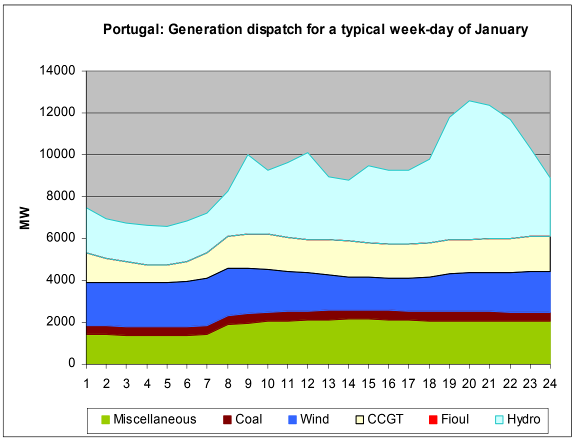
What appeared at first from the analysis of the results yielded by the whole set of simulations undertaken at the various time horizons addressed in the study (2007, 2013 and 2018) and for the different scenarios defined for the expansion of generation (minimal, best estimate) and cross-border transmission (existing, developed as planned), is that the probabilistic approach and the power system modelling that are the core of ANTARES model proved well fitted for the task to be carried out.

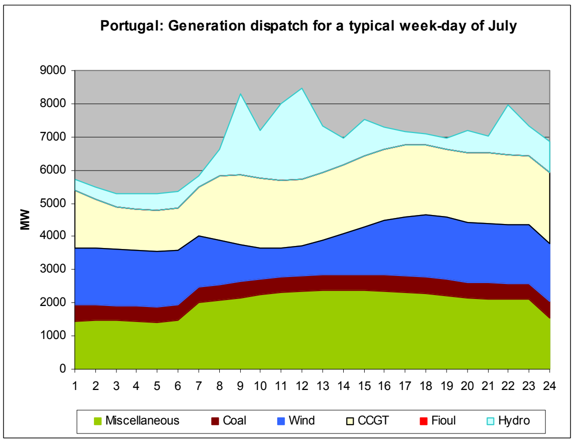
14.2.3 MAIN HYPOTHESES

14.2.3.1 LOAD FORECASTS AND GENERATION MIX IN THE THREE COUNTRIES

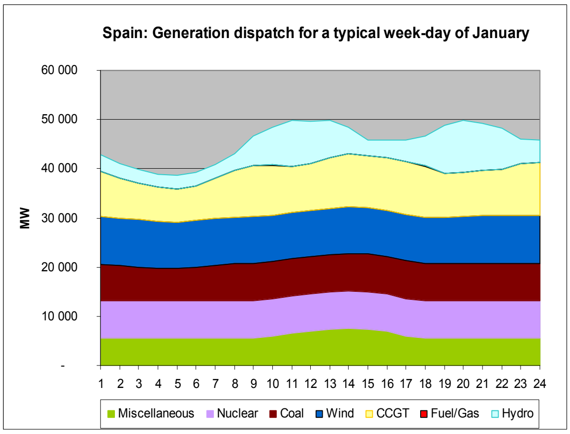
Fig. 72 below shows some typical generation dispatch expected in France, Spain and Portugal for the year 2018.

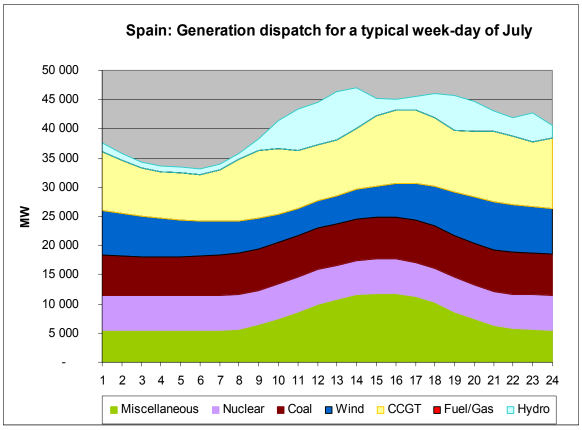
Portugal



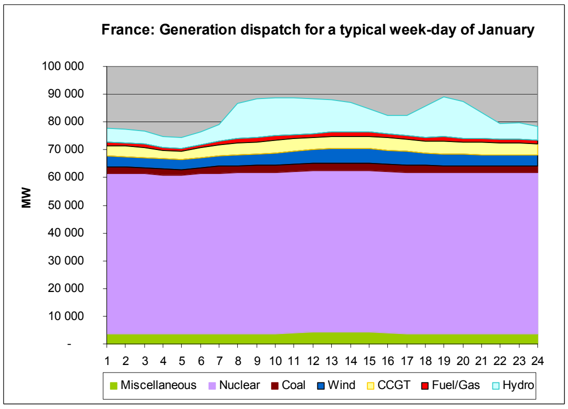


Spain





France



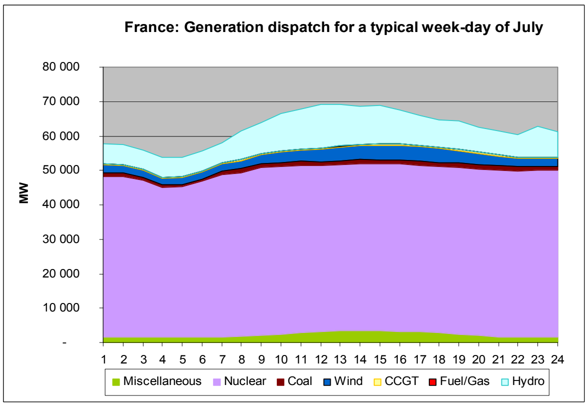


FIG. 72 TYPICAL GENERATION DISPATCH EXPECTED IN PORTUGAL, SPAIN AND FRANCE IN 2018

14.2.3.2 PLANNED DEVELOPMENT OF INTERCONNECTIONS

SPAIN-PORTUGAL BORDER

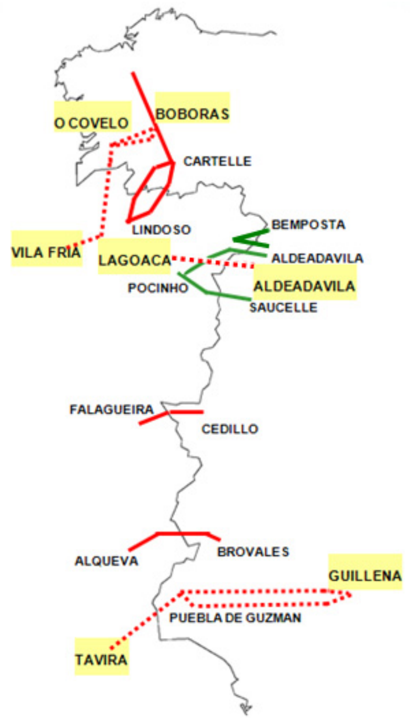


FIG. 73 PLANNED INTERCONNECTIONS BETWEEN SPAIN AND PORTUGAL

As shown on Fig. 73 just above, three new 400kV cross-border lines are planned within the coming 5 years. All of them are currently in the design and permitting phase:

- New Duero Interconnection 400 kV (expected commissioning date 2009/2010)

The project is mainly comprised of a new 400 kV OHL interconnection line Aldeadávila (ES) - Lagoaça (PT), including new Lagoaça substation (PT). It also includes the lines Lagoaça-Armamar-Recarei 400 kV in Portugal and the Armamar (PT) 400/220 kV substation. The total length is 106 km.

On a first phase (2009) a new 400/220 kV substation (Lagoaça (PT)) will be created with only 220 kV level installed, and there will be some rearrangements and reinforcements on the local 220 kV network structure. On river crossing a new 220 kV double line with separated circuits, firstly Aldeadavila (ES) - Lagoaça (PT) 1 & 2 and changing later to Aldeadavila (ES) - Pocinho (PT) 1 & 2, will substitute the existing two 220 kV lines Aldeadavila (ES) – Bemposta (PT) and Aldeadavila (ES)-Pocinho (PT).

- New Southern Interconnection (2011)

A new 263 km-long 400 kV double-circuit OHL is planned between Guillena (ES)-Puebla de Guzman (ES) - Tavira (PT) - Portimão (PT), including new Tavira (PT) and P.Guzman (ES) 400 kV substations. On the interconnection section P.Guzmán (ES) –Tavira (PT), initially only one circuit will be placed. The section Guillena-P.Guzmán has been already commissioned in 2009, but operating in 220 kV.

- New Interconnection in the North of Portugal (2014)

New 400 kV 167 km-long OHL double circuit line between Bóboras (ES) - O Covelo (ES) - Vila Fria (PT) - Vila do Conde (PT) - Recarei (PT), including new 400 kV substations O Covelo (ES), Boboras (ES), Vila Fria (PT) and Vila do Conde (PT).

On the section O Covelo (ES) – Vila do Conde (PT), only one circuit will be placed**.**

FRANCE-SPAIN BORDER

New HVDC link in Eastern Pyrenees (2014)

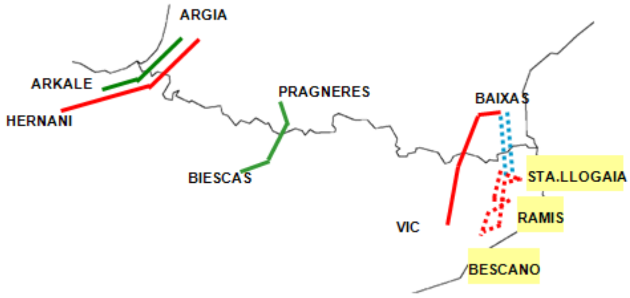


FIG. 74 PLANNED GRID DEVELOPMENT IN EASTERN PYRENEES

Following the lack of public acceptance of the OHL project conducted by both TSOs in Eastern Pyrenees, M. Monti was appointed in 2007 European Coordinator for the development of this interconnection. After additional studies by an independent expert (CESI) and stakeholders consultation, he came to the conclusion that the unique feasible solution was a totally underground link.

This conclusion has been endorsed by both governments at the Zaragoza summit on 27 June 2008.

The new link will be HVDC, totally underground and connect Baixas (FR) to Sta Llogaia (ES) (60 km), taking best advantage of existing infrastructures. On the Spanish side, a new 400 kV line is also planned between Bescanó (ES) and Sta Llogaia (ES), which in addition to support the regional distribution network and to feed the high speed train , will allow to connect the new interconnection to the existing network (see Fig. 74 just above).

Both TSOs have created a joint venture company, INELFE, in order to carry out the project. Studies and Project have got a Community financial support under TEN-E programme umbrella.

At short-medium term, some internal reinforcements are planned in Spain in order to increase the exchange capacity with France.

On the whole, including the cost of some internal reinforcements that are needed to take full benefit of the NTC increase provided by the new interconnections, the investment costs amount to around 300 M€ for the Spain-Portugal border and around 850 M€ for the French-Spanish one.

14.2.3.3 Increase in cross border capacities

In the exercise carried out, the behaviour of the system has been simulated with the following Net Transfer Capacities (NTC) between the three countries:

With Existing Grid (2007):

TABLE 11 CROSS-BORDER CAPACITIES WITH EXISTING NETWORK

	Peak		Off-Peak	
	Winter	Summer	Winter	Summer
Spain -> Portugal	1000	1000	1300	1200
France -> Spain	1200	1100	1400	1300
France -> Spain	1400	1200	1400	1200
Spain -> France	500	500	500	500

With the planned reinforcements, these exchange capacities would be by 2018 as shown on Table 12 below. The values have been obtained from recent bilateral joint studies:

TABLE 12 CROSS-BORDER CAPACITIES WITH THE PLANNED PROJECTS

	Peak		Off-Peak	
	Winter	Summer	Winter	Summer
Spain -> Portugal	3200	3200	3200	3200
France -> Spain	3200	3200	3200	3200
France -> Spain	3000	2750	2700	2550
Spain -> France	1700	1700	2800	2750

14.2.4 Economic Benefit Assessment of Interconnections Development in CSW Region

Below are briefly described the results of the study regarding expected use of interconnections as well as benefits regarding security of supply, RES integration, CO2 emissions mitigations and IEM facilitation.

14.2.4.1 Use of interconnections

On the whole, simulations show an increased use of the interconnections in RG CSW. But it is important to note that the amount and direction of expected cross-border power flows are highly dependent on the load conditions and available generation in each country. Not only seasonal and hourly variations are likely, but also random phenomena due to climatic conditions. For example, winter situations with low temperatures (thus high load in France), high wind in Southern Europe and favourable inflows in Spain and Portugal should lead to flows from Portugal to Spain and from Spain to France. Conversely, in summer situations with low wind and hydro reserves in the Iberian Peninsula, nuclear energy from France may substitute some CCGT generation. In addition, different scenario from those simulated in the study (e.g. delayed or faster implementation of generation in the countries) may lead to different flow patterns on the interconnections.

Both pictures hereafter depict the average energy flowing through the interconnections.

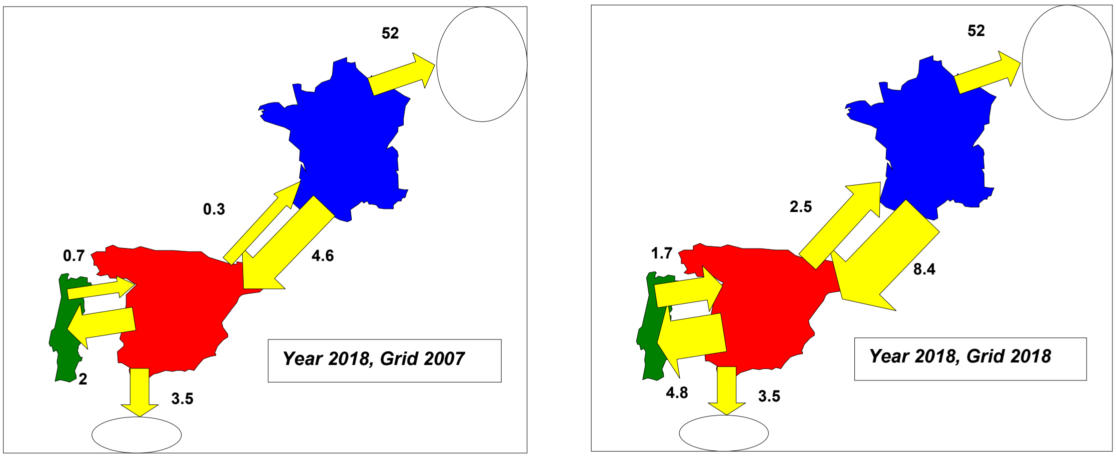
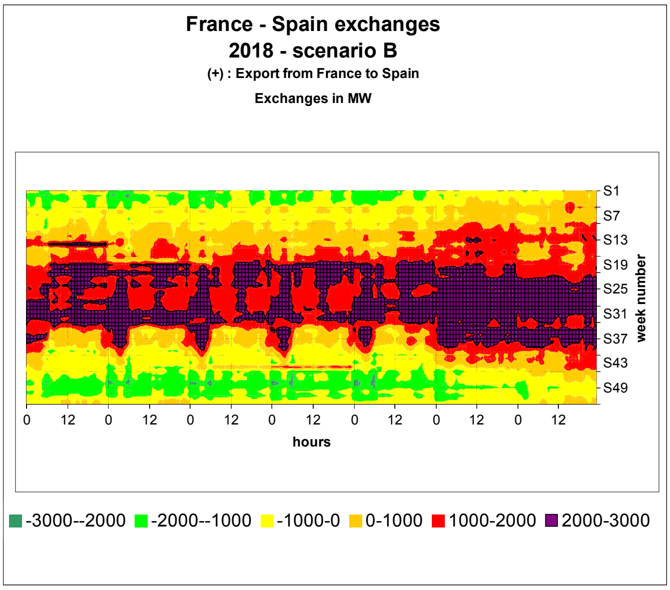


FIG. 75 AVERAGE CROSS-BORDER ENERGY FLOWS FOR THE YEAR 2018

With the planned projects, the sum of import and export cross border flows, which is an indicator of the use of the interconnections, increases from 2.7 to 6.5 TWh for the Portugal – Spain border and from 4.9 to 10.9 TWh for the Spain-France border.

Without the planned projects, less than half of the cross-borders energy flows in each direction could be accommodated.

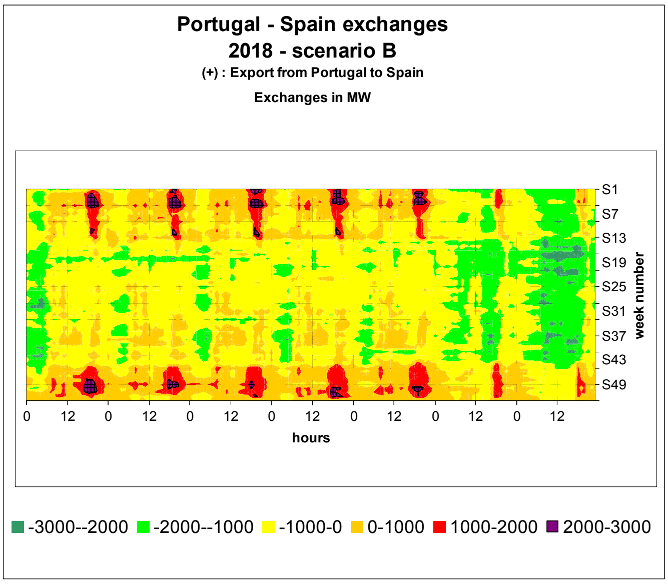
The two figures below display the average hourly exchanges on each interconnection with the week number on the vertical axis (S1: first week of January), and the days of the week (from Monday to Sunday) on the horizontal axis.



- Massive exports from France to Spain in summer and spring, especially at nights and in the weekends (off-peak periods of the year)
- Important exports from Spain to France in winter during winter days (peak periods)

This behaviour was already observed in 2008-2009

FIG. 76 FRANCE –SPAIN HOURLY EXCHANGES WITH THE 2018 GRID (AVERAGE VALUES)

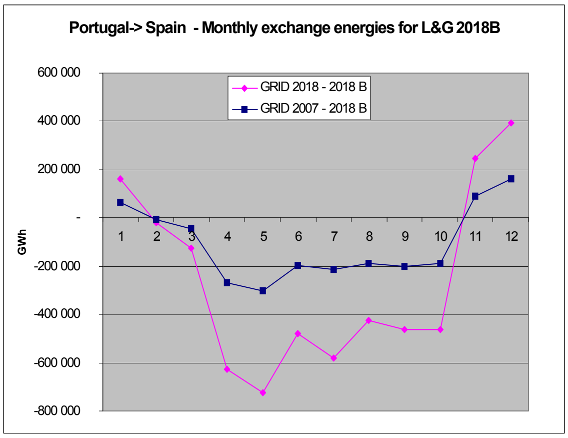


- Massive Portuguese imports from Spain in the week end in summer and spring
- Important exports from Portugal to Spain in winter during week days (peak hours)

FIG. 77 SPAIN- PORTUGAL HOURLY EXCHANGES WITH THE 2018 GRID (AVERAGE VALUES)

As these graphs are based on average hourly values, singular situations, were interconnections are more used, are not adequately reported. In this sense, it is expected that the interconnections are used even more than what the graphs just above reflect.

Fig. 78 below shows the average monthly energy exchanged on both interconnections for scenario 2018 B, with today's grid (Grid 2007) and with the reinforced interconnection as planned in 2018 (Grid 2018).



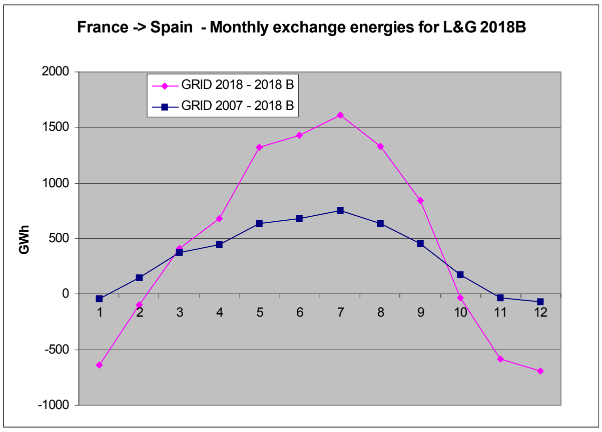


FIG. 78 AVERAGE MONTHLY EXCHANGE ENERGY THROUGH PT-ES AND FR-ES BORDERS

In winter the Iberian Peninsula exports to France, where margins in competitive power plants are small due to the very high level of load especially in cold conditions. Conversely, the Iberian Peninsula imports from France in Spring and Summer when the French generation mix is mainly nuclear-hydro.

Power flows are oriented from Portugal to Spain in winter and from Spain to Portugal the rest of the time, especially in spring. As already mentioned, this average behaviour should not hide potentially very different patterns in specific situations.

14.2.4.2 SECURITY OF SUPPLY

The evolution of adequacy indicators shows contrasted evolutions between Portugal and Spain on the one hand and France on the other hand. Starting in 2007 with suitable performance for all three countries, the situation remains about the same for Portugal and Spain by 2018, while at the same time adequacy would drop to unacceptable levels in France if no external support were available in tight operation situations (whatever border it could come from: UK, BE, DE, CH, IT, Iberian peninsula), especially in cold temperature winter periods[55]. Regarding French adequacy, the results of this study are consistent with the '09 edition of RTE's French Adequacy Report.

L & G 2018 - B		EENS (GWh)
countries alone	PT	0,0
	ES	0,1
	FR	47,0
	CSW	47,1
GRID 2007	PT	0,0
	ES	0,0
	FR	39,4
	CSW	39,4
GRID 2018	PT	0,0
	ES	0,0
	FR	25,3
	CSW	25,3

TABLE 13 EXPECTED ENERGY NOT SUPPLIED

[55] The load in France is especially sensitive to temperature (an increase of 2100 MW/°C is already currently observed at winter peak load).

Table 13 shows that the Expected Energy Not Supplied decreases by around 14 GWh/year with the planned development of interconnections. As already mentioned just above, this improved SoS mainly benefits France.

It should nevertheless be reminded that the simulations have been conducted under the assumption that in tight situations, support to France would only be possible from the Iberian Peninsula.

The study carried out by the CWE Forum showed that this support is very likely to be available by 2015 also from CWE countries, so that the actual benefit from increased interconnection with Iberian Peninsula is probably lower than computed. Conversely, the assumptions made in the study have not allowed assessing the additional support from the Iberian Peninsula to other European countries, apart from France.

Spain and Portugal don’t benefit from interconnections regarding security of supply.

Another feature to be remembered is that even the “best estimate” scenario may be too conservative for 2018, as only reasonably likely projects are considered. Since the time to build new wind farms or CCGTs is only 3 - 5 years, one can imagine that new units - that are not even envisaged yet - may come into operation within 8 years

With the above-mentioned reserves, the simulations show that the planned development of interconnections make possible an additional support from Iberian peninsula to France of around one third of the expected energy that would not be supplied in 2018 if France was not connected to any other country. To quantify accurately the benefits in terms of Security of Supply, an extensive modelling of all the interconnected system would be required.

14.2.4.3 Benefits in terms of Renewable Energy Sources Integration

The analysis of the interconnected system shows that a very large share of the 120 TWh of load increase between 2007 and 2018 (at the RG CSW scale) could be covered by the development of renewable energies (mainly wind and solar, together with some hydro in Portugal and Spain).

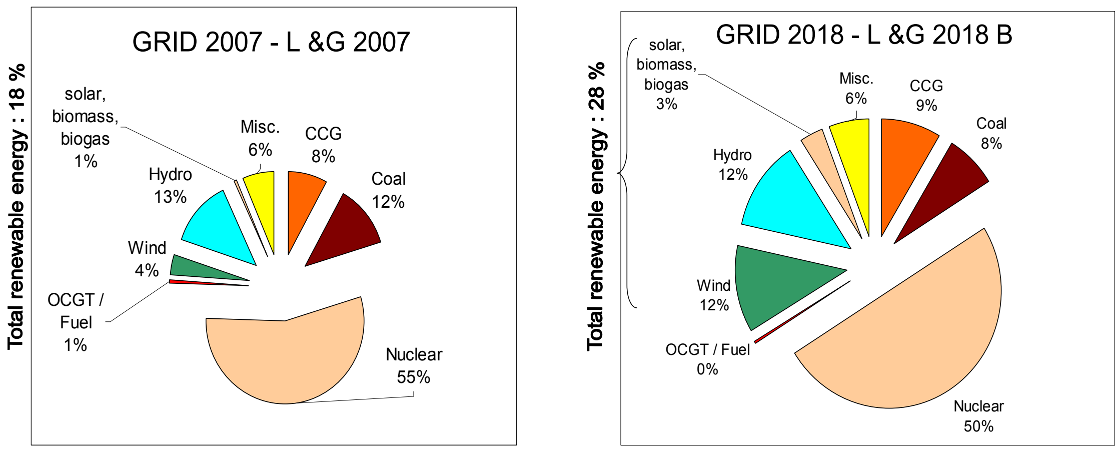


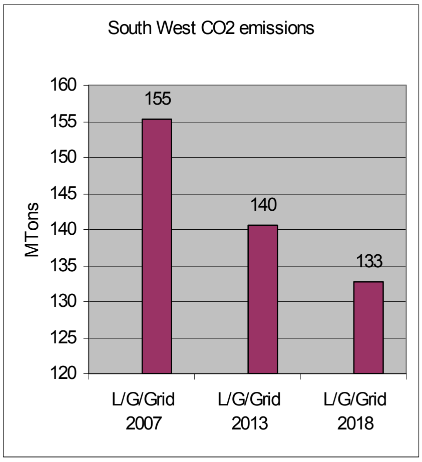
Fig. 79 Contribution of each technology to the total energy generated within RG CSW for 2007 and 2018

The part of energy generated from RES in RG CSW would increase from 18% in 2007 to 28% in 2018 (see Fig. 79 just above).

More than 1 TWh of this RES generation increase would be due to better use of must-run RES generation in the Iberian Peninsula thanks to the increased interconnection capacity.

14.2.4.4 Saved CO2 emissions

In addition to the increased share of RES energy, an overall decrease by 29 TWh of coal generation is expected in RG CSW from 2007 to 2018 (decommissioning in the three countries), partially substituted by gas in CCGT. Considering a slight decrease of peak oil-fired units generation, this evolution results altogether in a 22 Mtons (14%) decrease of annual CO2 emissions between 2007 and 2018. Out of these 22 Mtons, 2-3 Mtons are saved thanks to the planned development of interconnections between the three countries (see Fig. 80 just below).



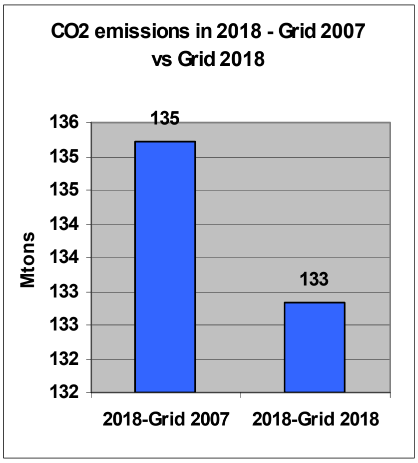


Fig. 80 Expected amount of CO2 emissions

14.2.4.5 Benefit for Internal Electricity Market

In addition, these cross-border transmission projects are expected to alleviate transmission congestion, equivalent to a decrease of energy rescheduled each year around 7 TWh. This corresponds to energy from CCGT (-5.3 TWh) and OCGT/oil plants (-1.5 TWh) being substituted by RES (+1.3 TWh), nuclear (+4.9 TWh) and coal plants (+0.6 TWh), as shown on Fig. 81:

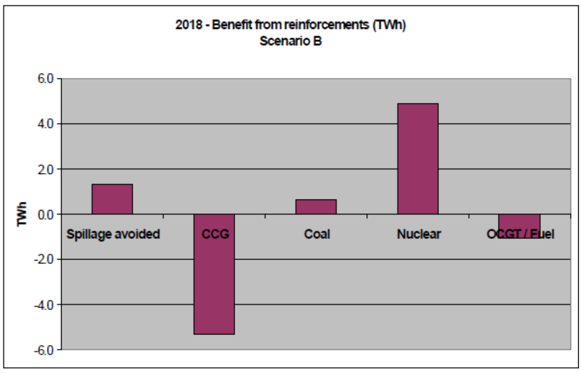


Fig. 81 Avoided yearly energy rescheduled with planned interconnection projects

On the whole, the planned projects of interconnection development should allow around 7 TWh to be generated from less expensive generation in RG CSW.

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Under the rather conservative assumption of an average cost saving of 10 – 20 €/MWh, the annual social benefit[56] brought by the reinforcement of the interconnection would be estimated in the range 70 – 140 M€.

This social benefit should have an impact on the prices of energy and also on congestion rent, which reflect the gap between market prices in the different countries, so that at the end of the day, consumers should experience a positive impact.

Portugal and Spain have a common market (MIBEL). This market is possible thanks to the great level of interconnection (achieved and planned) between these two countries. The physical use of Portugal-Spain interconnections cannot be completely assessed considering only the net power transfer. In some situations, at the same time that power is going from the North-West of Spain to the North of Portugal, power is also going from the South of Portugal to the South of Spain. In these cases, the power that flows through interconnection lines is bigger than the net power transfer.

14.3 FROM MARKET MODELLING TO NETWORK STUDIES (RG NORTH SEA)

14.3.1 INTRODUCTION

ENTSO-E's Regional Group North Sea consists of TSOs of UK, RoI, DK, NO, NL, FR, BE, LU and DE. AT is a corresponding member. As such the Group has to be seen as an extension of the former CWE region and has been developed as the right TSO platform to deal with both North Sea on- and offshore grid developments, as it is reporting directly towards ENTSO-E's System Development Committee. The Regional Group North Sea will base their work on existing models, studies and analysis within the current platforms (PLEF and CWE). These studies, models and analysis will be extended to the full geographic area of the Group. Goal is to develop a North Seas Master plan covering both on- and off-shore grid extensions, further developing the regional market and regional grid models, studies and analysis.

The intention is to deliver an analysis of the different bottlenecks in the North Seas region by performing common grid calculations, rather than to aggregate bilateral studies results.

14.3.2 COMMON GRID CALCULATION: CONTEXT AND HYPOTHESES

Nowadays, it is observed that situations in one part of an interconnected transmission grid might lead to problems in another distinct part. One can say that the bottlenecks are linked in a supra-national or regional way rather than caused by national or bilateral cross-border constraints. In order to detect those regional bottlenecks, a common view has to be developed by performing grid calculations in a more regional way than only within bilateral studies between TSOs. A global view on the regional behaviour of the market and the grid will probably demonstrate other bottlenecks or at least with other importance and are as such complementary to the bilateral studies already performed between the different TSOs.

[56] Assessed as the saving in generation costs for the CSW system ; the way this amount could be shared between generators, customers and TSOs is another issue, that depends especially on the way the markets are organized.

As a starting point for conventional bilateral studies a set of representative snapshots, covering a wide range of market situations in the complete area, needs to be developed for the Region North Sea. As generally known, a crucial step in performing grid calculations is the definition of those hypotheses. The result will not only depend on generation, demand and exchanges, but also on the localization of the different generating units and load distributed in the area. .

Because of the complexity and the uncertainty on the future generation (both volume and location), a snapshot approach is however not sufficient anymore. Firstly and by definition, snapshots don't take into account the probability at which a bottleneck occurs. On the other hand, one can't estimate the extent of the observed bottlenecks, nor their impact on the neighbouring grid. Therefore, it's needed to enlarge the scope of the approach to a more probabilistic way.

14.3.3 FROM MARKET SIMULATIONS TO INPUT FOR GRID CALCULATIONS

A market model for the North Sea Region simulates the electricity market behaviour for a given period, normally one year consisting of 365 days, in time steps of an hour or less. But it only leads country per country to aggregated results for the produced power per power plant type and exchanges with the rest of the world. Combined with input data, as being the demand and the installed power per plant type in each country, one can calculate the balance of the different countries in stake. From this grid point of view, this can be seen as if a country is represented by only one node. To be able to perform transmission grid calculations these *single node model data* have to be translated into a format that is linked with the detailed transmission grid model.

One could of course model each single generating unit of each power plant type into the market model. Anyway the results will depend on parameters that are used to estimated the generation costs of each unit, parameters that are really difficult to apprehend, e.g. the efficiency of an existing or of a future generating unit, the particular operating conditions (even local taxes have an impact), the transportation distance for the fuel.

At this stage of common grid calculations the chosen approach for generation localization is that for each TSO the control area is divided into one or several regions for which the amount of installed power per generation type is known. Just as an example of such a division, in this case for Germany, please find below a figure providing installed capacity per fuel type per region. .

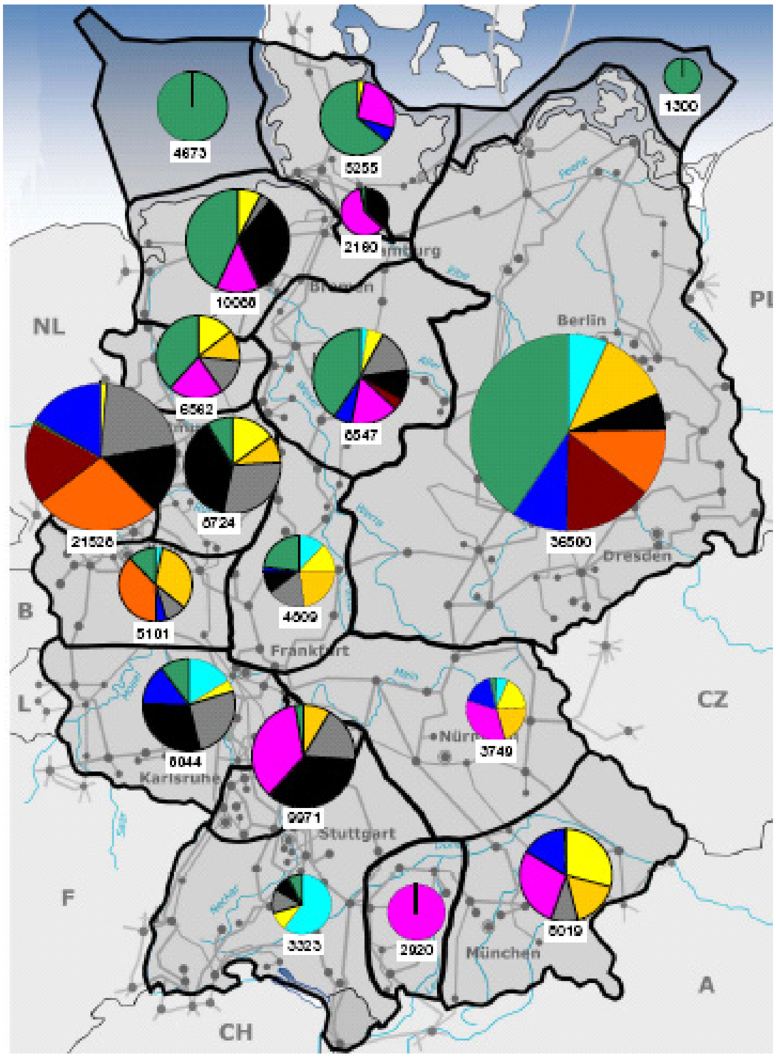

FIG. 82 EXAMPLE OF A DETAILED MODEL TAKING INTO ACCOUNT THE DIFFERENT AMOUNTS OF INSTALLED POWER PER POWER PLANT TYPE. THE SIZE OF THE PIES CORRESPONDS TO THE TOTAL INSTALLED POWER IN THE REGION, WHILE THE SUBDIVISIONS VISUALIZE THE CONTRIBUTION OF EACH PRESENT PLANT TYPE.

By using a region oriented approach, one tries to minimize the impact of the uncertainty on the specific localization of different future power plants on the results of the common grid calculations, while one maintains the granularity needed to detect bottlenecks due to the regional localization of generation unit types.

On the other hand, such an approach also averages out the probability on the availability of the different power units in neighbouring regions. It has to be clear that the situations, resulting from this averaging, are per definition less extreme so that only reduced needs for grid extensions will be observed.

Once s the list of installed generation power per region is available, the link between the predicted generation levels for the different plant types per country, resulting from the market simulations, can be made by distributing them proportionally to the detailed grid model units. Same approach could be implemented for the regional load.

14.3.4 DETECTION OF BOTTLENECKS

The identification of bottlenecks in the interconnected grid could be done in several steps which have to be performed sequentially.

STEP 1: GRID MODEL

In the first step, all nodes of a grid model for the respective time horizon have to be aggregated into regions representing generation and demand of some 1,000 MW. Bottlenecks are expected not to occur within these regions under normal conditions and exchange between these regions should be realised mostly via the EHV grid. The existing physical transmission capacity (Boundary Limit) has to be identified for each border between regions. In case of very high need of additional transmission capacity convergence of AC load flow programs is uncertain due to high reactive power demand. So as a preliminary step a PTDF (Power Transfer Distribution Factor) matrix has to be calculated.

STEP 2: MARKET MODEL RESULTS

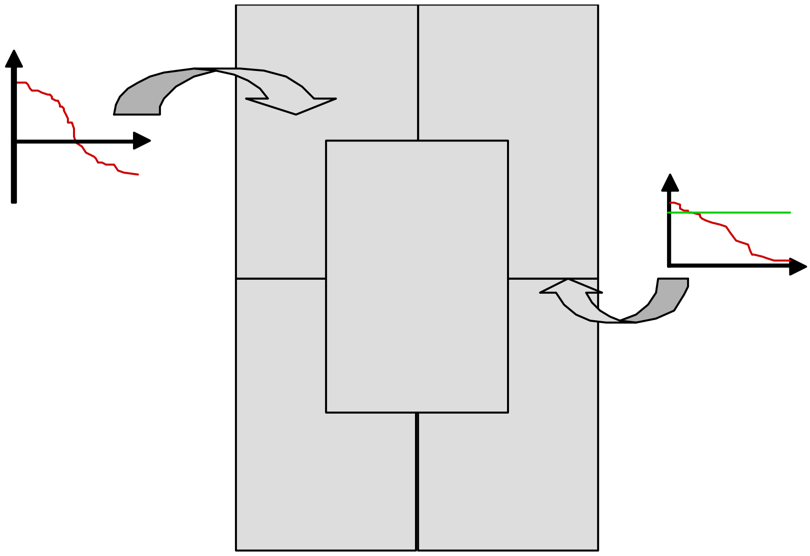

FIG. 83 A SCHEMATIC EXAMPLE OF A REGIONAL MODEL OF A TRANSMISSION GRID.

The market model calculations will then bring forward time series for demand and generation and consequently the balances of these regions. When a market areas consist of more than one region the respective results of the market model for demand and generation within this market area has to be distributed into the regions.

STEP 3: ADOPTION OF MARKET MODEL RESULTS TO THE GRID MODEL

The exchanges between regions as results of individual balances have to be calculated. This has to be done for each point in time via load flow calculations or with simplified calculations using the PTDF matrix. As a result of this step time series for usage of all borderlines are available..

STEP 4: IDENTIFICATION OF EXCEEDING POWER

With the boundary limits of step 1 and the ordered usage of borderlines of step 3 the possible occurrence of congestion for each single border can be calculated. An additional result is the energy of not transferable power within one period of the market simulation. Comparing the estimated usage of several borders for each point in time it can be concluded whether power flow could be relocated on another route or power flow violates boundary limits on consecutive borders.

STEP 5: CONCLUSIONS FOR GRID REINFORCEMENTS

With the results of step 4 grid extensions can be compared by several criteria as

- Not transferable energy
- Probability of congestions
- Shadow prices for energy (if delivered by market model).

After one of these criteria has been chosen, the needed additional transmission capacity can be concluded. If this transmission capacity concerns a border between market areas a new market simulation has to be performed resulting in new market prices. The benefit of this connection is the difference of the socio economic welfare of both variants. If this transmission capacity concerns a border between regions of one market area costs for Re-Dispatch of power plants to solve the identified congestion operational can be taken into account.

STEP 6: BENEFIT OF STRENGTHENING THE TRANSMISSION GRID

In the previous step only the needed new transmission capacity between regions is identified. The way to realise this additional capacity in the real grid has to be investigated with the standard planning methods. This has to take into account usage of phase shifters, strengthening existing lines or building new lines. In all cases, the optimal points of connection have to be identified under bi/trilateral participation of the system operators of all involved regions.

The calculated annual cost of these measures has to be compared with the socio-economic welfare, the shadow price difference or the avoided costs for Re-Dispatch.

In this way, it can be shown that the transmission grid is not a cost factor, but a productivity factor for the economy.

14.3.5 OUTLOOK FOR A REGIONAL PROBABILISTIC LOAD FLOW APPROACH

This methodology will lead to a good approximation of future energy flows in a big mashed grid considering the quality of input data but to an underestimation of transmission need in perspective of power due to averaging of generation. This problem can be solved by a probabilistic approach for load flow calculations concerning only few regions and their interfaces in detail but the whole system with regional balances. As an input the results of market modelling have to be analyzed in a way that duration curves of the main factors and their correlations are available. Additionally typical duration curves of the regional demand as well as of the power plants and distributed generation have to be identified and set into correlation with the outcome of the market simulations. A Monte-Carlo simulation with all of these duration curves and correlations then results in a more realistic variation of border transmission capacity usage.

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[15] APPENDIX 4: DETAILED FOCUS ON SOME SPECIFIC PROJECTS

Even before the establishment of ENTSO-E, TSOs have worked together to realise common development projects. This appendix extends the brief overview of three major projects and studies presented in Chapters 6 and 10, and are meant to illustrate the variety of issues that TSOs face and the solutions developed. The following projects are presented:

- The grid development in the Alps region of Germany, Austria and Switzerland axis demonstrates the complexity of the context that motivates grid development. In particular, this project addresses the significant development of wind generation in the north of Germany and new pump storage facilities in Austria and Switzerland, resulting in the need to mutualise these resources and therefore increase the transfer capacities between these countries.
- The Savoie-Piemont HVDC Project between France and Italy illustrates the technical challenges that TSOs face in implementing new transmission infrastructures due to the specificities of projects. This project demonstrates the integrated approach in technical choices and in making the best use of existing infrastructure resulting in the most efficient and sustainable solution, exploiting potential synergies with existing or new highway and railroad infrastructures.
- The connection of the Turkish power system to continental Europe and the related grid development in Greece and Bulgaria is a major project of ENTSO-E (started within UCTE) for the expansion of the synchronous European area to the East and potentially support the creation of the Mediterranean ring. It highlights the complex studies and identified measures that need to be undertaken by the TSOs to ensure the reliability of the whole system.

15.1 GRID DEVELOPMENT IN THE ALPS REGION ON THE GERMANY, AUSTRIA AND SWITZERLAND AXIS

Due to increasing north-south transits as a result of the high wind energy of the on- and offshore plants in North Germany and the planned new pump storage power plants in Austria and Switzerland the need for transmission capacity between Germany and Austria, as well as Switzerland increases. The transmission corridor from the area of Oberschwaben/Lake Constance (in Germany called “Bodensee”) region to Vorarlberg and further to the eastern part of Switzerland is also affected by this new situation (see Fig. 84).

Moreover, the successive grid extension in Germany from 220 kV to 380 kV requires a coordinated and future-oriented planning of interconnection lines in the grid area affected by the conversions.

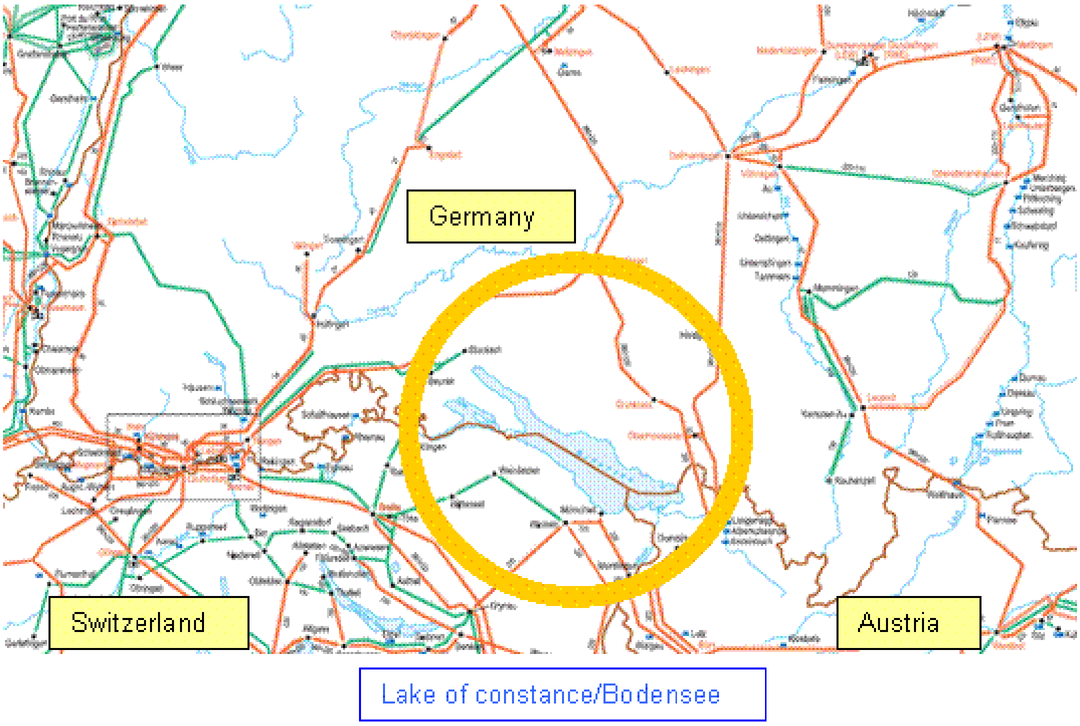

FIG. 84 CURRENT GRID

In view of these developments the concerned transmission grid operators Amprion, EnBW Transportnetze, VKW Netz and Swissgrid have determined in a common working group the future needs in international transmission capacities. The task of the development of the energy supply in this area had also been focused in the grid analyses performed by that working group.

The basis for the calculation of the future grid situation in the area of Lake Constance were for the first time the UCTE (in the meantime, ENTSO-E) summer and winter-planning datasets for 2013.

Additional expertise of the involved companies, information from previously published studies and reports, in particular concerning generation and load forecasts as well as planned extension projects had been considered in these datasets.

- Planned pump storage power plants in Austria (Vorarlberg and Tyrol) and Switzerland
- Grid extension in Germany (dena I)
- Grid restructuring in Vorarlberg and Switzerland

For reaching the EU's aimed "20-20-20-objectives" the extension of the wind energy at European level, in particular the offshore wind production, and the further extension of pump storage power plants in the Alpine area will be pushed.

Based on the Austrian "Masterplan Wasserkraft" the EU objective of 20% of renewable energy in the overall energy consumption in 2020 in Austria means an increase of currently 23.3% to 34% until 2020. Therefore the extension of hydropower will also be accelerated in the alpine area.

The scope of the calculations is covering load flow calculation, network security (N-1) analysis and calculation of NTC values. The future grid situation was important for the choice of the scenarios and variants. Among the involved companies the following worst-case-scenarios were chosen:

- Winter day: peak load, high export GE, strong wind, turbine operation
- Winter night: weak load, high export GE, strong wind, pumping operation
- Summer day: peak load, low export GE, weak wind, turbine operation

Based on the outcome of this study which is expected in 2010 further analyses and first realization concepts will be made by the involved companies.

15.2 THE SAVOIE-PIEMONT HVDC PROJECT BETWEEN FRANCE AND ITALY

15.2.1 EARLY HYPOTHESIS AND STUDIES

Currently on the French – Italian border there are 4 tie-lines: 400kV single circuit line "Villarodin (FR) – Venaus (IT)", 400kV double circuits line "Albertville (FR) – Rondissone (IT)" and 220kV single circuit line "Trinitè Victor (FR) – Camporosso (IT)" (see Fig. 85).

Since '80s it was deemed that they were not enough with respect to the Italian need of achieving high values of energy import from France, as well as from the Italian neighbouring Countries where there was a steady power surplus, particularly from nuclear power plants.

First grid studies for a new interconnection between France and Italy were performed in the '80s and they led to the choice of a new link between Grande-Ile (FR) and Piossasco (IT).

Due to many reasons, among which some environmental constraints, this project experienced an important slow down, it was delayed and then put in stand-by, even though it was still clear the benefit of increasing the Italian import from France.

FIG. 85 FRENCH – ITALIAN BORDER IN 2009

As from 2005, both TSOs assessed the opportunity of using planned cross-border transport infrastructure to implement a new FR-IT cross border link; first railway and then highway cross-border planned tunnels were considered, all these studies got community financial support under the umbrella of TEN-E programme[57].

Load flow analysis were carried out on the basis of the UCTE Reference Case tuned to the specificity of the study – e.g. with the demand/generation evolution forecast and with the planned reinforcements and developments as stated in the French and Italian Plans.

Network studies, highlighted as best nodes for the new tie-line the substations of Piossasco (IT) and Grande-Ile (FR) and confirmed the possibility to exploit a new 1000MW cable at its maximum rate, even envisaging further reinforcement opportunities as well as the voltage level upgrade (up to 400kV) of “Casanova - Asti – Vignole” 220kV lines and the link of S. Colombano substation to the existing 400kV line “Vignole – La Spezia”.

HVDC technology proved to be the only possible solution in the tunnel and also the most suitable from power system point of view. The implementation in the planned safety gallery of the highway Frejus tunnel proved easier than in the railway main train tunnel.

Therefore, more detailed feasibility studies as well as a preliminary design of the link focused on that solution. (see Fig. 86).

[57] Lyon –Turin study ref 2005-E204/05-TREN/05/TEN-E – S07.59331, ref 2007-E221/07-TREN/07/TEN-E – S07.91403

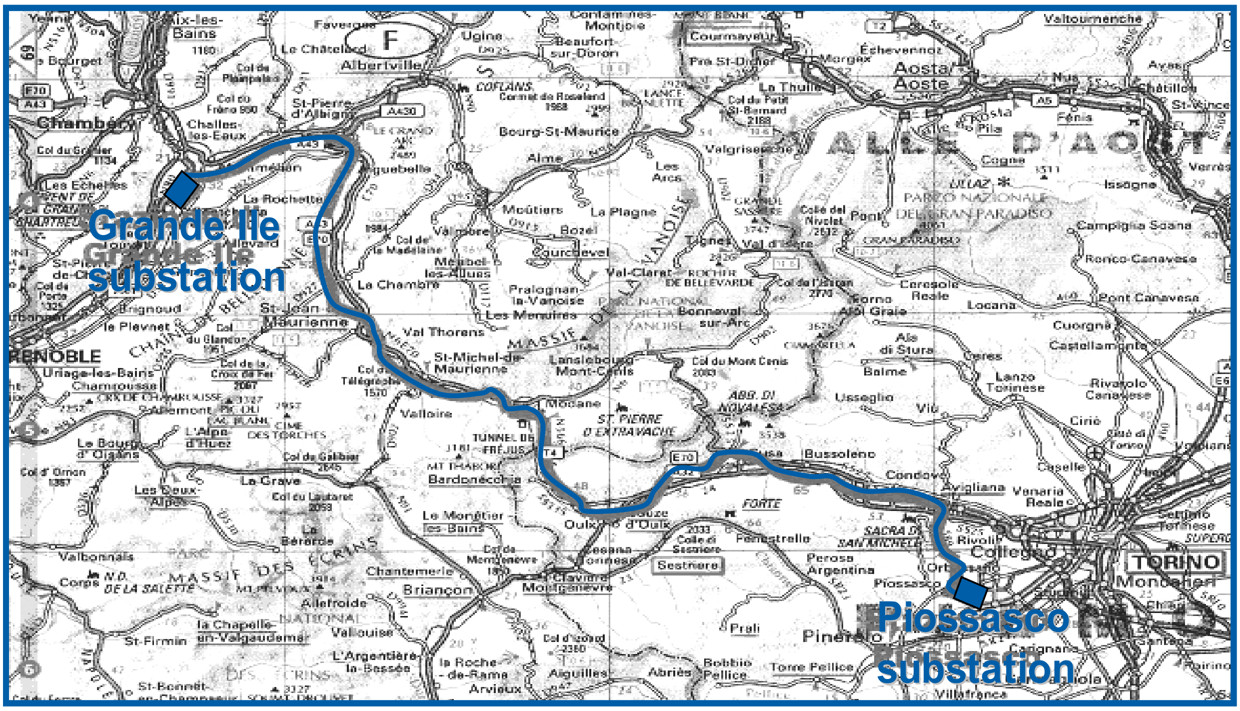

FIG. 86 POSSIBLE ROUTE UNDER CONSIDERATION FOR HVDC PROJECT

Two technologies were examined for the cables: mass impregnated and XLPE.

Their advantages and disadvantages were mainly related to the different grid losses produced and to the weigh that impacts the feasibility of installation along the highways, inside the tunnels and along the viaducts (that was the most critical issue).

Design proposals were carried out for both the solutions, taking into account the kind of motorway infrastructure to be compliant with (see Fig. 87 and Fig. 88).

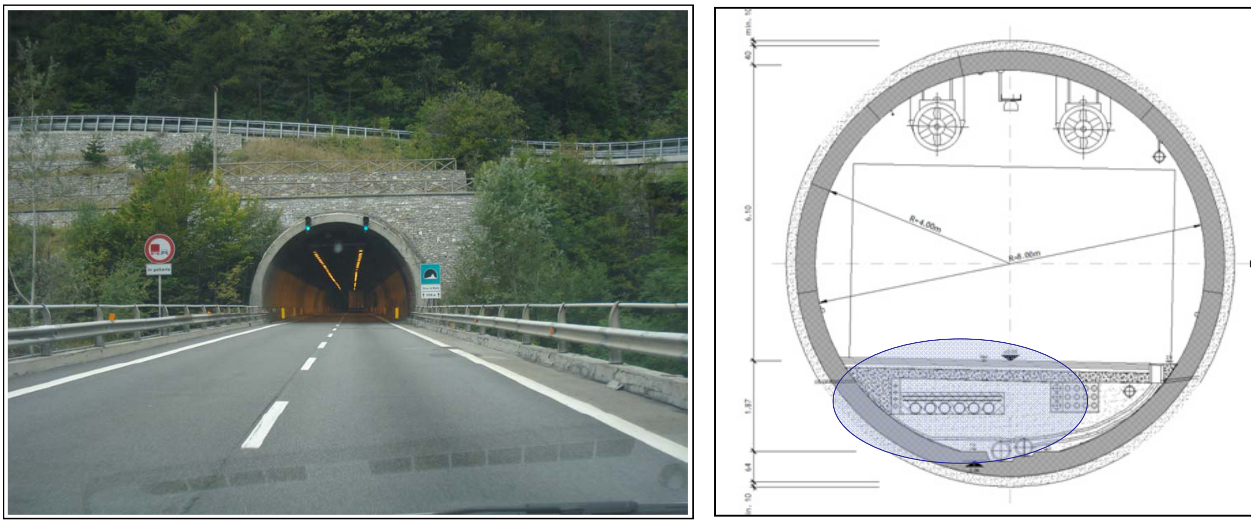

FIG. 87 A TUNNEL; TYPICAL LAY-OUT OF THE CABLES INSIDE THE SAFETY GALLERY OF THE MOTORWAY FREJUS TUNNEL

Moreover, two technologies were examined even for the converter stations (LCC and VSC) and several configuration schemes (above all, mono-block bipolar solution with metallic return or double-blocks without metallic return) were assessed from many points of view. i.e. focusing on their availability, cost and expected behaviour.

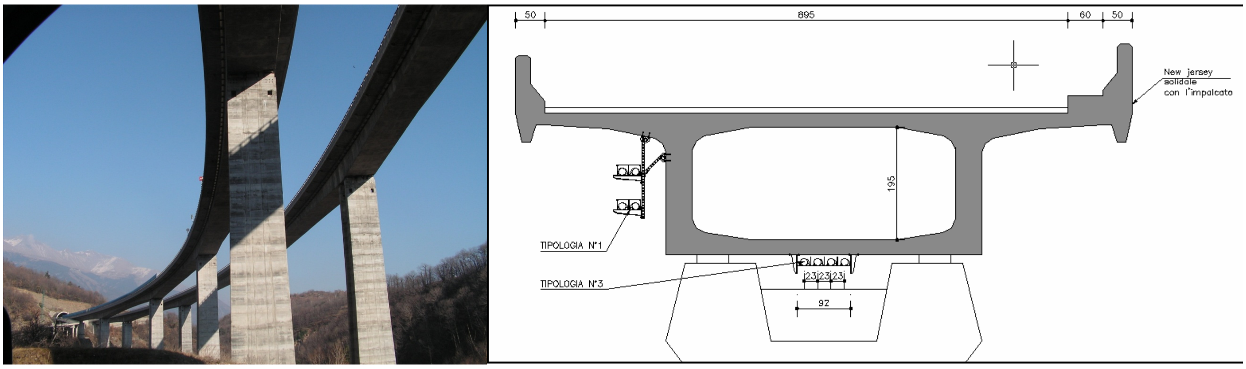

FIG. 88 A VIADUCT; TYPICAL LAY-OUT OF THE CABLES ALONG THE IT MOTORWAY A32 VIADUCTS (2 OPTIONS)

15.2.2 HVDC LINK: DETAILED STUDIES FOR DYNAMIC BEHAVIOUR

In 2009 Terna and RTE launched a detailed study for the evaluation of the dynamic behaviour of the new interconnection project "Savoie-Piemont" and of the whole system surrounding the new tie-line.

The dynamic studies focused on the impact of the HVDC connection:

- on the angle stability of generation units (nuclear, hydraulics and thermal)
- on the transient behaviour of the voltage in case of AC faults
- on the risk of cascade tripping of AC lines.

The study concluded that both technologies LCC and VSC are suitable solutions. In particular, the level of grid meshing of the area is high and there are a sufficient number of power plants that regulate the voltage to a satisfying level.

Actually, the simulations show that the addition of the HVDC interconnection does not significantly affect the stability of close hydraulic and nuclear power units: the stability margins remain comfortable.

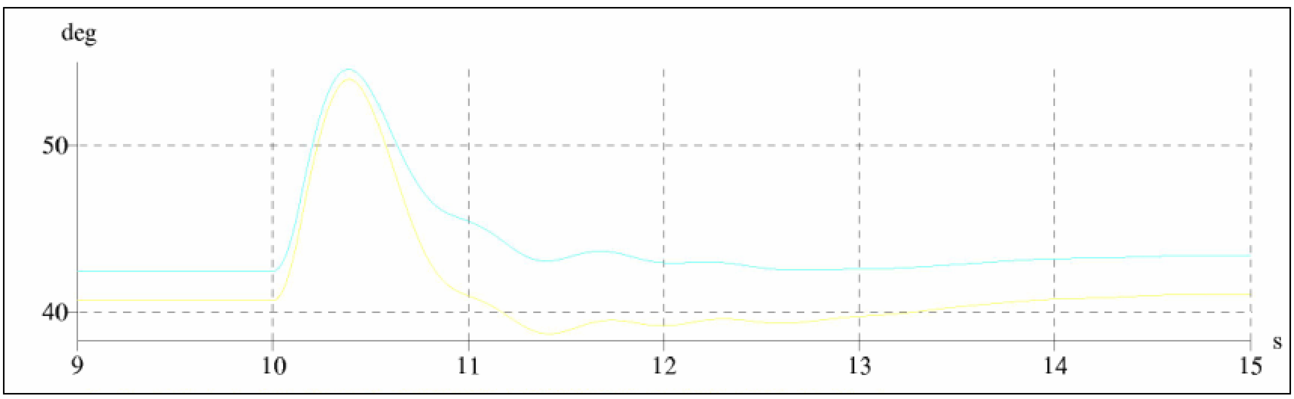

FIG. 89 AN EXAMPLE OF ANGLE STABILITY OF A NUCLEAR GENERATION UNIT

As an example, the curves of the angle position of an important French nuclear power group close to the Italian border, when a fault occurs on the “Grande-Ile-Albertville” AC line shows that the HVDC link has a very limited influence during the studied short-circuit (see Fig. 89: the yellow curve is the result with the HVDC link, while the blue one is without the new interconnection).

Nevertheless, in particular situations, low voltages could occur near Albertville. The contemporary fault of the 400 kV double circuit line Chaffard Grande-Ile does not cause critical operating conditions. Simulation highlights that the remaining interconnections are able to face the extreme event respecting the current limits in degraded conditions and also voltage profile and generators angle stability are not critical.

With reference to LCC technology and 1x1000 MW scheme, since security margins are quite narrow, it’s possible that less probable network scenarios slightly different by the considered reference one, could lead to exchange limitations aimed at fulfil the operation security criteria.

The main conclusion was that both LCC and VSC appear suitable solutions, even if VSC technology offers a better voltage regulation in steady state and in transient operation.

15.2.3 HVDC LINK: FINAL CONFIGURATION

Nevertheless, technical constraints on the cable, especially regarding the installation and repair conditions, lead to recommend a solid cable (polyethylene insulation, PE). As the capability of PE cable to withstand polarity reversal is not proven at the present status of the art for the DC voltage level that would be necessary, LCC technology should be discarded and VSC technology chosen for the converter stations.

In addition, the VSC technology turns to be more robust towards further developments, provides voltage regulation capabilities and makes possible to reduce the necessary filters.

Afterwards, detailed studies concerning several configuration schemes were performed by Terna and RTE, in cooperation with Suppliers and Research Institutes, taking into account their feasibility, availability, cost and expected behaviour, even concerning reliability and maintenance.

The main result was the choice of an electrical scheme in a double modules configuration (2 AC/DC converters), each for half of the rated power and equipped with two cables a pole (4 cables at all) (see Fig. 90).

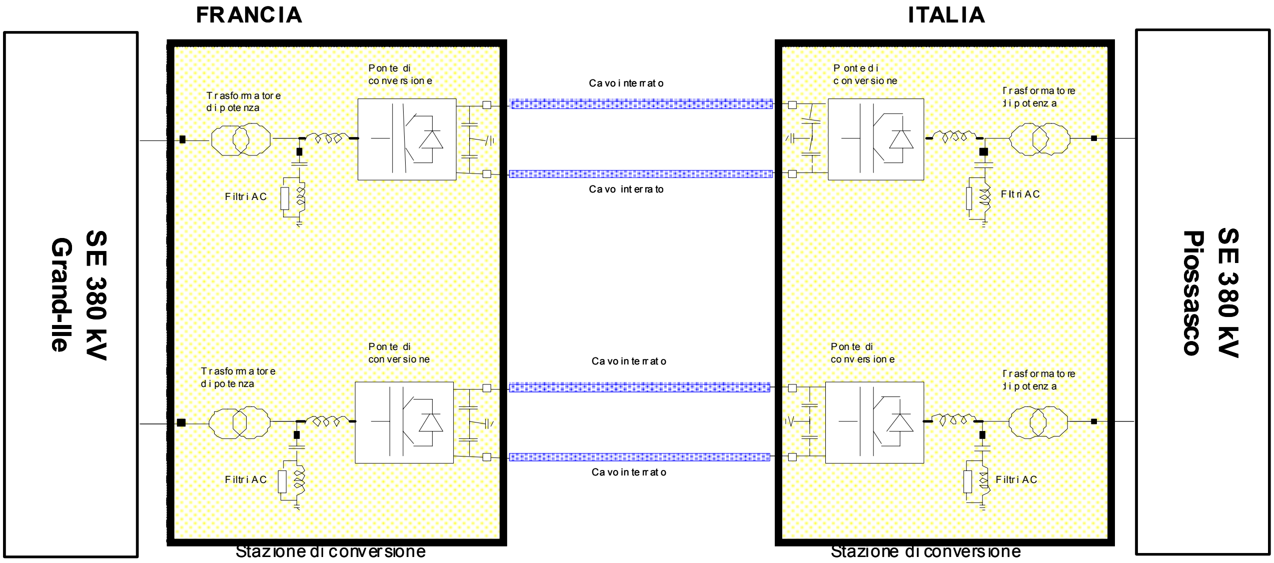

FIG. 90 HVDC SCHEME

15.2.4 FRENCH – ITALIAN SYSTEM ADEQUACY STUDY AND MARKET SIMULATION IN THE LONG TERM HORIZON

Terna and RTE launched an adequacy study and a market simulation for a better assessment of the benefits from the new interconnection.

The methodology for a valuation of the new interconnector is based on the comparison, with and without the new interconnector, of the optimal generation dispatches in the interconnected power system (market simulation) and of the risk on security of supply (adequacy study).

The new interconnector should allow more than 5 TWh of additional exports directed from France to Italy in reference year 2018 thanks to the great base-load generation development in the Central West European (CWE) region (nuclear, wind, coal). The existence of cheap base-load generation margins at the northwest border of Italy will remain the predominant determinant later on with the wind development and nuclear recovery in Great Britain.

The social welfare increase due to the new interconnector, estimated as the variable generation costs savings, would be of about several hundred M€. The impact on the global CO2 emissions should be of –1.5 to -2.5 MtCO2/year for the regional generating fleet if the substitution is made of nuclear power, wind power and/or carbon capture storage coal.

Using a conservative approach, the social benefit from the new interconnector is estimated really high, even based on a conservative price spread between the CWE region and Italy. The part of that social benefit that would end up as a TSO-revenue is highly dependent on future regulation and market organization.

The simulation of the interconnected power system shows that the new interconnector will reduce the risk of shortfall in France in case of low temperatures. The average generation margin in Italy definitely exceeds its existing export capacity to France. The new transmission capacity will therefore increase the part of that margin available for import into France in case of emergency.

The above mentioned adequacy and market studies have been performed with different tools (the French and the Italian tools) and it's expected that new simulation extended to a wider area (i.e. Continental Central South Regional Group) could be performed in the next months aiming at confirming, even in different frames, these results.

15.2.5 AGREEMENTS, MEMORANDUM OF UNDERSTANDINGS AND PERMITTING PROCEDURES

Following the Agreement of November 30th 2007 - when Terna's CEO and RTE's President signed a Memorandum of Understanding aimed at increasing the French – Italian transmission capacity - on October 19th 2009 Terna has delivered to the Italian Ministry for the Economic Development (who is in charge of the approval of the Transmission Network Development Project) the final project.

Its impact on the Italian territory can be summarized as follows:

- 95 km from the border to Piossasco (the whole link, from Grande-Ile to Piossasco amounts to 190 km);
- one Regional Administration Authority (Piedmont Region) involved;
- one Local Administration Authority (Turin Provincia) involved;
- 25 Municipalities involved.

Its impact on the French side is quite similar:

- 95 km from the border to Grande Ile
- One Department (Savoie) involved
- 30 Municipalities involved.

15.3 INTERCONNECTION WITH TURKEY: EXPANSION OF THE 400KV NETWORK TO NORTH GREECE AND GRID REINFORCEMENTS IN BULGARIA

15.3.1 INTRODUCTION

One major task for South Balkan is the connection to Turkey. Turkey will be connected to the synchronous continental European grid through three 400kV lines (two to Bulgaria and one in Greece) as shown in Fig. 94. This task includes the creation of a 400kV corridor in North Greece, from Thessaloniki (one of the major consumption centres in the country) to Turkey, and the reinforcement of the South part of the Bulgarian 400kV network.

The corridor from Thessaloniki to Turkey includes 376.2 km of overhead lines and two new EHV substations. This is a "multi-task" project as it will contribute to:

- system extension to Turkey

- accommodation of new thermal power plants
- accommodation of wind generation in the area.

A schematic diagram of the transmission system in the area east of Thessaloniki is depicted in the map of Fig. 91. At present, the area is served by a 150kV network (green lines) and only one 400kV line connecting the substations (S/S) Thessaloniki and Fillipi.

Interconnection of Greece and Turkey power systems, created the need of expansion of the 400kV network in North Greece. The construction of the interconnection line with Turkey was launched after a common bilateral agreement. This project is related to the synchronisation of Turkish power system with ENTSO-E European one. Respective projects include the following:

- Construction of the new 400kV EHV SS Lagadas in Thessaloniki (244)
- Construction of a new 400kV double circuit line Lagadas-Filippi (244)
- Redirection of the existing 400kV single circuit line Thessaloniki-Filippi from SS Thessaloniki to the new SS Lagadas
- Construction of a new 400kV double circuit line Fillipi-N. Santa (completed in 2008)
- Construction of a new 400kV EHV SS N. Santa (245)
- Construction of the 400kV GR-TR interconnection line N.Santa-Babaeski (completed in 2008)

The lay-out of the 400kV extension in North Greece is shown in the single line diagram of Fig. 92 and the main technical characteristics of the projects are shown in Table 14.

Reinforcement projects in the South part of the 400kV Bulgarian network include:

- Construction of the new 400kV OHL Maritsa East – Plovdiv (257)
- Construction of the new 400kV OHL Maritsa East – Maritsa East 3 (258)
- Construction of the new 400kV OHL Maritsa East – Burgas (262)
- Construction of the new double circuit 220kV OHL Plovdiv – Aleko (260)
- Construction of the new 400kV OHL Plovdiv - Zlatica (259)

The location of lines is shown on Fig. 93, depicted with magenta colour for 400kV and dark blue for 220kV lines. The main technical characteristics of the projects are shown in Table 15.

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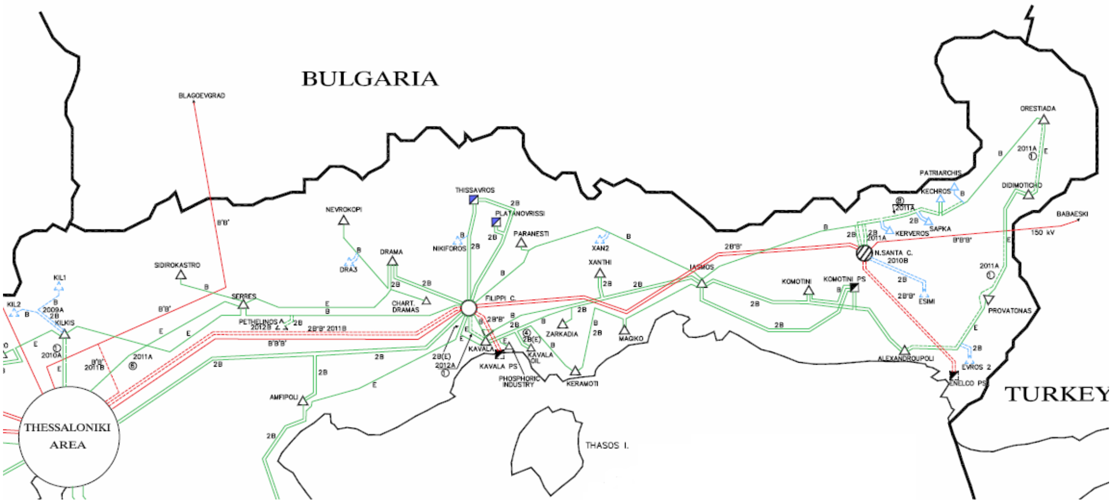

FIG. 91 NORTH GREECE TRANSMISSION SYSTEM

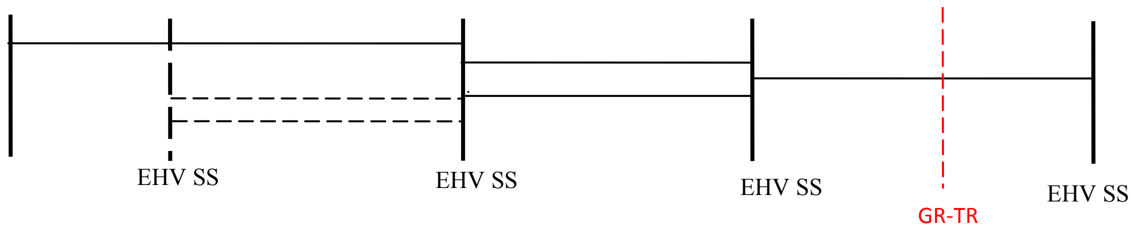

FIG. 92 EXTENSION OF 400KV IN NORTH GREECE

TABLE 14

Substation	Substation	Element	Description	Status	Cost (ME)
Lagadas		Substation	3x150kV buses 3x400kV buses 1x400kV coupler 1x150kV coupler 4 autotransformers 3x 30kV inductors 8x400kV bays 9x150kV bays	Design and permitting	31
Lagadas	Fillipi	Line	Double circuit, 2*954D, 110.3 km	Design and permitting	34,6
Fillipi	N. Santa	Line	Double circuit, 2*954D, 138km	Completed	43,5
N.Santa		Substation	3x150kV buses 3x400kV buses 1x400kV coupler 1x150kV coupler 4 autotransformers 4x30kV inductors 3x400kV bays 4x150kV bays	Under construction	25
N. Santa	Babaeski	Line	Single circuit 3*954, 69.6km in the Greek side. Single circuit 3C, 58.3 km in the Turkish side	Completed	20 (Greek side)

TABLE 15

Substation	Substation	Element	Description	Status	Cost (ME)
Maritsa East	Plovdiv	400kV New OHL	Single circuit 3xACO 400 93 km	Design and permitting	30
Maritsa East	Maritsa East 3	400kV New OHL	Single circuit 3xACO 400 13 km	Design and permitting	3
Maritsa East	Burgas	400kV New OHL	Single circuit 3xACO 400 135 km	Design and permitting	44
Plovdiv	Zlatica	400kV New OHL	Single circuit 3xACO 400 75 km	Under construction	24
Plovdiv	Aleko	220kV New OHL	Double circuit 3xACO 400 2x40 km	Design and permitting	32

The thermal limit of the new lines will be 1700MVA for 400kV and 360MVA for each 220kV line. Except line Plovdiv – Zlatica, the other lines will use the route of the existing lines on new towers. These transmission projects are "multi-task" since they will contribute to:

- Accommodation of new thermal power plants
- Enhancement of the interconnections with Turkey and Greece.
- Increase the transfer capability of the south 400kV Bulgarian ring.
- Increase the security of supply of the big consumers (Plovdiv and Burgas cities) with a significant load growth.

The new interconnection line between Greece and Bulgaria foreseen for 2012-2015 (256) will further strengthen the network in the region. In the following paragraphs, an outline of the studies carried out for the interconnection of the Turkish Power System is presented, as well as the justification of the described projects contribution to the accommodation of new conventional and RES generation in North Greece and Bulgaria.

FIG. 93 REINFORCEMENTS OF THE SOUTH PART OF THE 400KV BULGARIAN NETWORK

15.3.2 STUDIES FOR THE INTERCONNECTION OF THE TURKISH POWER SYSTEM

Studies for the synchronization of the Turkish Power System with the ENTSO-E (former UCTE) Power system have been performed by a consortium of TSOs namely RWE TSO, RTE, EON, HTSO, ESO, and HEP TSO. Also, EKC and TEIAS, have participated in the execution of studies as associated partners.

The studies were organized in two groups including “static studies” and “stability studies”. The objective of “static studies” was to investigate the impact of the interconnection of the Turkish Power System at a regional level (i.e. the Turkish network and the networks in the Balkan area) in terms of static security analysis (power flow). The objective of the “stability studies” was to assess the impact of this new interconnection in terms of static and dynamic stability. This assessment has been carried out not only at a regional level but also on the entire former UCTE level.

15.3.2.1 OBJECTIVE OF THE STUDIES

Concerning the static studies, the objective was to:

- Investigate (in terms of static security considering standard security rules) the technical feasibility of the interconnection of the Turkish system to UCTE by three 400 kV lines, two lines between Hamitabat S/S (Turkey) – Maritsa S/S (Bulgaria) and one line between N.Santa S/S (Greece) and Babaeski S/S (Turkey), the topological situation right after the connection of Turkey. (Fig. 94)

- Calculate the maximum allowable total Import-Export between Turkey and Southeast European countries using load flow analysis.

For the calculation of the Transfer Capacities (TC) steady state analysis with respect to the well known N-1 criterion has been considered. During the course of the project it was decided that some critical contingencies– known to the participating TSOs from the operational experience of their own systems– which involve the failure of two Network elements, therefore been N-2 contingencies, to be also examined.

Results were also verified (re-evaluated) taking into consideration actual switchgear settings in the area, in order to define the exchange power flows that can be securely transferred.

Transfer capacities calculated in the "Static Study" as done in similar studies in the past, were further verified (evaluated) with transient dynamic stability criteria (taking into consideration actual switchgear clearing times and settings), to define the exchange power flows that can be securely transferred.

Regarding small signal stability, previous system extensions have been accompanied with a significant impact on the small signal stability behaviour of the extended interconnected system. Hence an in-depth small signal stability analysis was performed.

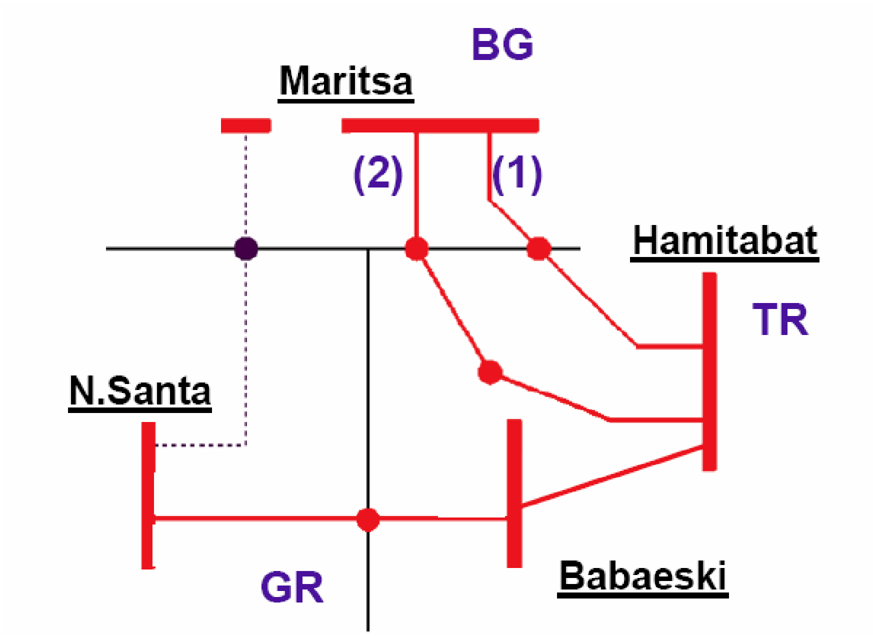

FIG. 94 INTERCONNECTION LINES OF THE TURKISH POWER SYSTEM

The aim of this investigation was:

- To confirm that the whole system stability is independent of the contingency.
- The calculation of eigen-frequencies.
- The calculation of the damping ratio for each eigen-frequency.
- The calculation of participation factors corresponding to critical eigen-values.
- To propose proper countermeasures to prevent the loss of small signal stability.

The study was mainly based on eigen-value analysis approach.

Regarding transient stability, time domain simulation was performed to verify the global behaviour of the system. In this frame (Critical Fault Clearing Times) CFCTs for most important elements for the networks under consideration were calculated.

The study included the analysis of the transient stability during and after three phase short circuits, this being the most severe case, concerning the capability to maintain synchronism of the parallel operation of Turkey and UCTE through Bulgaria and Greece after short circuits. To this aim, time domain simulations were carried out for 3-phase short circuits at nodes in the System of Turkey, which are in proximity of large power stations. For those nodes, which are critical regarding global synchronism of the systems of UCTE and Turkey, the critical fault clearing times were determined. In case of risk of loss of global synchronism, the effect on systems of neighbouring countries was analysed in terms of:

- Power flow through transmission system
- Voltage at neighbouring 380 KV nodes
- Voltage of generator and auxiliary supply of generating units

Necessary countermeasures analysed, including:

- Protection devices, in order to ensure the required clearing times
- Disconnection of the system by protection against out of step operation
- Limitation of long distance transits

The appropriate measures will be defined in order to avoid non-acceptable risk for the neighbouring systems and the system of Turkey as well

15.3.2.2 CONCLUSIONS OF THE STUDIES

In terms of system topology the realistic scenario after the connection of Turkey is the one with three transmission lines at the interface. That is the 400 kV lines between Turkey and Bulgaria and the new line between Turkey and Greece. This triple interface guarantees a safe interconnection of the Turkish power system from the static security point of view. It is also adequate for significant power exchanges of the order of 1000 MW in both directions for all N -1 contingencies and it has been also verified for some critical double contingencies.

For exchanges in both directions between Turkey and ENTSO-E interconnected system, a limiting factor of the Total Transfer Capacity (TTC) is related to the bottlenecks identified in the South part of Bulgarian system, near the interconnection point.

The proposed upgrade of the 400kV Bulgarian grid , with building of the new 400kV lines “MaritsaEast–Plovdiv” ”MaritsaEast – MaritsaEast3”, “Maritsa East – Burgas” and 220kV double circuit 220kV line “Aleko-Plovdiv” alleviates the bottlenecks, which limit the TTC of Turkey. The calculations with the upgraded Bulgarian grid show that the TTC of Turkey increases with 28% in comparison with the calculated TTC when the Bulgarian grid is not upgraded.

Nevertheless, during exports from Turkey to western directions in the order of 400 MW, in case of line opening in the corridor between Greece and Turkey, the phase angle at the opened ends reaches 30 degrees. This angle increases, up to 60 degrees, for transfers of the order to 1000 MW. In such an event, re-dispatching or reducing the export will be needed for re-closing of the open line. This is alleviated if another line in the vicinity, from N. Santa (GR) to Maritsa (BG) is available. In all cases an adequate Transmission Reliability Margin

(TRM) should be kept in the tie-lines (in the order of 100 MW for the line between Greece and Turkey and 150 MW for the two lines between Bulgaria and Turkey).

With the connection of Turkey a new critical inter-area mode in the range of 0,15 Hz appears accompanied by insufficient damping. This insufficient damping is attributed to inadequate parameter settings of existing voltage controllers and turbine governors of hydro power plants. Governors of hydro units are in the most part operated with deactivated transient gain reduction during grid operation mode in order to speed up primary control response. This contributes not only to the excitation of low frequency inter-area oscillations, but has also a negative effect on the frequency control of the Turkish Power System. To counteract on the insufficient damping it has been recommended to eliminate at first as far as possible the stimulating causes. This is possible by the usage of controller structures and parameter settings that fulfil both local or unit requirements and power system requirements. Further on the implementation of damping measures (Power System Stabilizers) that are capable to damp frequency oscillations in the range of 0,15 Hz is mandatory.

Also the damping of the already existing critical inter-area mode within UCTE (approx. 0,2 Hz) is further reduced. With respect to this mode the best possible locations for the implementation of damping measures are situated in both border regions (Spain, Greece/Turkey). The investigations showed that a power export from Turkey to UCTE leads to a significant deterioration of the overall damping. Therefore from the stability studies it follows that the power exchange between Turkey and UCTE has to be limited to 500 MW for the trial operation phase.

The stability investigations revealed the possibility of Wide Area Asynchronism. In order to reduce the probability of Wide Area Asynchronism it has been recommended to install a System Protection Scheme that separates the systems if necessary As was also consistently monitored during the project there was a persistent frequency control problem in the Turkish Power System attributed most likely to deficient controller structures and parameter settings of turbine governors mainly in the large hydro power plants (e.g. Atatürk and Karakaya). The synchronous interconnection of Turkey to UCTE is feasible provided that the frequency control problem is also resolved and the damping performance of the majority of the generation stations is improved by new Power System Stabilizers and/or optimized parameter settings of the existing controllers.

15.3.3 ACCOMMODATION OF NEW CONVENTIONAL AND RES GENERATION IN THE GREEK POWER SYSTEM

Currently, conventional power stations shown in Table 16 are in operation in the area. Their contribution to the power system security and reliability is important, since they participate in the Automatic Generation Control (AGC) and they also provide voltage support at the border of the Hellenic power system. In addition a production licence has been issued for two units with an installed power of 447MW and 440 MW respectively. The first one shall be connected to the N.Santa S/S and the second to Fillipi S/S 400kV buses.

TABLE 16

Station	Technology	Installed power (MW)	Connection
Thisavros	Hydro power	3x128	EHV SS Fillipi
Platanovrisi	Hydro power	2x58	EHV SS Fillipi
Komotini	Combined cycle	495	150kV network

Regarding renewable generation, east of the 150kV S/S Iasmos (Thrace region) a number of wind farms are in operation. The total installed capacity is 195 MW and with the present network conditions any further increase is limited by the available transfer capacity (ATC) from Thrace to the system; static security is the limiting factor.

Due to favourable wind conditions, a considerable interest exists in the area for further development of wind farms. In this context scheduling of the connection of wind farms with a total installed capacity of 116 MW has been already planned. This shall be possible upon the completion of the 400kV extension projects. According to network studies 800MW of wind generation, in addition to the above figures, shall be possible to be installed in the new 400kV network. New wind farms in the area, shall be connected at the 150kV buses of the SS N.Santa with a radial interface.

Overall, extension of the 400kV network in North Greece, with the topology described above, shall contribute to the security and reliability of the area. In particular the construction of S/S N.Santa shall allow the safe integration of much higher wind power levels, overcoming the existing congestion on the 150kV network of the area. In addition, together with the construction of the double circuit line Fillipi-Lagadas and the S/S Lagadas shall allow the reliable transmission of power injected by conventional and renewable generation in the area as well as the transfer of power levels exchanged via the interconnection with Turkey. This is not possible at the moment since in case of loss of the 400kV single circuit line Thessaloniki-Fillipi, the contingency can possibly result in overloading of the 150kV lines connected to S/S Fillipi and subsequently to cascading events that may lead to islanding of the area.

15.3.4 ACCOMMODATION OF NEW THERMAL GENERATION IN THE BULGARIAN POWER SYSTEM

Two new thermal generators are under construction and first one will be put in operation in the mid of 2010 year. The connection point of the generators will be the 400kV substation “Maritsa East”, which is under construction. With this new power, the total generation of Maritsa East complex exceeds 3000MW. According to the results of the studies conducted by the Bulgarian TSO, the enhancement of the West part of the 400kV network mentioned above will be necessary for the safe integration of new generation due to the following reasons:

- The calculated three phase short circuit clearing time of the biggest generators in the complex increases to the secure level, when the new lines are considered in operation.
- The existing grid topology does not provide N-1 security of the region, when the expected new generators will be put in operation.

[16] APPENDIX 5: SOCIAL ACCEPTANCE OF PROJECTS

According to Art 8.10 (c) of the Regulation (EC) 714/2009 "*a review of barriers to the increase of cross-border capacity arising from different approval procedures or practices may be annexed to the network development plan*". Such a review is made in the present Appendix, with a main part dedicated to authorisation procedures and as second one to EMF.

16.1 CHALLENGES WITH PERMITTING PROCEDURES

16.1.1 INTRODUCTION

The security of supply and the integration of renewable energy production into the electricity network are important challenges for the governments of all European states. Therefore, the development of grid electricity infrastructure is of crucial national and European importance.

The European Commission has identified numerous high-priority electricity infrastructure projects with respect to the European renewable energies objectives.

Nonetheless, to date, many electricity infrastructure projects face severe obstacles during the authorisation phase. Beside the complexity of the project itself, the duration and complexity of the authorisation procedures are the main reasons for delays in completing high-priority electricity infrastructure projects across Europe. Frequently, such projects take more than 5-10 years to pass the hurdle of authorisation procedures required by national law.

Inappropriate legal frameworks for authorisation procedures, opposition from local groups, and ineffective administrative and conduction of the authorisation process, constitute the main obstacles for their timely and effective completion.

The objective of this chapter is to identify the main problems associated with the authorisation procedures of infrastructure projects in general for the construction of High Voltage (110 kV and above) transmission lines and substations in particular, and to propose possible improvements at both, national and European level.

16.1.2 THE DIFFERENT STEPS FOR A NEW INFRASTRUCTURE PROJECT

The development process for an infrastructure project involves the following steps:

- The preliminary technical stage: this step includes identification of grid extension requirements, the carrying out of feasibility studies, identification of environmental and public conditioning and the identification of preferred reinforcement schemes.
- The authorisation procedures: this step includes the identification of route alternatives for lines, the identification of new substation sites, the public consultation process, the identification of the preferred route, and the submission of the application to the permitting authorities.

- The construction phase: this last step after the necessary permission includes the detailed design review, the procurement process, erection, compensation commissioning and energisation.
- The duration of each step depends on the complexity of the project and on the opposition encountered. The durations may differ between different European countries. The Figure below provides an averaged overview of durations and process steps involved with respect to power line projects.

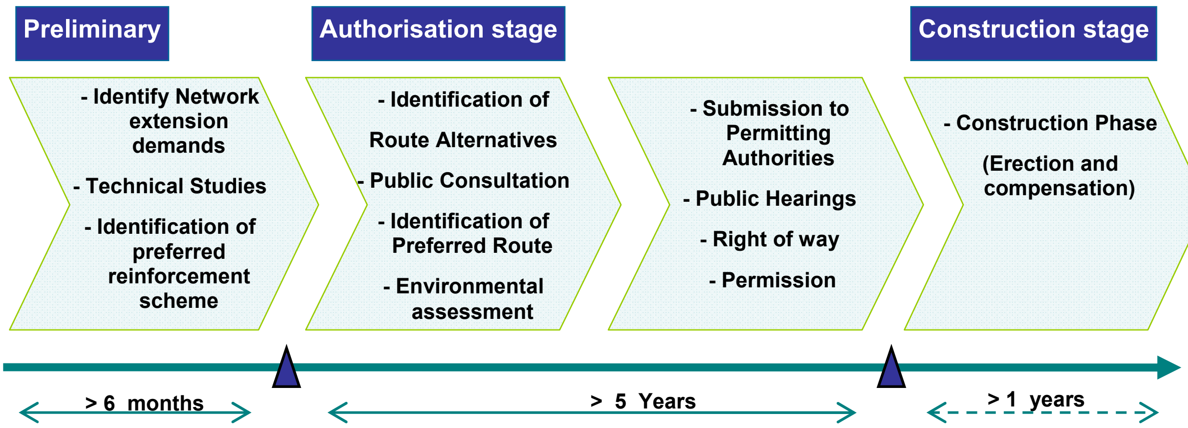

FIG. 95 TYPICAL PROJECT DEVELOPMENT PROCESS FOR LINES

The total duration for a line project on average can be greater than 5 years without obstacle or opposition, which is very rare. In reality, nowadays, the time between the start of planning and final commissioning of a power line is frequently more than 10 years, without encountering any major obstacles. With significant obstacles and oppositions projects can take up to 20 years to complete.

16.1.3 THE MAIN DIFFICULTIES OF THE PROCESS

The most time-consuming step of a power line project is the authorisation procedure. The legal, administrative and practical framework for authorisation procedures has revealed many – often similar – problems for TSOs in different European countries. Mostly, the problems encountered are irrespective of whether domestic or cross-border lines are concerned. However, cross-border lines are frequently perceived by the public as mere “transit lines” or “commercial lines” without or of limited benefit for the residents. Therefore, additional opposition against these lines may be encountered.

The main issues are:

- **Legal framework for the permitting procedures**: the legal procedures (generally environmental assessment, request for permission at national and local levels, public debates,) are similar in the EU, but the main phases (planning application process) are implemented in a different manner according to the national legislation of the different countries. Legislative differences may even be observed within one country between different regional legal entities or federal states. Questions rise: what kind of permitting procedures are required and which are the relevant authorities: local or national?

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- **Duration of permitting procedures**: the authorisation procedures required by law frequently takes between 5 – 10 years. Sometimes it may be observed that projects are completely blocked for a longer period of time or may even be abandoned due to the duration of the permitting process. Generally, there is a lack of reasonable and mandatory time limits for the duration of permitting procedures for transmission lines.
- **Social acceptance of projects**: electricity infrastructure projects are neither considered as necessary nor are their benefits understood by the public. This results in additional objections against the project at the regional planning procedure and the project approval procedure stage. Additional objections are focused on: doubts of the necessity for the project, visual impact, concern in relation to alleged health effects from electromagnetic fields, and devaluation of amenity and property. TSOs are often alone in defending the general benefit of the new transmission infrastructure projects and rarely get support from other stakeholders. Currently, the public interest and need for electricity infrastructure is usually advocated only by TSOs during the authorisation procedures.
- **Balancing environmental impacts and other public interests**: there is inadequate balancing between environmental impacts and other public interests in the evaluation of the importance of a certain grid project. Extensive statements and surveys regarding the diverse environmental aspects need to be submitted, while the necessity and the public interest of transmission line projects is advocated only by TSOs. The number of entities in charge of the Environmental Impact Assessment (EIA) is comparatively high and the interest and goals of the different entities are frequently competing.

16.1.4 IMPROVEMENT PROPOSED

In order to reduce the duration of the authorisation procedures, ENSTO-E proposes improvement in the following domains:

- Address the cultural and political issues relating to electricity infrastructure
- Recognition of the importance of priority electricity infrastructure projects,
- Legal framework for authorisation procedures,
- Management of infrastructure corridors,

16.1.4.1 ADDRESS THE CULTURAL AND POLITICAL ISSUES RELATING TO ELECTRICITY INFRASTRUCTURE

Grid extension projects need to be supported by all stakeholders (TSOs, regulators, politicians, national and European institutions). All stakeholders are responsible for communicating and explaining the benefits of the projects to the public:

- the vital importance of electricity infrastructure in general and the transmission grid in particular for the promotion of renewable energy resources (in particular, wind power) and the efficient use of primary sources, which are not equally widespread across the European countries, to ensure security of supply and to foster the European electricity market.

- that electricity infrastructure are in the public interest and not solely for the benefit the TSOs or other market parties involved ("public interest").
- that TSOs operate in a regulated environment, that inherently assures that electricity infrastructure projects are in the public interest.
- that TSOs are vitally interested in modern, reliable and efficient transmission systems and technologies, but at the same time they have the legal obligation to consider economic aspects adequately.
- the need for political commitments and Policy to support necessary infrastructure projects.

16.1.4.2 LEGAL RECOGNITION OF THE IMPORTANCE OF PRIORITY ELECTRICITY INFRASTRUCTURE PROJECTS

The public interest in important electricity infrastructure projects needs to be stated in law.

The law should also provide clear methods for cost allocation. If the use of overhead lines is prevented by technical or environmental reasons then other, probably more expensive, technologies need to be employed.

The necessity for critical infrastructural projects need to be legally justified (e.g. in a list of high priority projects) in order to prevent additional and recurring justification by the TSOs during the process. An example is the German Law "Energieleitungsausbaugesetz" that came in force in August 2009.

Trans European Network (TEN) projects and national laws need to be linked explicitly. By this means, TEN projects would be supported by the respective national laws, which strengthen the position of the TSOs and provides a countervailing factor to the local interests pursued by opponents of the projects.

16.1.4.3 IMPROVE A LEGAL FRAMEWORK WHICH ENSURES MORE EFFICIENT AUTHORISATION PROCEDURES

Authorisation procedures for electricity infrastructure projects should be centralised at the national level and should comprise:

- An integrated procedure for infrastructure project,
- A simplification of the procedure when the impact of project is low,
- An effective time-limit specifying the maximum duration of the permitting procedure,
- Clear definitions and descriptions of the documents needed for the permission procedures,
- A single consultation step.

The number of permits required could be reduced by creating an integrated procedure for infrastructure projects or for projects subject to an environmental impact assessment, including substations with the same requirements in all regions of the country. Therefore, the building permit together with the right of way procedures would allow the immediate beginning of the construction.

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For the upgrading of existing lines (e.g. to a higher voltage), the impact of the change is very limited. Therefore, a simplification of the procedures is needed to reduce their duration.

Effective and compulsory time limits are necessary to provide legal certainty for the TSOs, which is vital for a timely completion of permitting procedures (including the closing-off of submissions of allegedly new statements and evidence opposing the construction of an infrastructure project). By this means, the duration of a permitting procedure need to be limited to a maximum of 3 years.

The consultation mechanisms are vital, especially at the very beginning of a project. But duplication and repetition of consultation procedures are time-consuming. The option to combine all consultation steps in one single consultation would save time.

16.1.4.4 ENSURE INFRASTRUCTURE CORRIDORS

It is necessary to reserve so-called "infrastructure corridors" for high priority infrastructure projects, especially such projects which are part of the TYNDP, including reasonable time limits.

16.2 CHALLENGES WITH PERMITTING PROCEDURES – EMF ISSUES

16.2.1 TRANSMISSION OF ELECTRICAL ENERGY AND EMF

This chapter describes the position and requirements of ENTSO-E concerning exposure of the general public to electric and magnetic fields (EMFs) produced by electricity networks, especially by new transmission lines. In particular ENTSO-E stresses the importance of compliance with the EMF exposure limits, as contained in the EU Recommendation which is derived from internationally recognised independent scientific bodies. It is our objective to show that a proper handling of this issue contributes to meeting our mission with an appropriate social, economic and environmental consensus, therefore contributing to the Environmental EU policies.

The electrical transmission and distribution systems are operated with alternating voltage at a frequency of 50 Hz in Europe. Hence, it creates EMFs of Extremely Low Frequency (ELF), as is the case for all applications of electricity, including domestic appliances.

16.2.2 EMF EXPOSURE LIMITS

Research on the environmental impact of electric and magnetic fields goes back to the 1970's and was carried out by the World Health Organization (WHO) and the International Radiation Protection Association (IRPA). Subsequently the International Commission on Non-Ionizing Radiation Protection (ICNIRP) continued the work and developed a first guideline in 1998 with a scientific basis and a structure of numerical basic restrictions and reference levels.

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In 1999 the European Union published its Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC). This generally used the ICNIRP numerical values (e.g. reference levels for 50 Hz: 5 kV/m and 100 µT for general public, permanent exposure) but placed them in a practical policy framework taking account of the duration of exposure.

In July of 2009 the ICNIRP published a draft for consultation of "Guidelines for limiting exposure to time varying electric and magnetic fields (1Hz to 100kHz)".

ENTSO-E finds in general that the current ELF EMF basic restrictions of the ICNIRP Guidelines as used in the EU Recommendation are adequate and suitable in respect of exposure of the general population to electric and magnetic fields generated by high voltage electricity circuits.

16.2.3 ELF EMF AND PERMISSIONS FOR NEW TRANSMISSION LINES

In some countries TSOs are facing very long and onerous permitting procedures and a lot of objections to transmission grid extension projects, particularly high-voltage overhead lines. Uncertainties regarding alleged negative health effects of ELF EMFs, the lack of a clear policy endorsed and supported by politicians and legislators, and the sometimes inappropriate reference to the precautionary principle lead to considerable delays, legal actions, etc that jeopardize developments of the transmission system.

The TSOs understand the genuine concerns of the general public regarding alleged health effects from electric and magnetic fields and are willing to take these concerns into account when selecting the optimal route for their infrastructures. They wish to encourage the provision of accurate and correct information to the general public as recommended by WHO.

Communication of correct information concerning the scientific position on ELF EMFs is essential

TSOs, as developers of grid infrastructural projects, play an essential role in the communication of objective scientifically confirmed and accurate EMF research results. However, other bodies, such as the EU, national government authorities and agencies, local government, medical and scientific bodies etc. also have an obligation to correctly inform the general public. All too often, opponents to projects or representatives of pressure groups communicate results of non peer-reviewed research and even misinformation.

If the public is to be correctly informed, the following aspects need to be included in the communication:

- Significant exposure to various parts of the EMF spectrum is a fact of nature (magnetic field of the earth, natural light)
- Any use of electrical appliances, including household appliances implies EMF exposure which sometimes can be higher than from power lines (although clearly the exposure is not continuous)
- Even though research has been conducted for more than 30 years there is no scientific proven medical or laboratory evidence that links ELF EMF to adverse health effects
- Underground cables also generate magnetic fields which in the immediate cable corridor can even be higher than those of overhead lines.

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- The compliance with the ICNIRP guidelines and EU Recommendation is one aspect for finding a corridor for new circuits in the EU countries with a minimal impact to the environment.

ENTSO-E supports in principle the reviews and recommendations made by internationally recognised bodies such as ICNIRP and WHO, which are comprehensive and include all relevant scientific and medical disciplines, as the basis for any further decision-making in the field of ELF EMFs.

However, extra precautionary measures should be carefully balanced. In some cases even for new transmission lines short-time exposures above ICNIRP reference levels for permanent exposure - but still well below harm level - are not reasonably avoidable in all places.

ENTSO-E asks the EU for support and a clear and proactive communication of its position in order to support the need for transmission infrastructure development at appropriate cost.

16.2.4 Further Development

EU and National Government policy goals on sustainable development and energy can only be achieved when TSOs can expand, reinforce and operate the transmission grid on time and within budgets in a manner acceptable to local communities. To achieve this goal it is essential that there is a clear policy to comply with the internationally recognised reasonable limits and to communicate accurate information concerning EMF and that this policy must be supported by the EU and all national governments. This includes a clear concept of basic restrictions as well as a flexible adoption of a set of reference levels, taking account of the field level and duration of exposure.

ENTSO-E offers to contribute to a constructive discussion at the EC level creating a practical framework for the necessary grid extension in Europe.

Because environmental topics are becoming more and more relevant, and because of the likelihood of HVDC-lines being built, it will be necessary to get more scientific background about DC EMFs and ion current streams. Therefore we support research on these topics.

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[17] APPENDIX 6: SYMBOLS AND ABBREVIATIONS

AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power Generation
DC	Direct Current
ELF	Extremely Low Frequency
EMF	Electromagnetic Field
ETS	Emission Trading System
EWIS	European Wind Integration Study
FACTS	Flexible AC Transmission System
FLM	Flexible Line Management
HTLS	High Temperature Low Sag Conductors
HV	High Voltage
HVAC	High Voltage AC
HVDC	High Voltage DC
IEM	Internal Energy Market
LCC	Line Commutated Converter
LOLE	Loss of Load Expectation
NGC	Net Generation Capacity
NRA	National Regulatory Authority
NREAP	National Renewable Energy Action Plan
NTC	Net Transfer Capacity
OHL	Overhead Lines
PST	Phase Shifting Transformer
RAC	Reliable Available Capacity
RC	Remaining Capacity
RES	Renewable Energy Sources
RG BS	Regional Group Baltic Sea
RG CCE	Regional Group Continental Central East
RG CCS	Regional Group Continental Central South
RG CSE	Regional Group Continental South East

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RG CSW	Regional Group Continental South West
RG NS	Regional Group North Sea
SAF	System Adequacy Forecast
SoS	Security of Supply
TEN-E	Trans-European Energy Networks
TSO	Transmission System Operator
TTC	Total Transfer Capacity
VOLL	Value of Lost Load
VSC	Voltage Source Converter

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