
RED ELÉCTRICA DE ESPAÑA
Electricity interconnections:
a step forward towards
a single integrated
European energy market

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Electricity grids are a key element of today's electricity systems due to the fact that they facilitate the connection of generation power stations with end consumers, which is fundamental to a 21st century society, that is increasingly electricity dependent and that is constantly demanding more electricity.

As a part of the electricity grids, that are made up of a multitude of interconnected high voltage lines and substations, the international connections are the set of lines and substations of neighbouring electricity systems that allow cross-border energy exchanges. Interconnections link different countries with each other and not only allow systems to offer electricity generated nationally to neighbouring countries but also to receive energy to satisfy domestic demand.

Since electricity systems first began and throughout the 20th century to the present day, the development and management of electricity grids, especially those of high voltage transmission, have evolved from a more local level to move towards that of a national level and then subsequently to that of an international level, because electricity systems are more stable the more meshed and interconnected they are. It was in the 1950s that Europe began to interconnect electricity grids between different countries via what is known as international interconnections (or cross-border connections), with the initial objective of improving security of supply margins, although today interconnections are allowing a true integration of the different national electricity systems.

«*Electricity systems are more stable the more meshed and interconnected they are***»**

The role of international interconnections

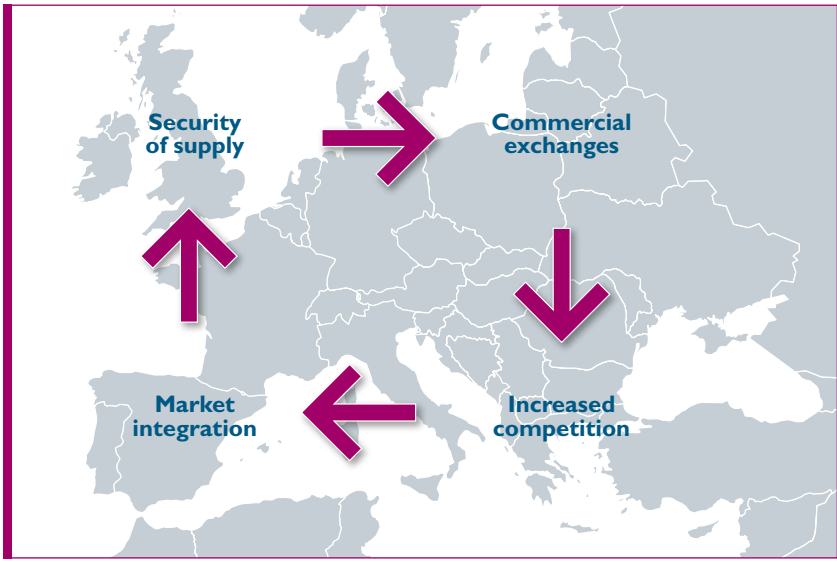
International interconnections generate a series of advantages within those countries that are connected. The most significant of these is the contribution to the security and continuity of the electricity supply within those interconnected systems, thanks to the energy exchanges that take place when they are needed. The interconnections are the most significant instantaneous backup for the security of supply. As an example, in January 2009, a strong wind storm affected facilities in both the Spanish and French areas of the Pyrenees and it was necessary, during several days, for the Spanish electricity system to provide support to ensure the energy supply in the French region of Perpignan under safe conditions.

The second advantage of interconnections, which is dependent on the first, is the increased efficiency of the interconnected systems. With the unused capacity, commercial exchanges are established daily taking advantage of the energy price differences between electricity systems. These exchanges make it possible for electricity to be generated using the most efficient technologies and allowing energy to be transported from where it is cheaper to where it is more expensive.

In addition, there is also a third advantage: increased competition between neighbouring systems. Imports of energy from other countries require agents of the country in question to have to make their bids more competitive if they want their offers to be accepted, bringing with it a reduction in the wholesale price of electricity.

Given the above, the interconnections play a key role in the integration of electricity markets. This is the objective sought by the so-called Internal Electricity Market in Europe (IEM), which is working on integrating all of today's existing markets within the European Union into one unique market.

Functions of the international interconnections



Tarifa station for the Spain–Morocco interconnection. / REE

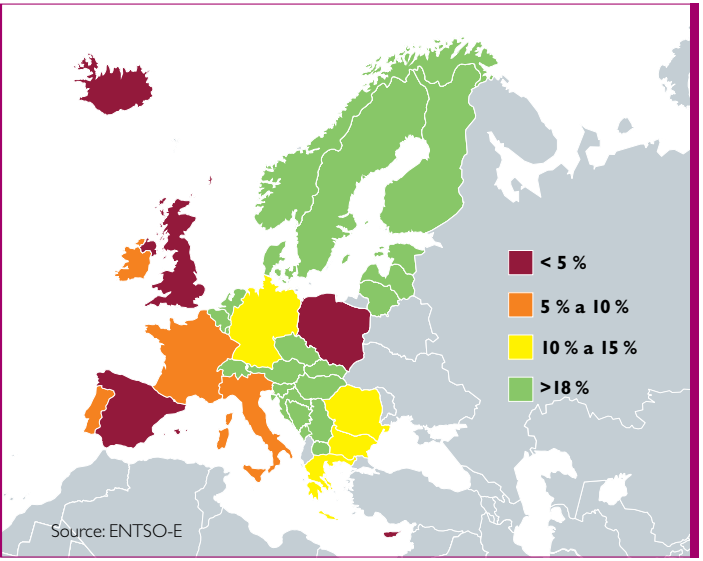
The commercial energy exchange capacity between countries

The exchange capacity is defined as the maximum instantaneous electrical power that can be imported or exported between two electricity systems whilst maintaining the security criteria of each of the systems.

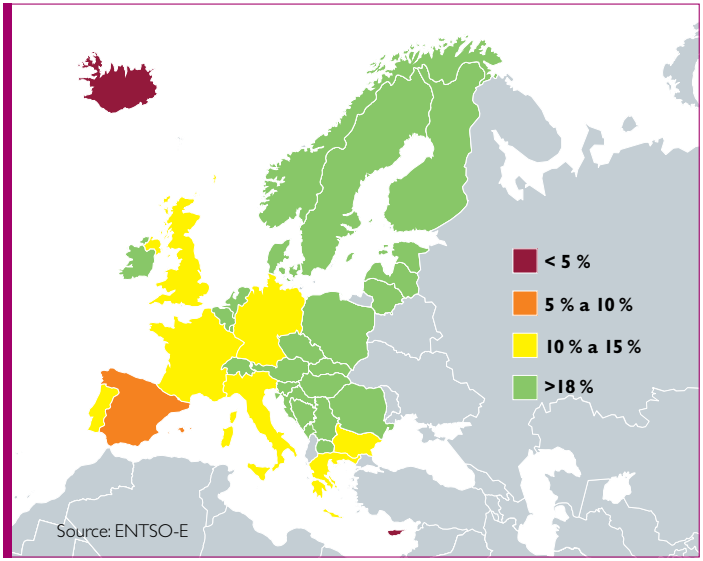
In order to calculate this capacity, the operator of each system carries out coordinated studies with neighbouring operators which take into account generation and demand forecasts, and those periods of facilities maintenance, as well as carrying out simulations that take into account the possible failure of the various grid elements. All these studies are conducted within different temporary horizons, from annual to daily forecasts, to therefore carry out the maximum commercial exchanges whilst always respecting safety criteria.

In order for every country to obtain the numerous aforementioned benefits, it is essential to maintain a high level of exchange capacity. In this respect, the European Union recommends that the minimum interconnection capacity between countries should represent at least 10 % of the installed generation capacity in each one of them.

Interconnection ratio (2011)



Interconnection ratio (2020)



Spain, an «electrical island»

Today the Spanish electricity system does not reach this minimum level recommended in Europe, as their commercial exchange capacity with the European system only represents 3% of the installed generation capacity in Spain. Strengthening the interconnections with its neighbouring systems is therefore the most important investment to be made by Spain, in the next few years, to complete the large investment effort made at a national level.

Furthermore, due to the geographical position of Spain, the possibilities of interconnection with the rest of Europe are very limited. The fact that only the interconnection with France allows us to exchange energy with the rest of the European Union, together with the low exchange capacity, makes the Iberian Peninsula an «electrical island».

Spain-France interconnection

Spain and France are connected by means of four high voltage lines: there are two in the Basque Country (one 400 kV line connecting Hernani with Argia and one 220 kV connecting Arkale with Argia), one in Aragon (220 kV line between Biescas and Pragnères) and one in Catalonia (400 kV line connecting Vic with Baixas). This set of lines allows a maximum exchange capacity of around 1,400 MW. Since 1982 no new interconnection lines have been built, despite the growth of the electricity demand in both countries.

In order to increase the power exchange capacity and strengthen the union with the European system, which is 10 times that of the Spanish electricity system and is the largest in the world, the construction of a new interconnection with France is being undertaken in the eastern Pyrenees, which is the most important project that Red Eléctrica (REE) will undertake, over the coming years, regarding the transmission grid.

This new direct current line, whose coming into service is planned for 2014, will represent the first interconnection with the European grid to be commissioned in almost 30 years.

The project, in addition to being a technological challenge due to its technical complexity and characteristics, will allow the power exchange capacity with France to be doubled. This new

Vic-Baixas line between Spain and France. / Michel Monteaux / RTE

interconnection will provide increased security in the electricity supply, not only at a national level, but also at a regional and European level, will improve the quality of service and drive the development of energy exchanges in the European market, whilst fostering a greater integration of renewable energies into the electricity system.

Similarly, the new cross-border link will guarantee the reliability of the supply in the deficient border regions, such as Girona, that did not have a sufficiently developed meshed grid. This situation clearly hindered the region's development as there was insufficient grid to supply energy to large and medium consumption clients.

Additionally with this new link it will be able to relieve the existing congestions in the interconnection, and it will contribute to the economic development of both regions.

However, this new project which foresees to increase to 2,800 MW the exchange capacity between Spain and France is still insufficient. Therefore, Spain's objective is to develop new interconnections in the 2020 horizon, with the aim of reaching an interconnection capacity of at least 4,000 MW.

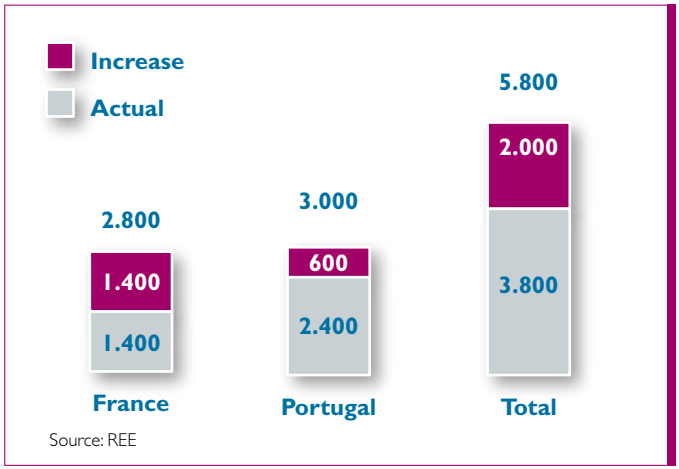
Spain-Portugal interconnection

The interconnection with Portugal poses a different situation. Currently between Spain and Portugal there are 7 lines: 4 of 400 kV and 3 of 220 kV which allow a maximum exchange capacity of between 2,000 and 2,400 MW to be reached. As in the interconnection with France two new lines between the two countries are being developed (one via Galicia and another via Andalusia) that, once they are put in service in 2015, will allow about 3,000 MW of exchange capacity to be reached.

Spain-Morocco interconnection

Spain and Morocco are electrically interconnected via 2 submarine power cables that provide a maximum capacity of about 800 MW. Currently this interconnection can be considered as the main electricity link between Europe and the countries on the southern shore of the Mediterranean basin and which may in the future, when projects such as Desertec and Medgrid have been completed, become the gateway to Europe for energy generated from renewable sources in North Africa.

Current power exchange capacity of Spain and 2016 forecasted



Source: REE

Development of new interconnections and forecasted commercial exchange capacities

Source: REE

Europe: the largest electricity system in the world

Traditionally the development planning of interconnections between two national systems were carried out bilaterally by the two countries concerned. However, this has changed in recent years due to the targets set by the European Union for the creation of the IEM. Grid planning is shifting from a national to a European level owing to the fact that all transmission grid development, and in particular that of the interconnections, influences the operating conditions of other systems and electricity markets.

With this vision, ENTSO-E (European Network of Transmission System Operators for Electricity) every two years publishes the *Ten Year Network Development Plan* (TYNDP) that identifies the European transmission grid developments to be carried out within a 10-year horizon. The TYNDP 2012 was published in July and is available on the ENTSO-E website (www.entsoe.eu). Thus, the planning of certain interconnections is already within the European arena and certain projects, once endorsed by the European Commission following the analysis of their advantages for the whole European electricity system, are identified as priority projects, therefore facilitating the associated administrative procedures and funding.

Due to the geographical layout of the different European countries, direct current submarine links will become very important to achieve the objectives set by the European Union and

have already become a trend amongst infrastructures identified in the TYNDP. England, for example, which is interconnected with France, Holland and Ireland with links of this type, also plans, in addition to strengthening these, to interconnect with Belgium and Norway. Other links already in operation are those in the North Sea linking Norway with Denmark and Holland, and Sweden with Denmark and Germany; in the Baltic Sea Sweden with Poland, and Finland with Sweden and Estonia, and in the Mediterranean Italy with Greece.

In the Iberian area, the future construction of submarine links has not been ruled out especially to strengthen the exchange capacity with France.

How are the interconnections managed?

Once the system operators have agreed, under the security criteria required by both systems, which part of the interconnection capacity can be allocated for commercial use, this is made available to agents, buyers and sellers, according to the allocation method that operates in each of the borders.

In Europe the commercial exchange capacity allocation has been standardised through two mechanisms: organised markets or via capacity auctions.

Organised markets

The interconnection between Spain and Portugal is managed through the Iberian Electricity Market (MIBEL) whose market operator is OMIE. In MIBEL, generators and consumers in Spain and Portugal present their bids in each market session for the purchase and sale of energy and after the matching process, by which prices are determined in both countries, an energy schedule is established through the Spain-Portugal interconnection for each hour.

The commercial exchange capacity, calculated by the system operators of both Spain and Portugal, REE and REN, plays a key role in fixing prices in both countries. If the energy flowing through the interconnection does not exceed the maximum set by the operators, the buying and selling price of energy will be the same in both Spain and Portugal, with this situation being referred to as market coupling. However, if the flow exceeds the maximum capacity designated, the markets are decoupled and the price of electricity is different in Spain and Portugal.

Brovales-Alqueva line in the area of Badajoz. / REE

The price difference between the two interconnected areas, Spanish and Portuguese, generates revenues called «congestion rents». These rents are shared equally between the two countries and are intended for the future development of interconnections or to reduce access tariffs.

To ensure the implementation of established energy schedules in the interconnection, the system operators of both Spain and Portugal monitor the status of interconnection at all times. The security of supply of the interconnected systems is paramount.

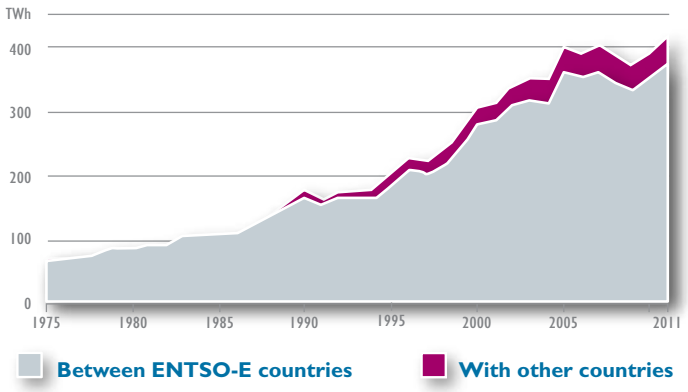
Capacity auctions

In comparison to the electricity markets, capacity auctions are used only to manage the commercial exchange capacity or rights of access to use the interconnection, this management is separate from the energy negotiation. The auctions that take place in different time horizons consist mainly of capacity allocation to those agents who are willing to pay more for it, with the agents later having to schedule the energy through bilateral agreements or through participation in the electricity markets on both sides of the border.

As a result of a capacity auction, all agents who obtained exchange capacity must pay a single price for the acquired capacity, receiving in return the right to use the interconnection to carry out commercial energy exchanges. This payment represents revenues for the interconnected systems, the «congestion rents» which as in the previous case is shared equally between the systems.

Source: ENTSO-E

Evolution of the international exchanges



Section of the interconnection between France and Germany through the Lorena region. / David Sauveur / RTE

At present, the allocation of the commercial exchange capacity between Spain and France is carried out through capacity auctions conducted by the operators REE and RTE for various time horizons: annual, monthly, day-ahead and intraday. For the upcoming future, work is being carried out on the integration of the long term auctions (annual, monthly) in a European regional platform.

REE and RTE, as operators of the Spanish and French electricity systems respectively, carry out available capacity forecasts and based on these studies determine the capacity that can be offered in each of the different auctions.

As with the interconnection with Portugal, the security of the systems takes priority over commercial exchange.

Regulatory framework. Moving towards the internal energy market in Europe

At present the regulations regarding the functioning of the Spanish electricity system are described in the operating procedures. These are a set of rules that describe the actions required to guarantee the electricity supply under the necessary conditions of quality, reliability and security.

In the case of the international interconnections a ministerial order exists in Spain (ITC/4112/2005) that governs their management, and since this regulation came into force several operating procedures have been developed (4.0, 4.1 and 4.2).

Due to the creation process of the IEM, a new regulatory framework is being developed at a European level, which is currently in a decisive phase after the coming into force in March 2011 of what is called the Third Energy Package. The development and future implementation of this new regulation will constitute the common European framework to manage the integration of the markets.

To achieve this level of management of markets and interconnections, the newly created Agency for the Cooperation of Energy Regulators (ACER), which groups together the regulatory

commissions from the different European countries, is drafting a set of framework guidelines relative to various aspects of cross-border energy trade exchanges and markets, system operation and the connection of generators and consumers to the grid.

Subsequently, and at the request of the European Commission, ENTSO-E is the organisation that is drafting the various grid codes that will allow the framework guidelines to be developed. This entire process is counting on the participation of all interested parties (operators, market agents and diverse associations).

Once each grid code is finished, ACER will check that it is in agreement with the relevant framework guideline and, after approval by the European Commission, it will be directly applicable in all member states above that of national legislation, which must be adapted.

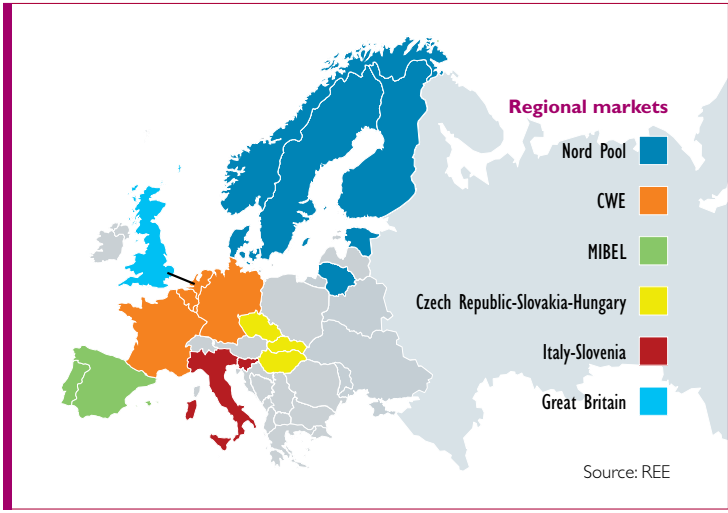
Currently all European operators are working simultaneously on the development of various grid codes and on multiple projects to implement changes with these codes accordingly. The IEM creation process, which is being closely monitored within the scope of the Florence Forum, has 2014 as its target date.

Regional markets, an initial drive towards integration

As a first step towards integrating the various national energy markets in a single European market, different regional markets in Europe have started to be developed.

The first European regional market became operational in 1996. This is called Nord Pool and is currently formed by Sweden, Finland, Norway, Denmark, Estonia and Lithuania.

The MIBEL is the second regional market in Europe, formed by Spain and Portugal which became operational on July 1, 2007. Previously, in 1998, Spain had already created its own electricity market.



Pas de Calais converter station (France) of the France-England interconnection. / Laurent Weyl / RTE

Although the management in these two markets is carried out through a single operator, Nord Pool Spot and OMIE respectively, in other parts of Europe it is done by several operators. This is the case of the Central European region CWE (France, Germany, Holland, Belgium and Luxembourg), in which there are three operators (EPEXSPOT, APX-ENDEX and BELPEX), and also the case of the coupling of markets between Italy and Slovenia, as well as between the Czech Republic, Slovakia and Hungary.

In the coming years the various European regional markets are going to be coupled in parallel with regulatory developments. At the end of 2012 this will be done by the day-ahead markets of Central Europe, Scandinavian countries and the United Kingdom, and later, in 2013, MIBEL will join this great block.

To guarantee the adequate coupling of the different European regional markets it is necessary to count on the compatibility of hours and products, and a certain degree of harmonisation of the operating rules of the markets and of the security criteria of the different systems involved in order to prevent incidents, that may occur in a given country, from spreading to the rest of the European system.

Renewable energies, one of the areas that most benefit from international interconnections

In recent years Europe has been backing the development of renewable energy so that it may be an important part of the energy mix of each country.

As proof of this commitment, the European Union has set an objective (known as 20/20/20) regarding energy matters for the year 2020 which is to reduce CO_2 emissions by 20%, improve energy efficiency by 20% and increase generation from renewable sources by 20%.

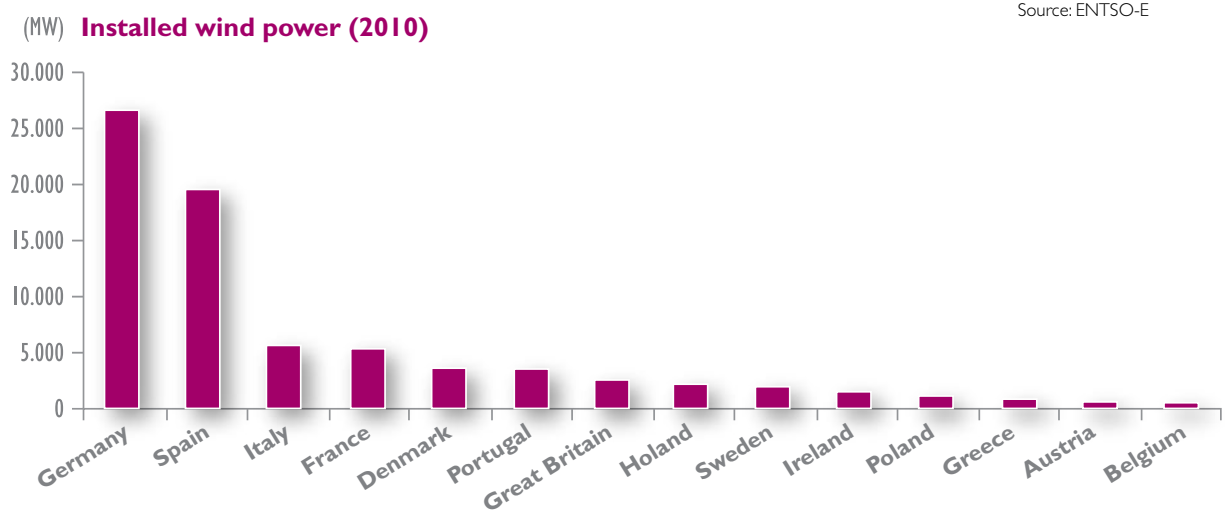
To achieve these goals it is necessary to adequately manage and integrate these energies into the system. The management of renewables, especially wind and solar, is complex given that the generation of these technologies does not necessarily occur when the system demand requires it, as is the case of conventional energy that is manageable.

In order to compensate for the variability of these energies, and not to endanger the security of supply and maintain the balance of an electricity system, the system operator counts on manageable generation and international interconnections. As the interconnection capacity increases, the total volume of wind power production that the system is able to integrate safely is also maximised, because energy obtained from this source and for which, at times, there may not be sufficient capacity in the system itself for it to be absorbed, can be sent to neighbouring systems, rather than being wasted. At the same time, when faced with a lack of renewable production or grid problems, a high degree of exchange capacity allows energy to be received from other countries.

In order to integrate larger amounts of renewable production, Red Eléctrica along with their counterparts in France and Portugal is developing mechanisms that allow the use of the exchange capacity that is freed up after its commercial use, facilitating a better generation forecast of these energies closer to real time, and therefore more accurate. These developments are taking place in parallel with the European grid codes.

Finally, only with the backing of a solid grid, sufficiently meshed, correctly interconnected and with the adequate management mechanisms with other systems will it be possible to continue integrating renewable generation into the Spanish system and by extension into that of Europe in an efficient and safe manner.

Source: ENTSO-E



Unique interconnections

Spanish interconnections

- Spain-Morocco: only fully operational interconnection between Europe and North Africa.
- Spain-France: the future interconnection between Santa Llogaia and Baixas, that will be commissioned in 2014, will be a direct current interconnection with the highest capacity in Europe (2x1,000 MW) and the longest underground link (64.5 km).

European interconnections

- Albertirsa (Hungary)-Zakhidnoukranska (Ukraine): the European interconnection with the highest voltage (750 kV) and longest length (477 km).
- Redipuglia (Italy)-Divaca (Slovenia): 400 kV interconnection with the highest capacity (1,840 MVA).
- Varna (Bulgaria)-Isaccea (Romania): 400 kV interconnection of the longest length (235 km).
- Rüthi (Switzerland)-Meiningen (Austria): 220 kV interconnection with the highest capacity (945 MVA).
- Ivalo (Finland)-Varangerbotn (Norway): 220 kV interconnection of the longest length (228 km).
- Norned. Feda (Norway)-Eemshaven (Holland): world's longest submarine interconnection (580 km).

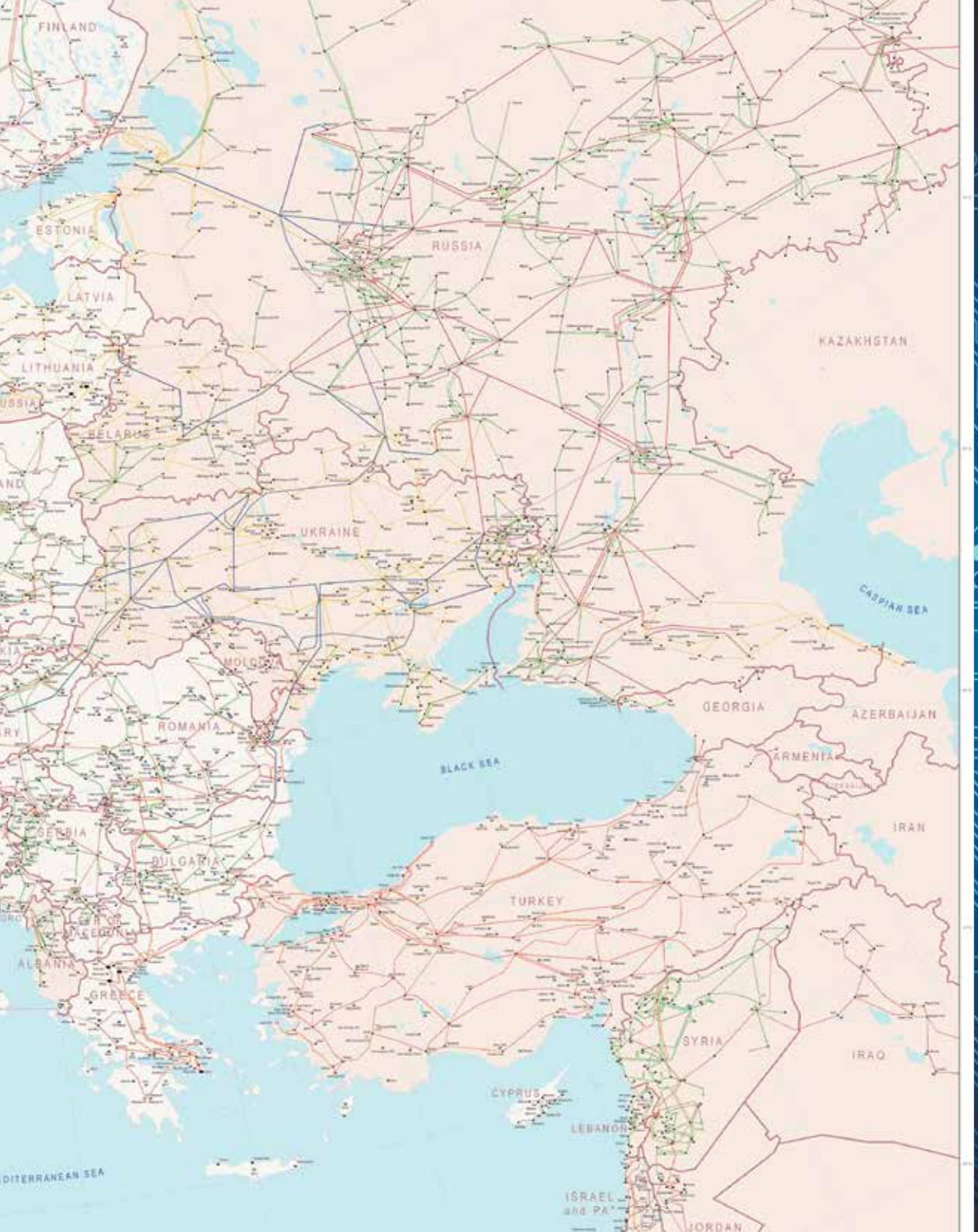
Interconnections with islands

- SAPEI. Sardinia-Italian peninsula: deepest direct current submarine interconnection (1,600 m). The second is the Rómulo project that connects the Iberian Peninsula with the Balearic Islands.
- BorWin: first interconnection project involving an offshore wind farm, in the North Sea.
- Ygne (Gotland, Sweden)-Västervik (Swedish peninsula): first direct current interconnection in Europe (1954).

European Electricity System (2011)

NORWAY
SWEDEN
BALTIC SEA
NORTH SEA
REPUBLIC OF IRELAND
UNITED KINGDOM
ATLANTIC OCEAN
ITALY
ADRIATIC SEA
SPAIN
PORTUGAL
MALTA

Source: ENTSO-E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Department of Comunication and Corporate Responsability • Press Office

September 2012

English translation by Wayman English International • www.waymanenglish.com
This English version is a translation of the original in Spanish.
In the event of discrepancy, the Spanish-language version shall prevail.