inelfe

Energie pour le futur
Energia per al futur
Energía para el futuro

Electrical interconnection through the Catalan Pyrenees

View of the Canigou mount in the French Pyrenees (Roussillon).

Index

1 The electrical interconnection through the Catalan Pyrenees, an essential infrastructure

Inelfe is a company created to build and commission a new interconnection between Spain and France, in order to increase the electrical energy exchange capacity between the Iberian Peninsula and the rest of Europe. The company was born as a result of an agreement signed in Zaragoza on 27 June 2008 between the Spanish and French governments to promote electrical interconnection and increase the energy exchange capacity.

The Iberian Peninsula currently has one of the lowest interconnection ratios in the European Union, meaning that it can import or export only a very small proportion of energy, thereby limiting the possibilities of helping or of receiving assistance in the event that there is a failure in any of the electrical systems.

This new interconnection line will allow doubling the level of interconnection between France and Spain from its current 3% to 6%, which would still be below the 10% minimum recommended by the European Union.

The new 64.5-kilometre line will connect the municipalities of Santa Llogaia (near Figueres, in Spain) and Baixàs (near Perpignan, in France). Following the recommendations of the project's mediator, Mario Monti, **the entire layout will be underground and, to the extent possible, will follow the existing infrastructure**, as is the case with the freeway AP-7 and the high-speed train linking Figueres and Perpignan. The 8.5 kilometre section which crosses the Pyrenees will go through a tunnel, while the rest of the line will be installed in a trench.

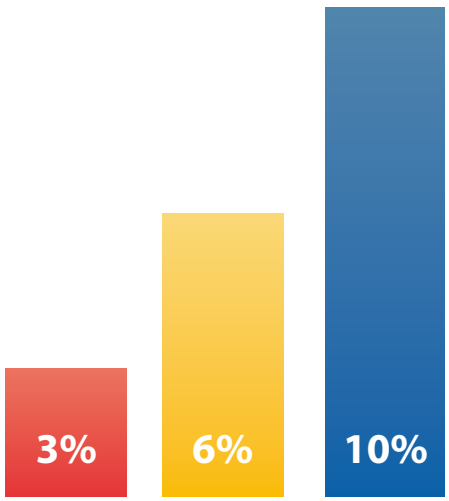
Due to its length and special characteristics, the connection will use direct current instead of the alternating current that other Spanish and French electrical grids use. For this reason the project also includes the construction of individual converter stations in Santa Llogaia and Baixàs. These stations will be responsible for transforming the direct current into alternating and vice versa. These converter stations will use VSC (voltage source converter) technology, an innovation which will facilitate the inversion of the current.

The interconnection's commissioning is projected for 2014.

The interconnection, which has a budget of 700 million euros, has been declared project of European interest and is being financed up to 225 million euros from the European Union within the framework of the EEPR (European Energy Program for Recovery) programs.

Inelfe has signed an agreement with European Investment Bank (EIB) to receive a loan of 350 million euros to be used in this project.

France-Spain interconnection capacity *



* Maximum technical import/export capacity between the Spanish and French power systems, measured in relation to the maximum demand recorded in mainland Spain.

Objectives

What is an interconnection?

Interconnections between national electrical grids have historically been developed along with each country's internal networks. Interconnections initially sought outside support in the event that there was any failure which affected the security of the national electrical supply.

However, it has been demonstrated that interconnections are not only useful for exceptional situations, but also offers outstanding advantages under normal operating conditions, such as:

- Optimising the electrical power stations' daily production.
- Increasing opportunities for operation with renewable energies.
- The creation of competition.
- Improvement of supply conditions.

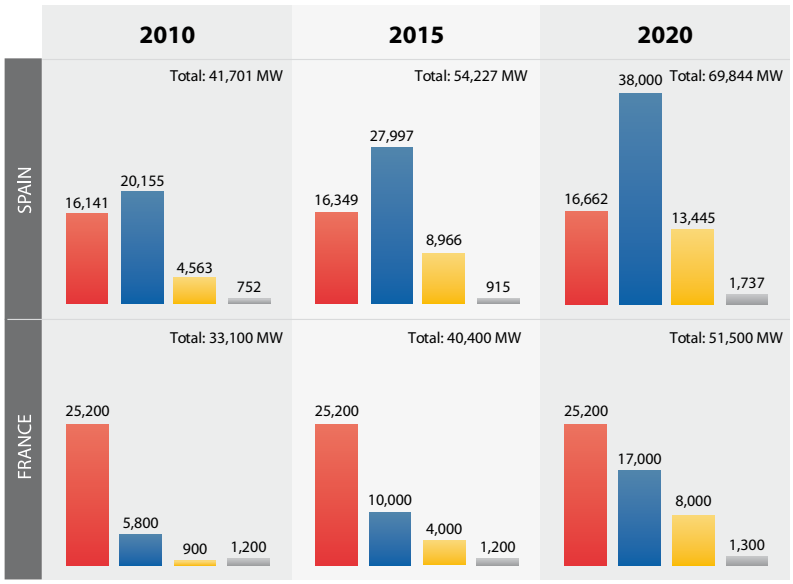
The importance of these interconnections explains why companies managing European networks are currently working on about fifty projects to enhance those already existing, in accordance with directives from the European Union.

The Spain-France interconnection

Electrical interconnection between Spain and France currently consists of four lines, the last of which was built in 1982: Arkale-Argia, Hernani-Argia, Biescas-Pragnères y Vic-Baixàs. These have a total commercial exchange capacity of 1,400 megawatts, meaning that they represent only 3% of the current maximum demand in the Peninsula.

The new ±320 kV line will allow doubling the current interconnection capacity, which will result in increased security of supply and, above all, greater stability of the grid by increasing its connection with the European system.

Installed power from renewable energies (MW)



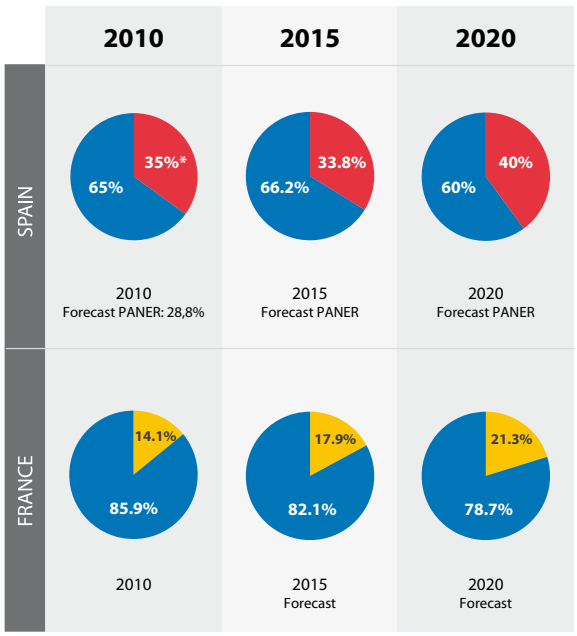
- Hydroelectric energy*
- Wind energy
- Solar energy
- Others

* In Spain, hydroelectric production data do not account for pumping.

Spain: Data from the Action Plan for Renewable Energies 2011-2020.

France: Data from the Report on Forecasts about the Power Offer/Demand Balance in France (2011).

Percentage of power consumption from renewable sources



- From renewable sources in Spain
- From renewable sources in France
- From non-renewable sources

* The PANER estimated a share of 28.8% of consumption from renewable energy sources in 2010, but due to favorable wind and water circumstances, power generation increased to 35%.

Spain: Action Plan for Renewable Energies (PANER) 2011-2020 and Report on the Power System 2010.

France: Report on Forecasts about the Power Offer/ Demand Balance in France (2011).

1. Renewable energy

In recent years both Spain and France have committed themselves to the development of renewable energy thus contributing to the European Union's 2020 objective in matters of energy: a 20% reduction in CO_2 emissions, a 20% improvement in energy efficiency and having a 20% of energy consumption come from renewable sources.

Increasing the production of renewable energy, whose generation is quite variable and dispersed geographically, demands a greater level of interconnection to provide more flexibility to the system. To the extent that the exchange capacity is increased, the total volume of renewable production which the system is able to integrate in secure conditions is also increased.

Presently, the limited level of interconnection also means the development of wind energy is limited.

Only with the support of a sufficiently-meshed solid network will be possible to continue incorporating renewable, cheaper energy without CO_2 emissions.

2. Security of supply

International interconnection is extremely important in order to assure the security of electrical supply in countries, since it allows exporting energy during periods of high production with low demand (for example, at night) and vice versa. It also enables importing electricity when there are sudden peak in demand or when a failure occurs in the electrical grid.

Increasing the interconnection capacity between France and Spain will allow providing more solidity to the European electrical network as a whole and, therefore, improving the capacity to resist possible risks and incidents.

This would mean a remarkable improvement in the quality and security of supply for both countries, most especially in the Empordà and Roussillon areas.

3. European electrical market

This new interconnection favours the exchange of energy between countries and, as a consequence, a deeper integration of the electricity markets, which will allow adjusting the electrical energy prices between the Iberian Peninsula and the rest of Europe.

In this way energy prices in Spain and France will be harmonized, while the electrical markets will become more competitive and less concentrated, which will ultimately result in a reduction in the prices for electrical energy.

4. Social and economic development

The security of electrical supply plays a key role in the social and economic development of regions. The quality of electrical supply is a critical factor for many companies that have decided to set up within the scope of the Girona and Roussillon regions.

Interconnection assures that level of quality, responding to medium-term supply needs and providing clear support for the social growth of both regions' municipalities.

In addition, this new line will guarantee feeding the future high-speed train in the Spanish part without burdening the area's stability of supply. If it were a lower voltage line, the loads required for the high-speed train would cause voltage drops and distortions in the network.

Key points

The new electrical interconnection between Spain and France is a necessary infrastructure which will allow:

- **Doubling the exchange capacity between Spain and France**
- **Making the most of electricity from renewable sources**
- **Assuring security of supply for the inhabitants of the Empordà and Roussillon**
- **Integrating the Iberian market into the European electricity market**
- **Promoting economic development in the area**
- **A feed for the high-speed train**

2 Description of the Spain-France electrical interconnection project

Extraordinary nature of the connection

The new electrical interconnection between Spain and France is an extraordinary project because it marks the first time that a direct-current line with alternating/direct-current conversion technology uses two connections, each one having a capacity of 1,000 MW and a voltage of ±320 kV.

The project's mediator is former European commissioner Mario Monti, who determined that a new interconnection line would have to be completely underground in order to prevent visual or scenic impact. This factor has marked the design of the entire connection. Using current technology, it is not possible to build an underground AC line of this length without installing a system of compensation for power losses, so DC was chosen. At both ends of the line, converter stations will be built using VSC (voltage source converter) technology, to perform the transformation between alternating current and direct current.

At present there are very few lines which use this technology; the longest VSC connection installed is the Trans Bay project (interconnection of Pittsburgh with San Francisco, California, wich is of 400 MW and a a voltage of ±200 kV), with power and voltage well below those of the future Spain-France interconnection.

Furthermore, in accordance with Mr. Monti's recommendations, the layout will follow the existing infrastructure (such as highways and railroad lines) to the extent possible. **The line will have an overall length of 64.5 kilometres (31 kilometres in Spain and 33.5 kilometres in France) which for the most part will be in underground trenches**. However, an 8.5-kilometre tunnel which will parallel the high-speed train will be built to cross the Albera massif.

Technical characteristics

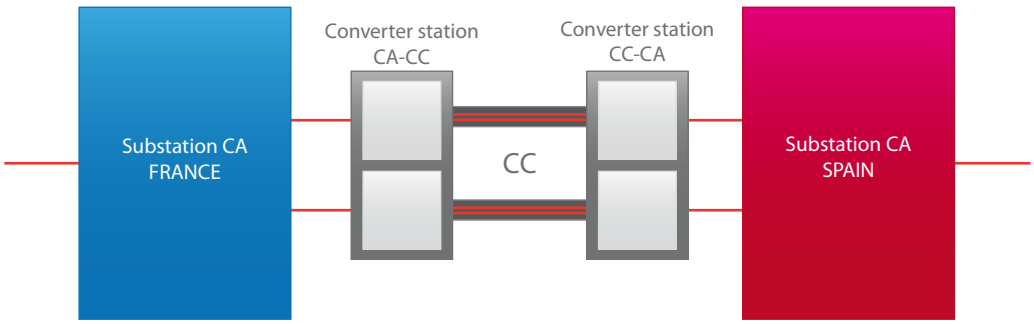
1. Direct current

Due to its length and excavation, the electrical interconnection between France and Spain can only be made in direct current. Direct-current connections have some advantages, such as less loss of energy, which allows reducing the number of cables necessary.

In this way the total construction width will be around 3 metres, as opposed to the 7 metres that would have been necessary for an underground alternating-current interconnection.

2. Transformer stations

The connection will interconnect two alternating-current grids through one direct-current line. Thus the project requires construction of a transformer station at each of its ends, meaning in Santa Llogaia (near Figueres, Spain) and Baixàs (near Perpignan, France). These transformer stations will be responsible for converting the direct current into alternating current and the other way round. To do so they will use VSC (voltage source converter) technology, which streamlines inversion in the direction of the current and the recovery of operations after a cut in supply.



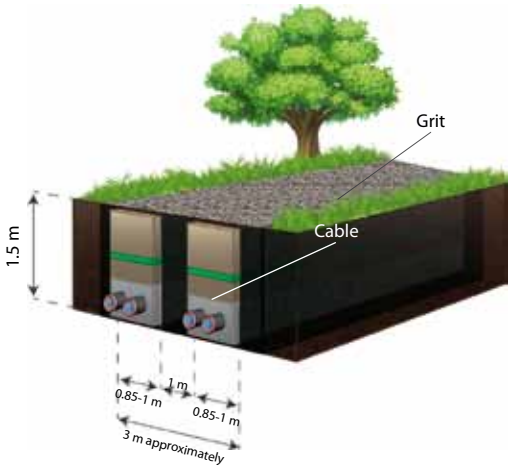
CC: Direct current
CA: Alternating current

3. Trench

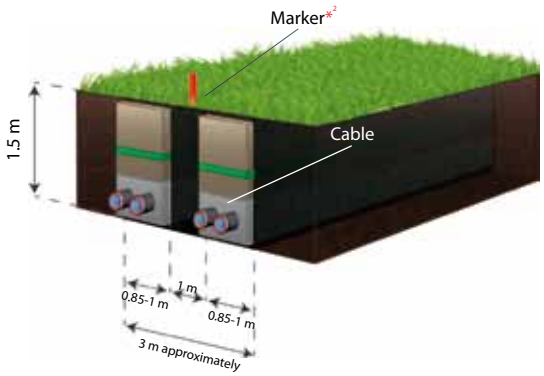
Most of the cable layout will be installed in a concrete trench with dimensions of approximately 1 metres wide by 1.5 metres high. This solution provides greater security for cables and frees the civil works from those for layout, which results in a lesser impact on the panorama.

Each of the two connections which the underground line has will be placed in an independent trench. Thus the cables will be separated by a sufficient distance of around one metre, which allows reducing any thermal influence between them. The total width of the building will be about three meters.

Spanish trench



French trench*[1]



The Spanish trench will be built under already-existing roads that will be rehabilitated after the work. Their width will be about 4 metres.

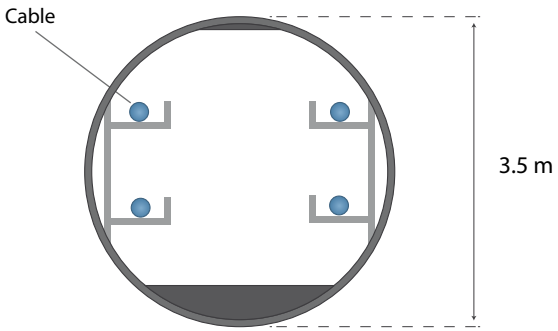
*[1] A 7-metre-wide area of ground in which it is not permitted to plant vegetation with long roots, in order to allow technical intervention if considered necessary.

*[2] Above the French trench, markers will be placed to identify the location of the power line.

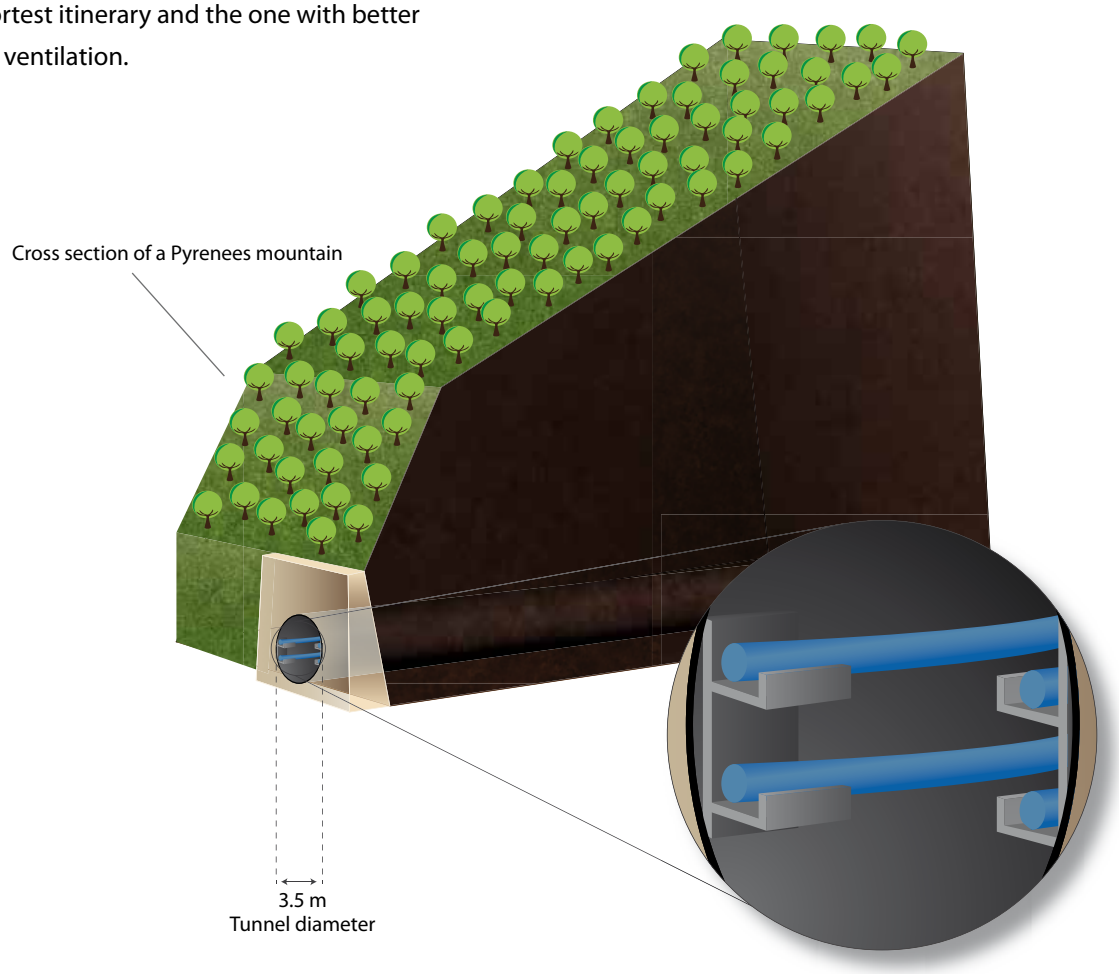
4. Tunnel

In order to cross the Pyrenees, an 8.5-kilometre long tunnel will be built with a diameter of 3.5 metres, which will be used exclusively for the connection's cables, since the facility will not be used for any other service. In addition, once the interconnection is in operation, the tunnel will be closed to pedestrian traffic; all maintenance will be done mechanically.

Tunnel section



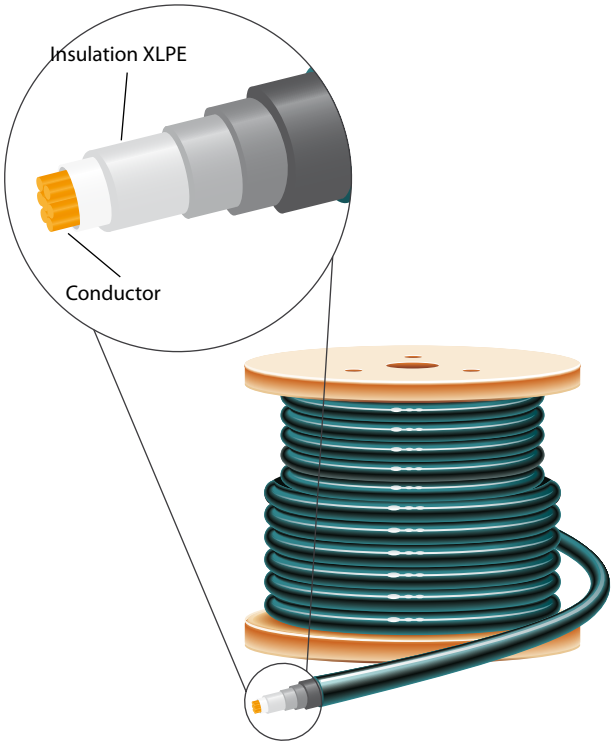
The tunnel layout will be parallel to the gallery built for the high speed train tracks. Its orientation will be north-south, because it is the shortest itinerary and the one with better natural ventilation.



5. Cables

The choice of conversion technology, as well as the power and voltage levels, conditions the characteristics of the cable. The technology chosen allows using cable with dry insulation (XLPE: cross-linked polyethylene) wich, since it does not require oil, orevents the risk of incidents such as spills, fire, etc.

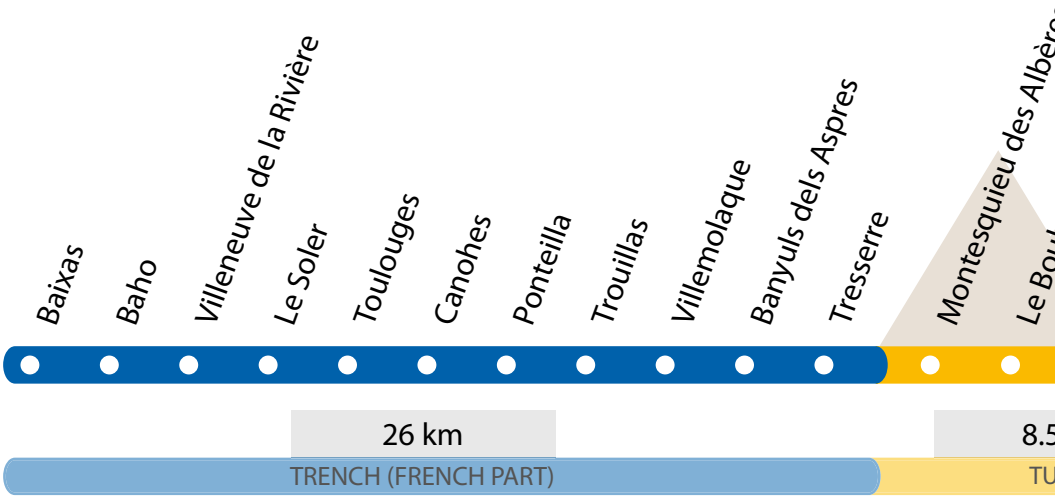
The interconnection consists of four cables, two for each one of the two connections. The cables will be transported by road, in coils of 85 tonnes each, which means it will be necessary to make 144 junctions throughout the entire layout, 12 of them within the tunnel.



General features of the Spain - France interconnection project

1	Current system	Direct current
2	Technology	VSC (voltage source converter)
3	Rated voltage	±320 kV
4	Transport capacity	2,000 MW (2x1,000 MW)
5	Number of circuits	2 independent systems
6	Number of electric cables	4 cables (2 per connection)
7	Number of fibre-optic cables	2 of 48 fibres
8	Estimated total length in Spain	31 km
9	Estimated total length in France	33.5 km
10	Total tunnel length	8.5 km
11	Cable technology	XLPE (cross-linked polyethylene)

The route



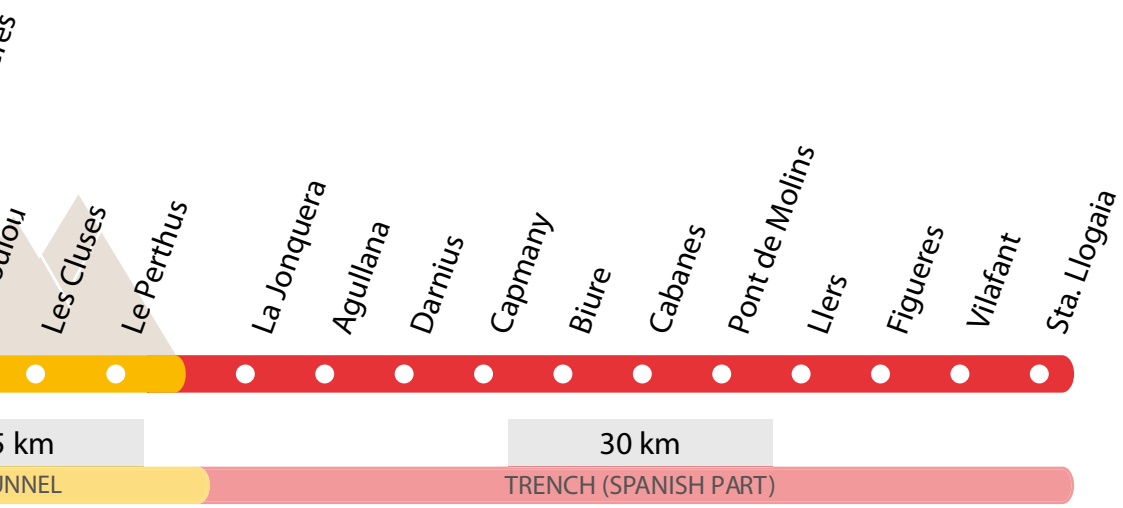
Total length of the int

The new electrical interconnection line between Spain and France has a length of 64.5 kilometres, 33.5 in France and 31 in Spain. It connects the towns of Baixàs, in the Rousillon region (France), and Santa Llogaia, in Alt Empordà (Spain).

The central part of the line will cross the Pyrenees at the Albera massif. An 8.5 kilometre tunnel will be built for this section, 1 kilometre in Spain and 7.5 kilometres in France. The rest of the line will be in underground trenches.

France. The layout proposed in the French section is the result of 15 months of consultations with the territory's stakeholders and associations. The line passes through the

View of Baixas (Roussillon), where the converter station of the French part of the link will be installed.



terconnection: 64.5 km

towns of Baixàs, Baho, Villeneuve-la-Rivière, Le Soler, Toulouges, Canohès, Ponteilla, Trouillas, Villemolaque, Banyuls dels Aspres and Tresserre. For most of its route it follows the layout of the high-speed train, until the tunnel entrance in Montesquieu des Albères. Then the tunnel passes beneath the municipalities of Le Boulou, Les Cluses and Le Perthus.

Spain. The Spanish section of the line will cross the Empordà along the municipal limits of Santa Llogaia, Vilafant, Figueres, Llers, Pont de Molins, Cabanes, Biure, Capmany, Darnius, Agullana and La Jonquera. The longest section of the layout runs parallel to freeway AP-7 and the high-speed train.

View of Santa Llogaia (Girona), where the converter station of the Spanish part of the link will be installed.

3 Environment

The projected electrical interconnection between Spain and France requires adopting a series of preventive and corrective measures in order to minimise as much as possible the impacts on its natural and social surroundings throughout its layout. Building the line will also mean forestalling the issuance of 2.3 million tonnes of CO_2 per year thanks to the greater incorporation of renewable energy into the grid.

One of the principal criteria followed in defining the interconnection's layout was to move the line's excavation as far as possible from the urban centers and areas of greater population density, as well as from natural spaces and enclaves of interest and woodlands. To the extent possible, the new interconnection takes advantage of the already existing layout of major infrastructure (freeway AP-7 and the high-speed train).

In order to reduce the line's visual and environmental impact as much as possible, a series of perforations have been programmed which are directed towards obviating major obstacles. Thus the line will pass under highways and railroads in those areas where both layouts are crossed. This same system of building micro-tunnels will be used to cross rivers, thereby preventing any impact on the flow or level of waters.

Inelfe is committed to using existing roads for constructing the line, and recovering them when the works have concluded.

Spain. In order to verify compliance with the measures set forth in the Environmental Impact Study, an Environmental Monitoring Program has been designed, including a follow-up committee created with the Autonomous Government of Catalonia's Environmental Department and Energy, Mines and Industrial Safety Bureau. In addition to verifying the measures adopted, the program will also check on the restoration of the areas affected and the cleanup after works.

France. Environmental measures planned in France are mainly related to the conservation of existing water courses, landscape integration and restoration of land after the work. These actions were agreed with the mayors, associations and public utilities and are supervised several times a year by a monitoring committee.

View of the Boadella swamp, on the Spanish side of the Pyrenees (Girona).

What is Inelfe?

Inelfe (France-Spain Electrical Interconnection) is a mixed-capital corporation, legally established on 1 October 2008, jointly-owned in equal shares by Spain's and France's electrical transport network management companies, REE (Red Eléctrica de España) and RTE (Réseau de Transport d'Électricité).

Its corporate purpose is to make the projected new electrical interconnection between both countries a reality. The connection will become operational in 2014, thereby assuring an increase in the electrical grid's security and the quality of supply for both countries.

Inelfe is a corporation with a simplified share structure; it is governed by French law.

inelfe

Energie pour le futur
Energia per al futur
Energía para el futuro

inelfe | Energie pour le futur
Energia per al futur
Energía para el futuro

Tour Ampere - 34 rue Henri Régnault (92068) Paris - La Defense Cédex
Tel. +33 (1) 44 45 37 20
Fax. +33 (1) 44 45 35 32
www.inelfe.eu
contact@inelfe.eu

Co-financed by the European Union
European Energy Programme for Recovery

September 2011