The electrical interconnection between the Iberian Peninsula and the Balearic Islands is fundamental to ensure and improve reliability of the electricity supply and to promote competition in electricity generation.

Red Eléctrica de España is the company responsible for implementing this submarine electrical interconnection which is due to be commissioned at the first half of 2011, along with the converter stations of Morvedre (400 kV) in Sagunto (Valencia), and Santa Ponsa (220 kV) in Calvià (Majorca). This is the first submarine high-voltage direct current (HVDC) link in Spain, and it ranks second in the world in terms of maximum depth at which the cables are laid (1,485 metres). This depth is currently only exceeded by the link between Sardinia and mainland Italy, where the maximum depth is 1,600 metres.

Amongst the advantages of this interconnection with mainland Spain will be the increase in both the quality and reliability of the electricity supply in the Balearic system, as demand on the islands increases. Furthermore, by integrating the Balearic system with the mainland grid it can be linked to the «Iberian electricity market». This is currently impossible due to the singular nature of the grids of the Balearic Islands, which do not allow a competitive generation market to be established on the islands.
The electrical interconnection is complementary to the construction of generation plants on the islands, and unlike other alternatives has a far more favourable impact on the Balearic environment. From an economic standpoint, the commissioning of this infrastructure implies a cost saving for the national power grid.

All the required infrastructure for this interconnection is set forth in the 2008-2016 electricity and gas transmission plans (Planificación de los sectores de electricidad y gas 2008-2016. Desarrollo de las redes de transporte), approved in May 2008, which includes the interconnection between the Peninsula and Balearic Islands. These planning reports are aimed at meeting the projected demand and minimum developmental requirements for interconnections and infrastructure, so as to guarantee the supply for the projected increase in demand, in line with adequate safety and quality standards, for the next decade.

Over the past ten years electricity demand in the Balearics has increased by a yearly average of 4 %, well above the national average, and has accumulated a 70 % increase in the same period. This increase is linked to the country’s economic progress. In the Balearic Islands this progress has been even more considerable as the service sector has been geared towards more value-added products, which imply greater electricity consumption with significant scope for future development.

### Actual demand in the Balearic power grid (2003-2010)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total (MWh)</th>
<th>Hourly max. (MWh)</th>
<th>Annual increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>5,191,562</td>
<td>1,073</td>
<td>10.49</td>
</tr>
<tr>
<td>2004</td>
<td>5,437,317</td>
<td>1,085</td>
<td>4.73</td>
</tr>
<tr>
<td>2005</td>
<td>5,709,845</td>
<td>1,095</td>
<td>5.01</td>
</tr>
<tr>
<td>2006</td>
<td>5,828,529</td>
<td>1,201</td>
<td>2.08</td>
</tr>
<tr>
<td>2007</td>
<td>5,963,142</td>
<td>1,145</td>
<td>2.30</td>
</tr>
<tr>
<td>2008</td>
<td>6,091,947</td>
<td>1,225</td>
<td>2.17</td>
</tr>
<tr>
<td>2009</td>
<td>6,028,152</td>
<td>1,207</td>
<td>-1.50</td>
</tr>
<tr>
<td>2010</td>
<td>5,887,000</td>
<td>1,157</td>
<td>-1.70</td>
</tr>
</tbody>
</table>
Rómulo Project

The Balearic Islands' power grid currently consists of two independent sub-systems: Majorca-Menorca and Ibiza-Formentera, which are not connected to the Spanish mainland grid. At the end of 2004, Red Eléctrica began analysing and defining the new interconnection, via detailed technological, electrical, environmental and economic studies, in order to meet the ever-increasing demand on the islands and enhance the quality and reliability of supply. The chosen technical solution consists of unifying the Balearic power grid by linking the two existing sub-systems, and then linking the Balearic grid to the mainland grid.

The Rómulo Project «The Peninsula-Balearic islands electricity interconnection» represents the largest investment ever made by Red Eléctrica in any one single project.

In May 2007, Red Eléctrica awarded the contracts for construction of the undersea electrical interconnection between mainland Spain and the Balearic Islands to the German company Siemens, which will be in charge of constructing the converter station at Sagunto (Valencia) and Calviá (Majorca), and to the consortium comprising of the Italian company Prysmian and the Norwegian company Nexans, which will be in charge of designing, manufacturing and laying the submarine power cables. Red Eléctrica managed to harness the production capacity of two of the companies with the most expertise in this highly specialised field, thus reducing the project's overall execution time.

The total amount awarded in these two contracts was 375 million euros and, due to the specialised nature of the work involved, it has been divided into two major areas.

The unification of the Balearic system and its link to the mainland grid, scheduled for the first half of 2011, paves the way for optimising the introduction of new generation facilities on the islands. It will also provide a more reliable and secure supply to the entire Balearic system.

Red Eléctrica de España was the Spanish company responsible for the Remo Project (Western Mediterranean power reinforcement - Refuerzo Eléctrico Mediterráneo Occidental), the electrical interconnection between Spain and Morocco commissioned in 2006. Now, in a tribute to the two historical figures, the submarine electrical interconnection between mainland Spain and the Balearics has been named the Rómulo Project.
**Iberian Peninsular-Majorca link**

The Morvedre substation (400 kV) was chosen as the link-up point with the mainland, based on several criteria: the shortest distance, the relatively shallow depth of the sea and other characteristics of the undersea route. On the Majorcan side, the link-up point is with the Santa Ponsa substation (220 kV).

It is a high-voltage submarine electrical connection, at ±250 kV, using a 400 MW bipolar connection which uses High Voltage Direct Current (HVDC) technology, given the distances covered and capacities required. The undersea cables are approximately 237 km long, and run at a maximum depth of 1,485 metres.

The bipolar or dual links are considered to be essential to attain adequate levels of reliability and security of supply and to enable it to function correctly, in the event of any of its elements being reviewed or maintained. Since it is the only link to the mainland, one of the most important factors to be taken into account is a high level of availability.

The project also includes the construction of two converter stations, one at either end, to ensure that the two power grids are fully joined and operational. The unique nature of this project makes it necessary to construct converter stations to transform the alternating current running through the transmission grid into direct current, so that current flows under optimum conditions so as to reduce transmission power losses resulting from the considerable length of the cable. Furthermore, land sections of underground cables just over 3 km in length will be built at each end, to connect to the converter stations.

**Environmental actions**

In designing this project, Red Eléctrica has implemented a comprehensive set of preventive and corrective measures aimed at minimising any effect on the natural and social environment in which the new facilities will be located.

Prior to choosing the final route, a number of alternatives were assessed, between various grid hubs on the peninsula’s Mediterranean coast and Balearic Islands’ grid. For each alternative, account was taken of the constraints deriving from the environmental conditions of the territory, including protected areas, in order to identify and classify the possible interconnection solutions.
Firstly, the substations of La Eliana, Benejama and La Plana were ruled out, due to the major environmental impact of the land sections. In a second phase, other possible solutions in Sagunto, Torreblanca and Vandellós were considered. The latter two were ruled out because of the existence of areas protected by the «Natura 2000» network, and the presence of sections of the seabed which were deemed unstable.

Finally, it was decided that the most feasible solution, causing the least environmental impact, was the interconnection between the Morvedre and Santa Ponsa substations.

The proposed route for the undersea cables was designed based on a detailed study of the seabed, measuring the bathymetry and physical characteristics of the subsoil along a 2 km-wide corridor covering the entire route.

In its underground and coastal sections, the chosen route avoids archaeological remains, fish farms and seagrass meadows in the Sagunto area. The preventive environmental measures minimise the effect on the tourist and fishing sectors, on cetaceans and on the Mediterranean fan mussel (which inhabits posidonia seagrass meadows) in the undersea section, and Greek tortoises in the land section of Santa Ponsa.

One of the most environmentally valuable items analysed is the Posidonia seagrass meadows, a Mediterranean species which is protected at European level. By implementing preventive, corrective and compensatory measures, the impact on this seagrass which grows in the Santa Ponsa cove has been minimised.

Manufacturing and method of laying submarine cables

The companies in charge of designing and laying the cables, namely the Norwegian company Nexans and the Italian company Prysmian, each manufactures one of the submarine HVDC cables (237 km) and half of the return undersea cable (118.5 km), making a total of 711 km of cable. Once the cables are manufactured and factory-tested, they are moved to large rotating platforms at the companies' facilities and are subsequently loaded directly onto the only two vessels in the world capable of undertaking this kind of cable-laying project, the *Skagerrak* and the *Giulio Verne*. 
These vessels are equipped with dynamic global positioning systems (DGPS) to accurately follow the planned routes and to remain steady when sea conditions force the work to be suspended for a few hours. The vessels are able to control and adjust their positions to a high degree of precision, using DGPS which sets their coordinates at any given time and automatically controls their position using 5 adjustable propulsion units.

The ship is positioned 500 metres from the coast, and from there it travels along the entire pre-established route, laying the cable on the seabed. When it reaches the opposite coast, it stops, and releases the remaining cable which, using floatation devices, auxiliary vessels and divers, is placed along the seabed up to the shore. The undersea cables are protected beneath the seabed inside a 1 metre-wide trench at depths of less than 800 metres.

Each ship has the capacity to transport 7,000 tonnes of cable, which is vital for laying each of these power lines, whose total weight is an estimated 6,700 tonnes. Accordingly, each submarine cable is laid in a single section, and it is therefore not necessary to join up different segments.

The *Giulio Verne*, which belongs to Prysmian and the *Skagerrak*, which belongs to Nexans, each lay one of the HVDC cables. Once the direct current undersea cables have been laid, the fibre-optic cable necessary to guarantee communications between both ends of the link is laid.

The process of laying the cables is closely monitored so as to ensure that the cable is correctly placed on the seabed, using a remote control vehicle (RCV) for small adjustments in the route and to negotiate irregularities in the seabed.


**General project planning**

**Project history**

- **July 2005-March 2006**
  Summary report to the Environment Ministry.

- **July 2005-October 2007**
  Environmental impact study and execution plans.

- **February 2008-July 2009**
  Processing environmental impact study and execution plans.

**Engineering and construction of the interconnection**

- **November 2004-April 2006**
  Feasibility studies.

- **April 2005- April 2006**
  Study of the seabed along the route.

- **May 2007**
  Contracts awarded.

- **June 2007-May 2008**
  Detailed engineering plans.

- **2008-2010**
  Manufacturing of cables and equipment.

- **April 2009-December 2010**
  Construction of converter stations.

- **2010-2011**
  Laying of cables and assembly.

- **2011**
  Testing and commissioning.
General characteristics of the mainland Spain-Majorca project

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>System</strong></td>
<td>Direct current system</td>
</tr>
<tr>
<td><strong>Nominal voltage</strong></td>
<td>±250 kV</td>
</tr>
<tr>
<td><strong>Thermal transmission capacity</strong></td>
<td>400 MW (2 x 200 MW)</td>
</tr>
<tr>
<td><strong>Number of circuits</strong></td>
<td>Bipolar link with metallic return cable</td>
</tr>
<tr>
<td><strong>Number of power cables</strong></td>
<td>2 power cables, one return cable</td>
</tr>
<tr>
<td><strong>Number of fibre-optic cables</strong></td>
<td>1 with 24 fibres</td>
</tr>
<tr>
<td><strong>Total estimated length</strong></td>
<td>244 km</td>
</tr>
<tr>
<td>Morvedre underground section</td>
<td>4 km</td>
</tr>
<tr>
<td>Undersea section</td>
<td>237 km</td>
</tr>
<tr>
<td>Santa Ponsa underground section</td>
<td>3 km</td>
</tr>
</tbody>
</table>

The Skagerrak, Norwegian vessel belonging to Nexans designed specially for undersea cable-laying.

Floating devices and motor boats are used to keep the cable end afloat and direct it towards the coast in order to link up to the underground cable.