The Electric Power System

- Spain -
Basic facts

- Area: 505 957 km²
- Number of TSOs: 1
- Number of DSOs: 336
  (source: MINETUR)
- 28 Mio. consumers
  (source: CNMC)
  (source: REE)
- Average interruption of electricity: 5.3 min (2014)
  (source: REE)
Spain in the European meshed grid

Interconnectors with:
- France
- Portugal
- Morocco
- Andorra

Source: ENTSO-E

Spanish Power System
Grid facts and characteristics

- Mainly 400 and 220 kV assets.
- Highly meshed transmission grid. High Psc.
- Limited exchange capability with other systems.
- Diversification of power generation technologies.
- Important contribution of renewable technologies.
Structure of electrical power system

Generators

International Exchanges · REE

Transmission network · REE

System Operator · REE

Outages

Ancillary services bids

TSO (foreign)

Market Operator · OMIE

Demand bids

Demand offers

Daily and Intradaily Market

Qualified consumers

Ancillary Services

Distribution companies

Suppliers

Last resort suppliers

Consumers with/without last resort tariff

Energy flows

Communication

Red de distribución < 132 kV

Subestación de distribución

Source: REE

Spanish Power System
Structure of electrical power supply. Interface T-D [MVA transformation]

TSO

Bulk-Industry & Singular Consumers (High-Speed Train)

400 kV

220 - 400 kV

TSO-Grid

≤ 132 kV

220 kV

Conventional and Renewable Generation

220/110 kV

≤U≥45 kV

110-U≥45 kV

20/10 kV

DSO-Grid

220/110-U≥45 kV

220/45-U>20 kV

220/U≤20 kV

120

24.79

9.290

220-380 V

Industry

Dispersed Generation

Spanish Power System
Map of the high voltage grid

Source: REE
Information on TSO

- Name: REE
- Network length (km) : 39 905
- Served area (km²) : 505 957
- Annual energy consumption (TWh) : 243,5

(source: REE)

- Website: [http://www.ree.es](http://www.ree.es)
## Information on TSO

<table>
<thead>
<tr>
<th>Description</th>
<th>1985</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tbody>
<tr>
<td><strong>km of 400 kV circuit</strong></td>
<td></td>
<td></td>
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<tr>
<td>Red Eléctrica</td>
<td>9,860</td>
<td>18,792</td>
<td>19,671</td>
<td>20,109</td>
<td>20,639</td>
<td>21,094</td>
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<tr>
<td>Other companies</td>
<td>899</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Total</td>
<td>10,759</td>
<td>18,792</td>
<td>19,671</td>
<td>20,109</td>
<td>20,639</td>
<td>21,094</td>
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<td><strong>km of &lt; 220 kV circuit</strong></td>
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<td>Red Eléctica</td>
<td>4,069</td>
<td>17,291</td>
<td>17,891</td>
<td>18,260</td>
<td>18,558</td>
<td>18,702</td>
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<td>109</td>
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<td>109</td>
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<tr>
<td>Total</td>
<td>14,327</td>
<td>17,401</td>
<td>18,001</td>
<td>18,370</td>
<td>18,667</td>
<td>18,811</td>
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<td><strong>Total km of the transmission grid</strong></td>
<td></td>
<td></td>
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<td>Red Eléctica</td>
<td>13,929</td>
<td>36,084</td>
<td>37,563</td>
<td>38,369</td>
<td>39,197</td>
<td>39,795</td>
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<td>109</td>
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<tr>
<td>Total</td>
<td>25,086</td>
<td>36,193</td>
<td>37,672</td>
<td>38,478</td>
<td>39,306</td>
<td>39,905</td>
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<td><strong>Busbars</strong></td>
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<tr>
<td>Red Eléctica</td>
<td>373</td>
<td>3,762</td>
<td>3,961</td>
<td>4,150</td>
<td>4,295</td>
<td>4,360</td>
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<td>Other companies</td>
<td>1,099</td>
<td>113</td>
<td>113</td>
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<tr>
<td>Total</td>
<td>1,472</td>
<td>3,875</td>
<td>4,074</td>
<td>4,263</td>
<td>4,408</td>
<td>4,473</td>
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<tr>
<td><strong>Transformer capacity (MVA)</strong></td>
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<tr>
<td>Red Eléctrica</td>
<td>2,311</td>
<td>66,596</td>
<td>68,996</td>
<td>74,596</td>
<td>76,871</td>
<td>79,871</td>
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<td>0</td>
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<td>Total</td>
<td>28,927</td>
<td>66,596</td>
<td>68,996</td>
<td>74,596</td>
<td>76,871</td>
<td>79,871</td>
</tr>
</tbody>
</table>

Source: REE

Spanish Power System
Cooperation of TSO and DSOs

Active power

- TSOs and DSOs calculate limits that apply to generators that contribute to a constraint.
- With this limits and the units involved, the TSO calculates the individual set-points according to regulation.
Cooperation of TSO and DSOs
Power factor regulation

- TSO
  - Network management
  - Generation management
- DSOs
  - Power factor set points
    - Transmission
  - Power factor set points
    - Distribution

- RESCC
  - Set points
  - Measurements

- TSO Settlement
  - Settlement

Scheme similar to active power.
Installed capacity with reference to primary resources (2014)

<table>
<thead>
<tr>
<th>Technology</th>
<th>MW</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Hydroelectric (1)</td>
<td>19,897</td>
<td>19.5</td>
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<tr>
<td>Nuclear</td>
<td>7,866</td>
<td>7.7</td>
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<tr>
<td>Coal</td>
<td>10,972</td>
<td>10.7</td>
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<tr>
<td>Fuel + gas</td>
<td>520</td>
<td>0.5</td>
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<tr>
<td>Combined cycle</td>
<td>25,348</td>
<td>24.8</td>
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<tr>
<td>Wind</td>
<td>22,845</td>
<td>22.3</td>
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<tr>
<td>Solar photovoltaic</td>
<td>4,428</td>
<td>4.3</td>
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<tr>
<td>Solar thermoelectric</td>
<td>2,300</td>
<td>2.2</td>
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<tr>
<td>Renewable thermal</td>
<td>1,012</td>
<td>1.0</td>
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<tr>
<td>Cogeneration and other non-renewable</td>
<td>7,075</td>
<td>7.0</td>
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<tr>
<td>Total</td>
<td>102,262</td>
<td></td>
</tr>
</tbody>
</table>

Source: REE
Energy production with reference to primary resources (2014)

<table>
<thead>
<tr>
<th>Technology</th>
<th>GWh</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric (1)</td>
<td>38,790</td>
<td>15.5</td>
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<tr>
<td>Nuclear</td>
<td>54,925</td>
<td>22.0</td>
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<tr>
<td>Coal</td>
<td>41,139</td>
<td>16.5</td>
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<tr>
<td>Combined cycle</td>
<td>21,328</td>
<td>8.5</td>
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<tr>
<td>Cogeneration and other non-renewable</td>
<td>25,596</td>
<td>10.2</td>
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<tr>
<td>Wind</td>
<td>50,630</td>
<td>20.3</td>
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<tr>
<td>Solar photovoltaic</td>
<td>7,794</td>
<td>3.1</td>
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<tr>
<td>Solar thermoelectric</td>
<td>4,959</td>
<td>2.0</td>
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<tr>
<td>Renewable thermal</td>
<td>4,718</td>
<td>1.9</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>249,880</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: REE
Development of generation capacity since 2005

Source: REE

Spanish Power System
Location of renewable energy sources

Wind

Photovoltaic

Thermoelectric
Development of wind power

+13191 MW
Development of photovoltaic power

+4385 MW

Spanish Power System
Development of thermoelectric power

+2300 MW


Spanish Power System
Development of mini-hydro power

Spanish Power System
Power balance in 2014

- Generation (TWh): 253.6
- Consumption (TWh): 243.5
- International Imports (TWh): 3.6
- International Exports (TWh): 7.0
Day-ahead market: MIBEL

No congestion Spain-Portugal
Market splitting

Day-ahead market: MIBEL

Market Splitting: Congestion (i.e. Spain → Portugal)