The Electric Power System

- Portugal-
Basic facts

- **Area:** 92 090 km²
- **Population:** 10 368 000 (31.12.2014) (source: INE)
- **1 TSO**
- **1 DSO (HV/MV/LV) + 2 regional DSOs (MV/LV) + 10 local DSOs (LV)**
- **Consumers:** 6 040 000 (source: ERSE)
- **Electricity demand (2014) (source: REN)**
  - Peak load: 8,3 GW
  - Consumption: 48,8 TWh
- **SAIDI (2014):** 77 min
  (unplanned interruption without exceptional contingencies at Low Voltage level) (source: EDP D)
Portugal in the European grid

- Interconnectors to:
  - Spain

- Dependence on the interconnections
  - Spain - France

Source: ENTSO-E
The electricity grid in Portugal is sub-divided into transmission grid (very high voltage) and distribution grids (high, medium and low voltage).

<table>
<thead>
<tr>
<th>Date</th>
<th>Voltage Level</th>
<th>Total length (approx.)</th>
<th>Responsability</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.12.2014</td>
<td>Transmission Grid</td>
<td>400 kV</td>
<td>2467 km</td>
</tr>
<tr>
<td></td>
<td>Transmission Grid</td>
<td>220 kV</td>
<td>3601 km[^1]</td>
</tr>
<tr>
<td></td>
<td>Transmission Grid</td>
<td>150 kV</td>
<td>2561 km</td>
</tr>
<tr>
<td></td>
<td>High Voltage</td>
<td>60 kV</td>
<td>9375 km[^2]</td>
</tr>
<tr>
<td></td>
<td>Medium Voltage</td>
<td>6 to 30 kV</td>
<td>72 315 km[^3]</td>
</tr>
<tr>
<td></td>
<td>Low Voltage</td>
<td>230 V or 400 V</td>
<td>105 000 km[^4]</td>
</tr>
</tbody>
</table>

[^1] Of which 95 km are underground cables.
[^2] Of which 530 km are underground cables and 60 km at 130 kV.
[^3] Of which 14 135 km are underground cables.
[^4] Of which approx. 30 000 km are underground cables.

Source: REN, EDP D and ERSE
Structure of the electrical power system

Portuguese Power System

Source: REN
67 Substations (VHV/VHV and VHV/HV)

14 Switching Stations (VHV)

Transformer Capacity: 35 754 MVA

*Autotransformers (VHV/VHV)*
14 040 MVA

*Transformers (VHV/HV + VHV/MV)*
21 394 MVA + 320 MVA

*Phase-shift Transformers*
1800 MVA
Information about Portuguese TSO

- **Name:** REN – Rede Elétrica Nacional, S.A
- **Served area:** 88,900 km²
- **Total network length (2014):** 8630 km
- **Annual transmitted energy (2014):** 42 TWh
- **Transmission Network Losses (2014):** 1.86%
- **Website:** [http://www.ren.pt](http://www.ren.pt)
Cooperation of TSO and DSOs

- Congestion of Transmission – Distribution interface
- Congestion of transmission and distribution lines
- Voltage support
- Load shedding
- Re-synchronization & black–start
Responsibilities of TSO & DSOs

- TSOs have overall responsibility for system security while DSOs have responsibility for the secure operation of their distribution networks and facilitators of final consumers supply.

- TSOs lead with the responsibility for balancing, frequency control and system restoration.

- DSOs are responsible for managing their networks, with an increasing emphasis on distribution congestion and voltage management.
Portuguese Power System

Power structure of Portugal

- Coal
- Natural Gas
- Hydro
- Wind
- Solar
- Biomass
- Urban Waste
Installed capacity with reference to primary resources

Source: REN
Energy production with reference to primary resources

Source: REN
Development of Generation Capacity since 2010 (share of primary sources)

Share of total installed capacity

Source: REN
Electricity consumption per customer groups (2013)

Source: DGEG
Renewables
Location of RES

Wind Farms

capacity [MW]
- [0.5 - 1.9]
- [2.0 - 9.9]
- [10.0 - 24.9]
- [25.0 - 49.9]
- ≥50

PV Farms

capacity
- [2.0 - 9.9]
- [10.0 - 24.9]
- [25.0 - 49.9]

Source: IWES

Source: e2p
Development of Wind Power

Source: e2p

Portuguese Power System
Development of PV Power

Source: REN

Portuguese Power System
RES Installed Capacity and Production since 2011

Max. Gen. Power: 8902 MW
Thermal: 292 MW
Wind: 3641 MW
Hydro: 4969 MW
PV: 0 MW
ca: 81,4% (06.02.2014; 19:00)

Min. Gen. Power: 303 MW
Thermal: 242 MW
Wind: 56 MW
Hydro: 5 MW
PV: 0 MW
ca: 2,9% (17.09.2012; 05:00)

Source: REN
Managing the power system (1/2)

29.03.2013 - Friday (Easter holiday)

Demand: 128.3 GWh

Hydro: 66 GWh (4160 MW)

Wind: 78 GWh (3780 MW)

Exports: 37 GWh (2000 MW)

Excess of RES generation
Market price along 24 hours = 0,00 €/MWh

1 coal power plant at technical minimum rated output: From 0h to 24h

Source: REN
Managing the power system (2/2)

1. Wind generation falls > 80% in 8 hours ...

2. Portuguese system goes from exporter (1 400 MW) to importer (800 MW) ...

3. ... with the support of large hydro dams

Market Prices:
0 €/MWh before 13h
33€/MWh at 23h

Portuguese Power System
Market
Price development for industry consumers

Average price of electricity for industry consumers [€/MWh]
Yearly consumption 500 – 2000 MWh

(*) UGS includes: CHP surcharge; Conventional Generation surcharge; Tariff Debt service; LV distribution concession levy; System Operator; Electricity tax; Other charges

Source: Eurostat and ERSE
Average price of electricity for households [€/MWh]
Yearly consumption about 3500 kWh

(*) UGS includes: CHP surcharge; RES surcharge; Conventional Generation surcharge; Tariff Debt service; LV distribution concession levy; System Operator; Electricity tax; Other charges

(**) Change of the VAT rate from 6% to 23% in October 1, 2011

Source: Eurostat and ERSE
Electricity market organisation

Market Structure

Source: REN
Electricity market organisation

Market Structure

Derivatives Market (OMIP)

Bilateral Contracts

Dayahead and Intraday Market (OMIE)

Bilateral Contracts for Ancillary Services

Ancillary Services Market

Mobilization of Ancillary Services

Settlement

Source: REN
Power balance in 2014

Generation (*)
49.0 TWh

Consumption (**) 
49.9 TWh

difference
0.9 TWh

(*) 2014 hydro capability factor: 1.27

(**) Includes 1.1 TWh of hydroelectric pumping

Source: REN
Energy exchanges in 2014

**Commercial flows**
- Export: 3.1 TWh
- Import: 4.0 TWh

**Physical flows**
- Export: 6.3 TWh
- Import: 7.2 TWh

Source: REN
The management of the Iberian spot electricity market is the responsibility of OMIE – Iberian Energy Market Operator.

On the spot electricity market, transactions are executed by the participation of agents on the daily and intraday market that aggregate, through market splitting, the Spanish and Portuguese zones of MIBEL. In 2014, the price of electricity was the same in Spain and Portugal for 90% of the time, which confirms that the integration of the Iberian market. Trading on the daily market is based on a daily auction, with settlement of energy at every hour of the following day.

EUPHEMIA is the algorithm approved for all European markets.

Complementarily, there are various intraday sessions, subsequent to the daily market auction, in which agents can trade electrical energy for the various hours of the day covered by that market. Trading is also done by auction.

Source: OMIE
Price Coupling of Regions (PCR) in Europe

WHAT is PCR?
Price Coupling of Regions (PCR) is the initiative of seven European Power Exchanges to harmonise the European electricity markets.

HOW is this done?
By developing a single price coupling algorithm to be used to calculate electricity prices across Europe.

Towards Single European Market: Next Steps

- Markets included in PCR - 2872 TWh
- Markets associate members of PCR
- Markets that could join next as part of an agreed European roadmap

Source: EpexSpot
Hedging tools (Futures and Derivatives)

- OMIP is the MIBEL derivatives exchange that ensures the management of the market jointly with OMIClear.

- OMIClear takes on the role of Clearing House and Central Counterparty in all the operations executed on the market managed by OMIP, being able to also clear trades on the OTC market or even other markets that have, as underlying assets, energy based products or such like.

Source: OMIP