Integrating Renewables in the Portuguese National Electricity Grid System

09 de maio de 2018
Portuguese Electricity System
The main figures

• Demand

![Graph showing demand and peak demand over years from 2008 to 2017.](image)

Demand is located in coast region, mainly in Lisbon, Oporto and Algarve

• Generation Installed capacity

<table>
<thead>
<tr>
<th>Potência instalada no final do ano</th>
<th>2017</th>
<th>2016</th>
<th>Var.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>19 800</td>
<td>19 539</td>
<td>260</td>
</tr>
<tr>
<td>Renovável - Renewable</td>
<td>15 597</td>
<td>15 087</td>
<td>510</td>
</tr>
<tr>
<td>Hidrica - Hydro</td>
<td>7 193</td>
<td>6 946</td>
<td>248</td>
</tr>
<tr>
<td>Eólica - Wind</td>
<td>5 090</td>
<td>5 070</td>
<td>20</td>
</tr>
<tr>
<td>Biomassa - Biomass</td>
<td>624</td>
<td>613</td>
<td>11</td>
</tr>
<tr>
<td>Cogeração - Cogeneration</td>
<td>351</td>
<td>351</td>
<td>0</td>
</tr>
<tr>
<td>Solar - Solar</td>
<td>490</td>
<td>459</td>
<td>31</td>
</tr>
<tr>
<td>Náo Renovável - Non-Renewable</td>
<td>6 403</td>
<td>6 452</td>
<td>-50</td>
</tr>
<tr>
<td>Carvão - Coal</td>
<td>1 766</td>
<td>1 756</td>
<td>0</td>
</tr>
<tr>
<td>Gás Natural - Natural Gas</td>
<td>4 607</td>
<td>4 636</td>
<td>-30</td>
</tr>
<tr>
<td>Cogeração - Cogeneration</td>
<td>778</td>
<td>807</td>
<td>-30</td>
</tr>
<tr>
<td>Outros - Others</td>
<td>40</td>
<td>60</td>
<td>-20</td>
</tr>
<tr>
<td>Bombagem - Pumps</td>
<td>2 698</td>
<td>2 437</td>
<td>261</td>
</tr>
</tbody>
</table>

Renewables are located in countryside, mainly in northern and central region of Portugal
Portuguese Electricity System
The main figures

• Demand supply evolution

- Hydro is highly dependent on wet/dry regime, whilst wind is more consistent
- Natural gas and coal supply is in counter-cycle with wet regime
Portuguese Electricity System
The main figures

• National Transmission Grid

<table>
<thead>
<tr>
<th>Comprimento das Linhas (km) Length of Lines (km)</th>
<th>2017</th>
<th>2016</th>
<th>Var.</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 kV</td>
<td>2 714</td>
<td>2 670</td>
<td>44</td>
</tr>
<tr>
<td>220 kV</td>
<td>3 611</td>
<td>3 611</td>
<td>0</td>
</tr>
<tr>
<td>150 kV</td>
<td>2 582</td>
<td>2 582</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potência de Transformação (MVA) Transformer Capacity (MVA)</th>
<th>2017</th>
<th>2016</th>
<th>Var.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoTransformação (MAT/MAT) Autotransformers (VHV/VHV)</td>
<td>14 340</td>
<td>13 890</td>
<td>450</td>
</tr>
<tr>
<td>Transformação (MAT/AT) Transformers (VHV/VHV)</td>
<td>22 722</td>
<td>22 426</td>
<td>296</td>
</tr>
<tr>
<td>Transformação (MAT/MT) Transformers (VHV/MV)</td>
<td>320</td>
<td>320</td>
<td>0</td>
</tr>
</tbody>
</table>

• National Transmission Grid Evolution

Largest growth in the 400 kV network
Portuguese Electricity System

The main figures

- **Interconnections**

  - **PT - > ES**
  - **ES - > PT**

  - 2 x 400 kV
  - 1 x 400 kV
  - 3 x 220 kV

- **Market splitting**

  - 400 kV: 6 circuits
  - 220 kV: 3 circuits

  - Downward trend
**Energy Policy**

**European and national goals**

- **European goal**

  The Renewable Energy Directive establishes an overall policy for the production and promotion of energy from renewable sources in the EU.

  - **2020 Target:** European Union intend to fulfil at least 20% of its total energy needs with renewables by 2020 - to be achieved through the attainment of individual national targets.

  - **2030 target:** at least a 27% share of renewable energy consumption.

- **Main 2020 national goals**

  - **31%** Share of renewable energy in gross final energy consumption.

  It means **60%** Share of renewable energy in electricity consumption.
Network Planning
Identification of System Needs

- Wind case study

In 2001 the Portuguese Government set as national goal, to increase the amount of electricity generation based on renewables sources, with a special focus on the wind development

- Identification of national wind resource potential carried out in cooperation with the University.

- From wind resource map, identification of areas of the territory with more potential for requests to new wind power generation projects.

- A significant wind resource areas are in inner countryside, in regions with lower consumption, and where the transmission grid was less developed or did not exist (need to develop the network).

- With this challenge, REN developed a wide study and make a Plan to reinforce the network, in order to enable the integration of new renewables and transmit its energy from the production areas to the consumption centers.

The geographic dispersion of RES generation required a strategic development of the network, including environmental and spatial planning aspects.
Network Planning
Capacity to integrate new generation

• Methodology

Network capacity for new generation using a methodology based on **nodal capacity calculation**, complying with network planning security criteria.

Network **capacities periodically evaluated and published by REN**, either considering larger horizons, considering potential new network reinforcements.

**National Directorate of Energy and Geology manage the network capacities**, giving the permits to the interested promotors when capacity exists.

Such methodology allows a **higher network guarantee**, meaning power plants won’t have production restrictions caused by network elements (unless exceptional situations).

Such methodology also allows a better quality of service, as it mitigates curtailment needs.
Every year REN publishes the Generation Reception Capacity at the transmission substations busbars for the short/medium term.

These values are the basis to accommodate players in electricity market and are utilized by the Directorate of Energy and Geology to issue licenses to connect new generation.
Network Planning
Network capacity and Grid code compliance

Beyond network capacity availability, the compliance of the Network Codes and Guidelines is needed

- Network Codes and Guidelines
  - Connection and system operation codes and guidelines:
    - Requirements for Generators;
    - Demand Connection;
    - System Operation;
  - Market and trading guidelines:
    - Capacity Allocation and Congestion Management (CACM);
    - Forward Capacity Allocation;
    - Balancing.

Requirements for grid connection of generators

- Availability of network capacity
- General system management
- System restoration
- Fault-ride-through capability and voltage support
- Voltage stability
- Frequency stability
Network Planning
How to match the network development with the progressive evolution of installed RES

• Methodology

Constructing double circuit lines, but installing only one circuit in the beginning when initially one circuit was sufficient.

Temporary operation of some lines or substations in a lower voltage level then the ones for which they were designed and constructed.

Adoption of Phase-shift transformers to better control network flows.
RES Integration Challenges
Wind generation volatility

Wind generation increase

18-Jan-2015

Wind generation decrease

25-Jan-2016

High variation
1000 MW/h

Storage to cope with wind volatility: e.g. hydro with reservoirs and pumping
RES Integration Challenges
Impact of generation mix

These different generations patterns lead to different power flow behavior
RES Integration Challenges
Voltage management

New paradigm

- New reactive patterns (trend to high voltages in the network)
- Less conventional generation in the network (typically with more reactive flexibility)

Actions
- Reduce reactive injection from wind farms
- Install shunt reactors in transmission network
In some TSO-DSO substations main flows are from the Distribution to the Transmission network.
Interconnection capacity supports renewables integration.

Interconnection capacity increase system security as it can provide support for lack of intermittent power generation or a way to export excess of energy that can’t be stored (namely wind).
Despite the Challenges of Integration RES...
Portugal runs on Renewable Energy alone

2018
March 9 (20:30)  March 10  March 11  March 12 (12:00)

- Main achievements
  - National consumption was fully ensured by renewable energy during 63 hours
  - Main contribution came from Hydro and wind farms
  - No coal and natural gas production
  - Portugal had a positive export balance

63 Hours

2018-03-11

- Hydro
- Run of River
- Wind
- Others
- Consumption
Planning for next decade
National Development Plan

National Development Plan (PDIRT 2018-2027)

The elaboration of the Transmission Network Development Plan (NDP) in Portugal is under the responsibility of REN, the Portuguese TSO.

National Development Plan (NDP) should be prepared every two years, covering a 10 years timeframe.

NDP incorporates network development solutions that allow the integration of renewables in the Portuguese National Electricity Grid Systems.
Planning for next decade
National Development Plan

Main reinforcement projects with significant impact on the capacity to integrate new generation

Estimative of Long Term Network Capacity for new Generation Reception
Thank You