Analysis of Distributed Generation and Power Losses

Viesgo Distribución

CEER Workshop for the Benchmarking Report on Power Losses
6 October 2016
1. Overview of Viesgo

2. Distributed Generation in Spain

3. Presentation of ABB & Viesgo’s deep-dive study on Grid Losses

4. Regulatory approach to Grid Losses Calculation

5. Next Challenges
Viesgo in figures

110 YEARS OF HISTORY IN SPAIN

MORE THAN 1,000 EMPLOYEES
MORE THAN 31,000 KILOMETERS OF DISTRIBUTION NETWORK
MORE THAN 4,150 MW CONVENTIONAL AND RENEWABLE ENERGY
MORE THAN 670,000 CUSTOMERS LIGHT AND GAS

SPAIN

Wind (448 MW)
Hydro (704 MW)
Mini Hydro (25 MW)
CCGTs (2,043 MW)
Thermal (913 MW)

202 MW
18 MW
388 MW
44 MW
24 MW
114 MW
15 MW
50 MW
123 MW
395 MW
16 MW
818 MW
12 MW
26 MW
2 MW
10 MW
11 MW
324 MW
5 MW
45 MW
20 MW
830 MW
589 MW
4 MW
24 MW
Viesgo Distribution - Overview

Fourth largest distribution network in Spain, with established track record and continued focus on efficiency and innovation

Key Figures

- **Distributed Energy**: 5.8 TWh of electricity with a peak demand of 0.9 GW
- **31,000 km** of lines (of which 17% are High and Medium voltage cables) and **120 substations**
- 688,676 customers..
- 99% of the customers have a **smart meter installed**.

Distribution Area Network Map (High and Medium Voltage)
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Distributed Generation scenario in Spain

Installed Wind Power – Spanish Energy System

% Renewable / Demand – Spanish Energy System

…where the penetration of Distributed Wind Farms is remarkable for Viesgo

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Rationale for a study about grid losses (I)

The real situation of a DISCO leader in renewables integration with...

1. **Demand far from generation sites.**

2. **Asymmetric Demand Characterization:**
   - 40% in HV/MV (distribution) & 60% flow to Transmission grid (Distribution grid as a TSO-like grid)
It was necessary to analyze losses behavior to test our experience in order to show that losses depend on the level of renewables integration (Viesgo integration rate: 2.5 vs 1 Spanish DISCOS).

Impact on Grid Operation and Assets Lifetime!!

* Integration rate defined as: Renewable power connected to the grid / consume in the hourly peak
Case Study Inputs (I)

1. Voltage levels considered in the analysis: 132 kV, 55 kV, 30/20 kV & <20 kV

2. 26 Cross Borders considered. XB losses allocated to Viesgo. No MV/LV considered

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
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<tbody>
<tr>
<td>132/55kV power lines (km)</td>
<td>2.046</td>
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<tr>
<td>30/20 MV power lines (km)</td>
<td>9.779</td>
</tr>
<tr>
<td>Interconnections with HV (nº)</td>
<td>6</td>
</tr>
<tr>
<td>Generation connected (MW)</td>
<td>2.500</td>
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<tr>
<td>Installed Power (MW)</td>
<td>2307</td>
</tr>
</tbody>
</table>

3. 16 Power mix generation cases: standard operational states in Viesgo Grid

...Although Wind generation is generally much higher that other sources

Generation by case (MW)
Distribution by case

Mix Power Cases

<table>
<thead>
<tr>
<th>Wind</th>
<th>Hydraulic</th>
<th>Cogen.</th>
<th>case</th>
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<tbody>
<tr>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>30%</td>
<td>70%</td>
<td>0%</td>
<td>2</td>
</tr>
<tr>
<td>60%</td>
<td>50%</td>
<td>0%</td>
<td>3</td>
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<td>0%</td>
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</tr>
<tr>
<td>100%</td>
<td>20%</td>
<td>0%</td>
<td>16</td>
</tr>
</tbody>
</table>
Case Study Inputs (II)

Simulation of Viesgo system topology:
- 4 subsystems with different levels of generation & interconnected

Total Generation by regional areas

High Wind power, exporter subsystem
Importer or Exporter subsystem depending on Wind power
WO Generation Importer subsystem
Importer or Exporter subsystem depending on Wind power
Case Study Inputs (III)

5. **Power balance simulation:**
   - Status by mix power case
   - **Steady peak demand considered = 880 MW**

![Power balances graph](chart.png)
Case Study Simulation Results (I)

Losses vs. export level

% Losses regarding consumption
Change vs. export level

Export (MW)

Export (+) / Import (-)
Case Study Simulation results (II)

Losses distribution by Viesgo Subsystem

Galicia subsystem: High Wind power, exporter subsystem: 1,200 Wind MW

Asturias subsystem: Importer or Exporter subsystem depending on Wind power 450 wind MW

Cantabria subsystem: WO Generation shingly importer subsystem

Castilla subsystem: Importer or Exporter subsystem depending on Wind power

Graphs showing losses evolution by case for Galicia, Asturias, Cantabria, and Castilla.
Main Conclusions (I)

1. Increase on Distributed generation implies an increase on losses
   - Peaks related to increases on wind Power generation & almost wo hydraulic generation.
   - Slopes after peaks are affected mainly by the increase of hydraulic generation.

![Losses vs. Generation Graph](image)
Main Conclusions (II)

Wind power generation implies a distortion on grid losses (HV/MV) for a higher generation to consumption ratios.
3. **132 kV voltage level concentrates grid losses** (wind Power connected to it)

4. Increase of Wind power indicates an increase on losses (e.g., Galicia subsystem)

5. Lower wind power combined with hydraulic indicates a progressive increase on losses

6. In general: **Losses levels are similar without generation inflow** to the grid
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Proposal to review Grid Losses calculation basics

1. Current Grid Losses Methodology

\[ \text{Losses} = \sum \text{Borders} - \sum \text{Demand} \]
\[ \% \text{Losses} = \frac{\text{Losses}}{\sum \text{Losses}} \]

**ENERGY BALANCE EXAMPLE**

<table>
<thead>
<tr>
<th>GWh</th>
<th>IN</th>
<th>OUT</th>
<th>NET</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSO-TSO</td>
<td>115</td>
<td>400</td>
<td>-285</td>
</tr>
<tr>
<td>DSO-DSO</td>
<td>400</td>
<td>850</td>
<td>-450</td>
</tr>
<tr>
<td>GENERATION</td>
<td>500</td>
<td>0</td>
<td>500</td>
</tr>
<tr>
<td>WIND-DSO</td>
<td>2.255</td>
<td></td>
<td>2.255</td>
</tr>
</tbody>
</table>

| TOTAL BORDERS | 3.270 | 1.250 | 2.020 |
| CUSTOMERS     | 1.850 | -1.850|       |

| LOSSES       | 170   |

2. Methodology Proposal

\[ \text{Losses} = \sum \text{Borders} - \sum \text{Demand} \]
\[ \% \text{Losses} = \frac{\text{Losses}}{\left( \sum \text{Borders} + \sum \text{Borders (OUT)} \right)} \]

**1. CURRENT METHODOLOGY**

| ENERGY NET (IN-OUT) | 2.020 |
| CUSTOMERS           | 1.850 |
| Losses              | 170   |
| % Losses            | 8.42% |

**2. PROPUESTA CALCULO % PéRDIDAS**

| ENERGY IN        | 3.270 |
| CUSTOMERS + ENERGY OUT | 3.100 |
| Pérdidas          | 170   |
| % Pérdidas        | 5.20% |

**Conclusions / Proposals**

- Grid Losses increase as energy flows increase in the network (Customers demand, generation, XB between DSOs and TSOs)
- Grid Losses % should only consider Distribution losses in the energy distribution process to customers.
- Mid Term: NRAs should develop Grid Losses schemes that consider State Estimation in Distribution Grids to calculate optimal energy flows and compare to reality in order to avoid the effect of Renewable.
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New operational challenges in a Distributed Generation

**ST-MT Scenario: The Distributed energy wave is here to stay**

- **Distributed generation current operational scenario for Viesgo**
- **Impact of Distributed Generation for DISCO Network**

**New Operational Changes. E.g. Dynamic Line Rating to improve Lines capacity**

**Impact of Distributed Generation for DISCO Network**

*Viesgo / KPMG 2016 simulation. 25k supply points MV/LV network*
Thank you!

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