Expanding visibility and controllability requirements: The solar PV case

IEA: Task 17
Sophia Antipolis - May 18th 2011

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Solar generation in Spain today

Influence of solar technologies in system operation
The new requirements established by the RD 1565/2010
Observability & Controllability
Voltage Control: RES generation
Generation tripping due to voltage dips
Challenges integrating solar energy for tomorrow
Conclusions
Installed capacity and demand supply 2010

Installed capacity January 2010

Demand supply 2010

<table>
<thead>
<tr>
<th>Technology</th>
<th>MW</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-power</td>
<td>16 657</td>
<td>17.5%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>7 455</td>
<td>7.8%</td>
</tr>
<tr>
<td>Coal</td>
<td>10 789</td>
<td>11.3%</td>
</tr>
<tr>
<td>Fuel-Gas</td>
<td>1 849</td>
<td>1.9%</td>
</tr>
<tr>
<td>Combined cycles</td>
<td>24 641</td>
<td>25.9%</td>
</tr>
<tr>
<td>Total (ordinary regime)</td>
<td>61 391</td>
<td>64.3%</td>
</tr>
<tr>
<td>Wind power generation</td>
<td>19 976</td>
<td>20.9%</td>
</tr>
<tr>
<td>Solar PV</td>
<td>3 634</td>
<td>3.8%</td>
</tr>
<tr>
<td>Solar CSP</td>
<td>630</td>
<td>0.7%</td>
</tr>
<tr>
<td>Biomass</td>
<td>684</td>
<td>0.7%</td>
</tr>
<tr>
<td>Special regime hydro</td>
<td>1 965</td>
<td>2.1%</td>
</tr>
<tr>
<td>Cogeneration</td>
<td>5 946</td>
<td>6.2%</td>
</tr>
<tr>
<td>Waste treatment</td>
<td>1 204</td>
<td>1.3%</td>
</tr>
<tr>
<td>Total (special regime)</td>
<td>33 791</td>
<td>35.7%</td>
</tr>
</tbody>
</table>

Total: 95 430 GWh

- 189.071 GWh Net Ordinary Regime
- 90.513 GWh Net Special Regime
- 4.412 GWh Hydro-pump storage
- 8.338 GWh International exchange
- 260.230 GWh
## Installed capacity and demand supply 2010

### Distribution by size

<table>
<thead>
<tr>
<th>Year</th>
<th>Solar</th>
<th>0 &lt; P &lt;= 0,005 MW</th>
<th>0,005 &lt; P &lt;= 0,1 MW</th>
<th>0,1 &lt; P &lt;= 1 MW</th>
<th>1 &lt; P &lt;= 2 MW</th>
<th>2 &lt; P &lt;= 5 MW</th>
<th>5 &lt; P &lt;= 10 MW</th>
<th>10 &lt; P &lt;= 15 MW</th>
<th>15 &lt; P &lt;= 25 MW</th>
<th>25 &lt; P &lt;= 30 MW</th>
<th>30 &lt; P &lt;= 50 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Nº Assets</td>
<td>12.712</td>
<td>41.232</td>
<td>286</td>
<td>76</td>
<td>52</td>
<td>45</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installed Power (MW)</td>
<td>59,8</td>
<td>2.907,3</td>
<td>148,0</td>
<td>119,7</td>
<td>200,8</td>
<td>358,6</td>
<td>24,8</td>
<td>20,0</td>
<td>499,1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Premium (€/MWh)</td>
<td>440,4</td>
<td>440,4</td>
<td>417,5</td>
<td>417,5</td>
<td>417,5</td>
<td>417,5</td>
<td>229,8</td>
<td>229,8</td>
<td>229,8</td>
<td>229,8</td>
</tr>
</tbody>
</table>

Smaller plant in households
Present solar photovoltaic power capacity and evolution

- **Official Network Planning for 2016** contemplates 6,319 MW.

(*) Date 1/5/2011
Commercial exchange capacity.
Solar generation in Spain today

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Influence of RES Generation in System Operation

CHALLENGES INTEGRATING RES

- Production not correlated with consumption
- Balance feasibility during off-peak hours
- Possibility of Generation Management
- Variability and predictability
- Dynamic behavior during disturbances

PILLARS TO SUCCESS

- Wind farm requirements
- Power system studies
- Wind and Solar forecast tools
- Monitoring & Controllability
- Network developments
- Industry response
Solar PV: Influence in system operation

Solar photovoltaic

- 2.4% of the total energy demand in 2010.
- Reduced observability by the SO. Will be solved by July 2011.
- Behavior in summer in accordance to demand requirements.
- In winter, peak demand is in the evening. No contribution.
- Connection to Transmission/Distribution: 2/98%

<table>
<thead>
<tr>
<th>YEAR</th>
<th>SOLAR PV PRODUCTION (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>40</td>
</tr>
<tr>
<td>2006</td>
<td>103</td>
</tr>
<tr>
<td>2007</td>
<td>466</td>
</tr>
<tr>
<td>2008</td>
<td>2 477</td>
</tr>
<tr>
<td>2009</td>
<td>5 347</td>
</tr>
<tr>
<td>2010</td>
<td>5 828</td>
</tr>
</tbody>
</table>

Source CNE

MONTHLY SOLAR PV PRODUCTION DISTRIBUTION (2010)

HOURLY SOLAR PV PRODUCTION DISTRIBUTION (2010)
Demand coverage

**Winter**
(13/12/2010)

**Summer**
(13/07/2010)

**PV power plants:**

Hour of the day October 20th 2010

- Plant 1: 30 MW
- Plant 2: 13 MW
- Plant 3: 7 MW
- Plant 4: 22 MW
- Plant 5: 48 MW
- Sum: 120 MW

Hour of the day November 21st 2010

- Plant 1: 30 MW
- Plant 2: 13 MW
- Plant 3: 7 MW
- Plant 4: 22 MW
- Plant 5: 48 MW
- Sum: 120 MW
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Observability is required to have real time information of the production of the renewable energy facilities.

This information is used to make reliable production forecasts for this type of installations.

Renewable forecasts are a basic tool for hot reserve evaluation. Its accuracy affects the required levels of reserve and helps dispatching manageable generation to counteract renewable and non manageable variability.

Receiving the real time measurements of all the generation facilities allow the SO to distinguish between generation and demand, avoiding demand forecast errors as well.
Observability: And if not, what?

Without a reliable forecast

Demand forecast errors

Increasing Uncertainties

Increasing the required level of reserves

Reducing RE production

Reducing the Security of the system
CECRE is a control centre devoted to special regime generation and specially to Wind Power:

- Integrated in REE’s control structure.
- Communication with generation Control Centres for supervision and control instructions.
- According to RD661/2007 all special regime facilities >10 MW must be connected to a RESCC.
- CECRE issues generation limitations through the SCADA system to the Control Centres.

How we have reach visibility and controllability over the wind?

**CECRE**

**RESCC**: Renewable Energy Source Control Centre

**CC**

- **CC**
- **CONV**: Control Centre for conventional generation

**RESCC**: Renewable Energy Source Control Centre

**Mini-hydro**

**Biomass**

**Wind**

**Industrial waste**

**Urban waste**

**Solar**
What we have reached with visibility and controllability?

- **Maximum production:** 14,962 MW (09/11/2010)
- **Minimum production in one year:** 164 MW (03/06/2009).

- **Maximum coverage:** 54% of demand coverage by wind energy (09/11/2010).
- **Minimum coverage:** less than < 1% of the demand (27/08/09).
Observability: Nowadays

- With the former regulation REE had only real-time telemetry of 3 % of the installed capacity.
- Not enough real-time data to extrapolate to 100% of the installed capacity.
- “Nowcasting” of solar PV with hourly irradiance values for each province.
- Significant differences between schedule and forecast.
- Variability seen as ripples in the demand and compensated by the secondary regulation.
Observability with the RD 1565/2010

- After 01/07/2011.

SOLAR PLANTS AGGREGATION

Solar plant aggregation
P > 10 MW

Connected to a RESCC
OBSERVABILITY & CONTROLLABILITY

Solar plant aggregation
1 MW < P < 10 MW

Connected to a RESCC or Distribution Companies
OBSERVABILITY

CECRE

12 second cycles

12 second cycles
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Voltage Control
RES generation

Before 1/4/2009

Voltage variation (7/2/2009)

From 1/4/2009:

- Most* of the special regime installations higher than 10 MW (already installed by the 1/04/2009) were asked to maintain an inductive power factor between 0.98 and 0.99.

  In order to:
  - Eliminate sudden changes in the voltage profile corresponding to the transitions off peak-intermediate-peak periods.
  - Avoid high voltage problems in the system.

*Except in certain nodes of the system where particular instructions were sent due to specific requirements.
Voltage Control with the RD 1565/2010

From 1/2/2011:

SOLAR PLANTS AGGREGATION

Solar plant aggregation
P < 10 MW

Solar plant aggregation
P > 10 MW

REACTIVE POWER TABLE

PARTICULAR INSTRUCTIONS

PARTICULAR INSTRUCTIONS

-3% 0% +4% 0% -3%

0.98 0.995 0.995 0.98

Inductive  Capacitive
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Generation tripping due to voltage dips

- From January 1st 2008 all new wind facilities must comply with PO 12.3.
- Of the installed wind turbines less than 1.000 MW have no fault-ride-through capabilities*

* Faults shorter than 100ms and voltages lower than 85% p.u.

- The facilities that get access after July 1st 2011 must comply with PO 12.3.
- The facilities that get access before July 1st 2011 will have until Octobre 1st to comply with PO 12.3.
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Challenges for the future

- **Short term measures: 2011**
  - Balance feasibility in off-peak hours could be an issue now.
  - Voltage control with set-points issued by the CECRE and dynamic voltage support.

- **Long term measures: beyond 2011**
  - Capability both technical and economical for RES to provide frequency control (primary reserve, inertia emulation...).
  - Increase the international exchange capacity.
  - Storage such as hydro-pump units and very fast thermal plants (open cycle gas turbine).
  - Correlation between wind and solar production.
  - Evolution of wind and solar forecast.
  - Demand side management.
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- Solar PV in Spain have reached high penetration levels and will continue to rise for several years.

- Integrating non manageable generation, like solar PV, is a challenging task: Low availability, production not correlated with consumption in winter, lack of firmness of generation programs and power balance difficulties.

- Complying with the new RD 1565/2010 with let the TSO to receive the real time measurements achieving visibility and controllability of the solar PV generation.

- In addition, if facilities are grouped in control centers with real-time contact with the System Operator through the CECRE, implies that curtailments take less time to be done so less strict limitations could be planned and placed, increasing RES production and installation.
Thanks for your attention!