Voltage Control for Wind Power Plants. Real Experience and Results in Vallejera Cluster in Spain.

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Introduction
Reactive Power Control
Operational Procedures in Spain
Voltage Control
Test in Vallejera Cluster
Conclusions
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Operational Procedures in Spain
Voltage Control
Test in Vallejera Cluster
Conclusions
• Wind Energy:

Installed capacity in 2009 with growth (by country)
• Wind Energy:

Wind supply as percent of demand (by Country)
The voltage level fluctuates:

- Grid failures.
- Generation demand profile: High voltage at nights and low voltage during the day.
- The Synchronous Generator of the conventional power plants cannot control voltage in every single point of the grid (local problem)

  Capacitors and Reactors banks installed along the grid.

- Wind Farms installed along the grid: the reactive power provided (absorbed and generated) by the WTG can help to compensate voltage fluctuations.
Introduction

Reactive Power Control

Operational Procedures in Spain

Voltage Control

Test in Vallejera Cluster

Conclusions
Voltage Control for Wind Power Plants. Real Experience and Results in Vallejera Cluster in Spain.

- Ability of the WTs to Absorb/Generate Reactive Power:

  Squirrel cage induction generator  Reactive Power available

  Doubly fed asynchronous generator

  Full Converter + synchronous generator
Voltage Control for Wind Power Plants.  
Real Experience and Results in Vallejera Cluster in Spain.

- **Close loop Control**

- **Impact of the Reactive Power Control:**

![Graph showing the impact of reactive power control on wind farm performance.](image)
RD661 established bonus and penalties depending on the Power factor supplied.

It does not been taken into account where the Wind Farm is installed nor if the Wind Farm has local voltage problems.

Now, the law has change RD 1565

<table>
<thead>
<tr>
<th>Power Factor Range</th>
<th>Bonus (%)</th>
<th>Penalty (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory range (0.98 IND-0.98 CAP)</td>
<td>0.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Between 0.995 IND and 0.995 CAP</td>
<td>4.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Introduction

Reactive Power Control

Operational Procedures in Spain

Voltage Control

Test in Vallejera Cluster

Conclusions
Requirements proposed by the OP12.2: Voltage control

- Future Operational Procedure
- Special requirements for Voltage Control
- For steady-state and transients (overvoltages and undervoltages)
- The voltage control consists of injecting reactive current in order to oppose to the voltage error
Requirements OP7.5

- Complementary Operational Procedure
- Verified the Requirements of the OP 12.2
- Validation Measure Instructions
- Formula defined:

\[
\frac{Q}{P_{an}} = -K_v \left( \frac{\Delta V}{V_{base}} - b \right)
\]

\[
\frac{Q}{P_{an}} = -K_v \left( \frac{\Delta V}{V_{base}} + b \right)
\]

\( b \): Dead Band; \( K \): Gain; \( \Delta V \): Voltage deviation
Voltage Control for Wind Power Plants.
Real Experience and Results in Vallejera Cluster in Spain.

Introduction
Reactive Power Control
Operational Procedures in Spain
Voltage Control
Test in Vallejera Cluster
Conclusions
Close loop Control

- The objective of the control is to reach the setpoint demanded by the TSO.

- The System Operator should send the voltage setpoint to the Dispatch Centre (CORE) and then it is transmit to the wind farms.
Voltage control:
- More complex strategies
- Difficult implementation in old wind farms.
- Dependency of the Short Circuit Power in each node.

To be defined:
- Voltage Control will require faster controllers, and Wind Farm communication infrastructures: problem for old Wind Farms.
- Bigger amount of data required by the TSO
- Predictions and availability will be required by the TSO in order to work out the setpoints.
- Interaction between different voltage controllers (grid line or node)
- Bonus
Voltage Control for Wind Power Plants.
Real Experience and Results in Vallejera Cluster in Spain.

Introduction
Reactive Power Control
Operational Procedures in Spain
Voltage Control
Test in Vallejera Cluster
Conclusions
OBJECTIVES

• Voltage control in the Transport Grid Cluster
• Requested by the TSO (REE)
• Validation of the Voltage control regulation defined in the OP12.2 and OP 7.5 with existing Turbines.
• Cluster controlled just by one Dispatch Centre.
• Time Scheduled project with deadline September 2010.
• Fulfil the setpoints demand by the TSO in a cluster with 6 wind farms
Cluster Topology

- Voltage Level 220kV.
- Installed Power 193 MW
- DFIG machines

<table>
<thead>
<tr>
<th>Facility</th>
<th>PCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARRASQUILLO</td>
<td>220 kV</td>
</tr>
<tr>
<td>CARRIL</td>
<td>45 kV</td>
</tr>
<tr>
<td>CHAMBON</td>
<td>20kV</td>
</tr>
<tr>
<td>NAVAZO</td>
<td>20kV</td>
</tr>
<tr>
<td>TERUELO</td>
<td>45kV</td>
</tr>
<tr>
<td>VALBONILLA</td>
<td>20kV</td>
</tr>
</tbody>
</table>
OPTIONS PROPOSED:

• **Option 1: Iberdrola Renovables regulator**
  - Big changes in the communications infrastructure
  - Long period test to check all the functionalities. (Different machines)

• **Option 2: New Voltage Control + current Reactive Power Control.**
  - Voltage Regulator placed in a new machine. Ibedrola Renovables design.
  - Regulation through the Reactive Power regulator at the Windfarm.
  - Several changes in the Windfarms communication infraestructure.
  - Short period test to check all the functionalities. (Different machines)

• **Option 3: Turbines Manufacture´s Voltage Regulator**
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General scheme: Control loop
TASKS:
• Supply of 4 UCCs
• Regulator Specification and design.
• Software installation in the UCC
• OPCTags Design
• Communication Test with the Dispatch Centre.
  – Setpoints Reception
  – Commands Reception / sending
  – Tags
  – Limits
  – Simulations
• Supply of Hardware at the Substation
• Windfarms Updating
• Reactive Power Regulator test
• Change of signals resolution and analysis of the channel traffic.
• Records analysis.

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Real Experience and Results in Vallejera Cluster in Spain.
Voltage Control for Wind Power Plants.
Real Experience and Results in Vallejera Cluster in Spain.

UCC Voltage Control Screen accessible from CORE:
Communication Channel refresh time improvement:

Comparison Study:

Improvements Result:
Protocol Test Implemented by REE:

PHASE I -> K=12 dead band ±0,0025 5 days: Fix V Setpoint

PHASE II -> K=6,12,25 dead band ±0,005 y ±0,00125 5 days
Steps made by the Tap changer

PHASE III -> K=25 dead band ±0,005 5 days: Fix V Setpoint

- Starting with every Windfarm with Cos Phi=1
- Disabled On-load Regulation transformer.
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Real Experience and Results in Vallejera Cluster in Spain.

TEST RESULTS
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PHASE 2F 10/11/2010 K=12; b=±0.00125
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Real Experience and Results in Vallejera Cluster in Spain.

PHASE 2D 08/11/2010 K=25; b=±0.005
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Real Experience and Results in Vallejera Cluster in Spain.

PHASE 3 11/11/2010 K=25; b=±0.005
Voltage Control for Wind Power Plants.  
Real Experience and Results in Vallejera Cluster in Spain.

Introduction
Reactive Power Control
Operational Procedures in Spain
Voltage Control
Test in Vallejera Cluster
Conclusions
Wind Power plays a very important role in voltage control (for grid stability).

Reactive Power Control implemented in Spain, contribute to stabilize the network operation but has both advantages and disadvantages.

Requirements of new Grid Codes in the area of Voltage Control are increasing.

Development and implementation of new technologies and communication architectures.

Many changes for old windfarms.

TSO in Spain has tests on site the requirements of the new OPs with existing turbines and just one Distpatch centre.

Manufactures, System Operators, Utilities, etc. should work together and it is very important to realize that changes need time and investments.
Voltage Control for Wind Power Plants.
Real Experience and Results in Vallejera Cluster in Spain.

Thanks for your Attention!

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