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Control systems for the integration of wind energy in the grid through a Renewable Energy Control Center



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23 de Mayo de 2010



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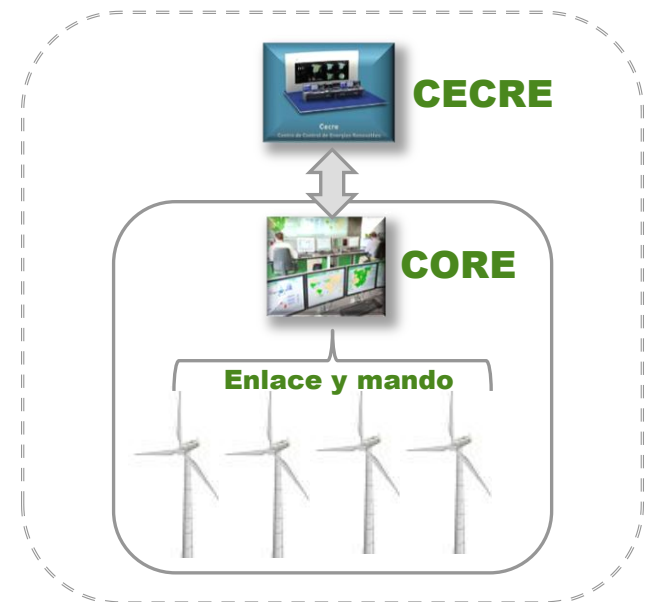
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Renewable Energies Control Centers in Spain

Object

- Wind energy in Spain has grown rapidly in recent years from around 2 GW in 2000 to 20 GW by the end of 2010. This has complicated the operation and control of the transport network
- The system operator (REE) has its own control center for renewable generation called CECRE, which applies different mechanisms to different renewable energies control center in Spain
- Both RD 661/2007 of 25 MAY, and RD 1565/2010 of 19 NOVEMBER, establish:
 - Obligation on all RE facilities higher than 10MW to be assigned to a control center.
 - A Control Center is a necessary condition for the perception of the reference tariff



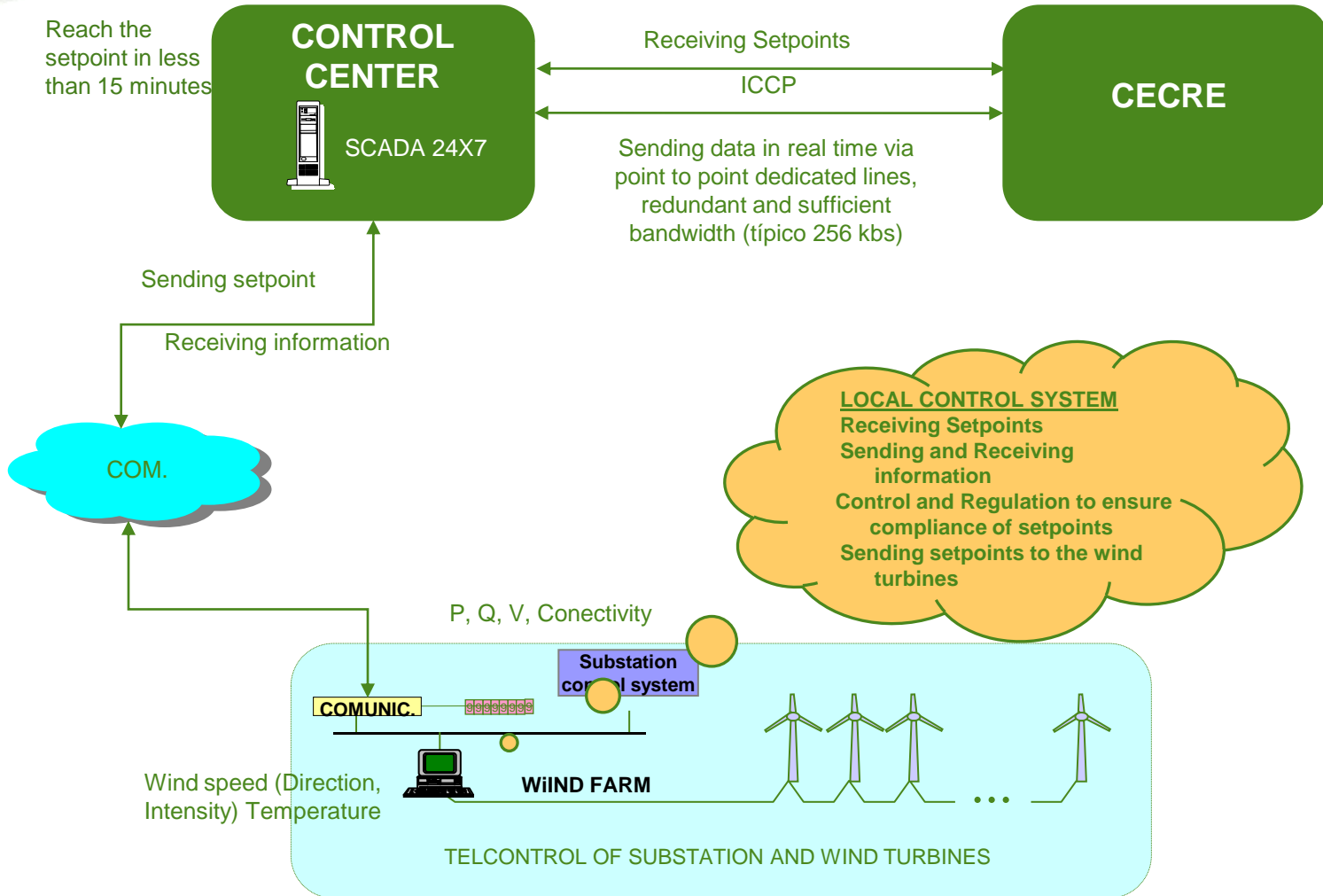
Renewable Energies Control Centers in Spain

Specific Functions

- To send in real time the following wind farm information:
 - Active Power
 - Reactive Power
 - Conectivity
 - Voltage, wind speed (Direction and intensity), Temperature.
- Receive Pmax setpoints per node and farm calculated by CECRE next to the flag code of the cause of restriction

Code	Reason of limited production
0	No limitation
1	Congestion of generation
2	Estability-Voltage dip
3	Short Circuit Power
4	Viability of power balance
5	Surplus generation nonintegrables in the system
6	Other

Renewable Energies Control Centers in Spain



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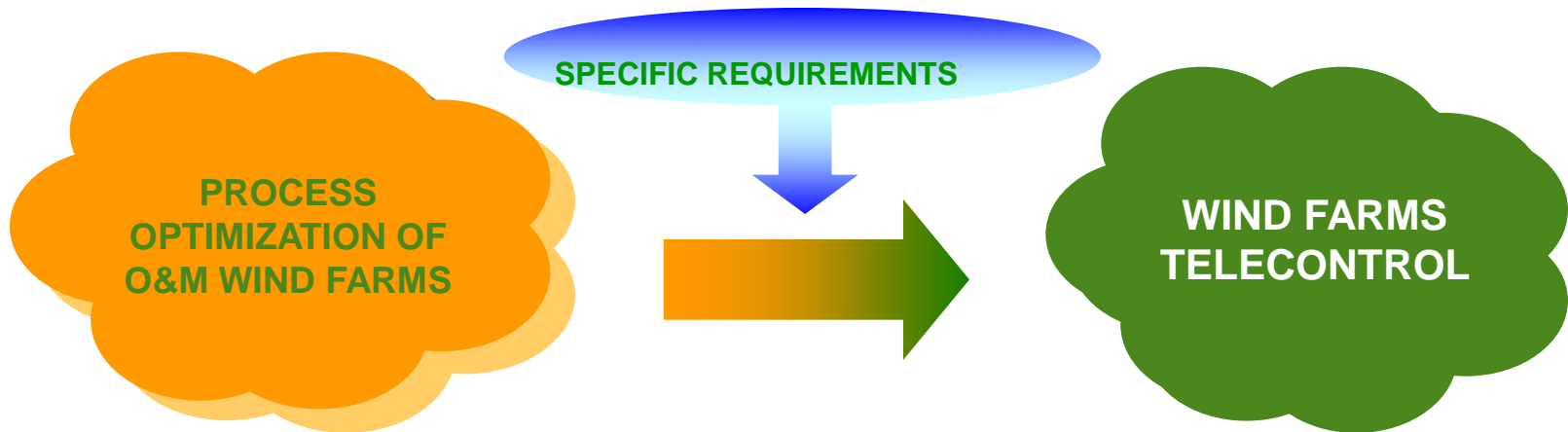
CORE of Iberdrola Renewables



- It is the Renewable Energies Operations Center that allows monitoring and remote operation 24 hours for any facility of renewable energy.
- It is currently in service and controls 220 WF, 6.500 MW, 70 small hydro, 1 solar thermal and 1 Biomass.
- Located in Toledo, controls all facilities in Spain, Mexico, Brasil, Portugal, France, Germany, Poland, Hungary, Greece and Italy
- Controls the forecast of all the installations under its control.
- The CORE has been developed by Iberdrola Renewables with the help of 'Iberdrola Engineering' and is a fully operational system that communicates today with 220 WF with real-time monitoring data on approximately 2,000,000.

CORE of Iberdrola Renewables

Approach and Purpose



- Reduction of Operation and Maintenance costs
- Maximize production through improved availability
- Centralized management of information in real time
- Centralized communication with other energy management centers
- Control of energy delivered to the network

CORE of Iberdrola Renewables

Specific Requirements

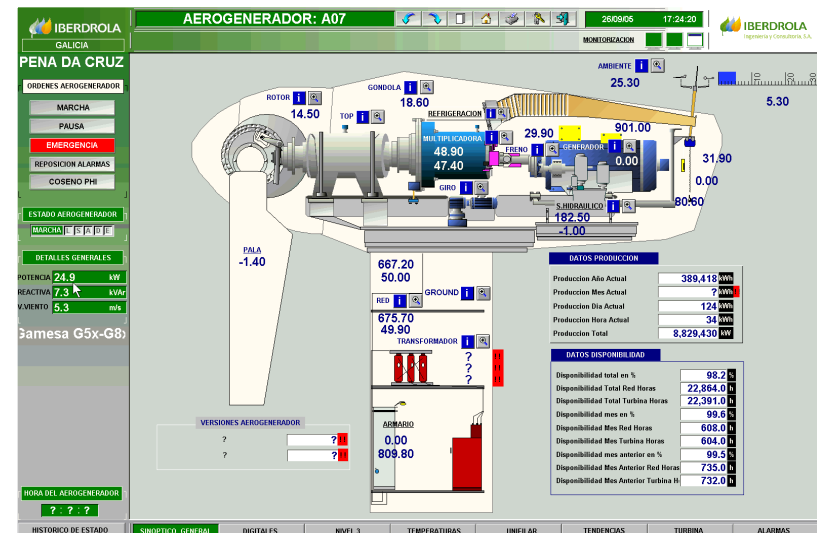
- System for highly distributed renewable facilities
- Processing large amounts of data in real time with different levels of information. Monitoring variables between 300-400 per MW
- Currently the Iberdrola CORE is monitoring in real time around 2,000,000 signals
- Multimedia management of alarms and events
- Communication protocol by exception, which allows continuous updating of a large number of data



CORE of Iberdrola Renewables

Specific Requirements

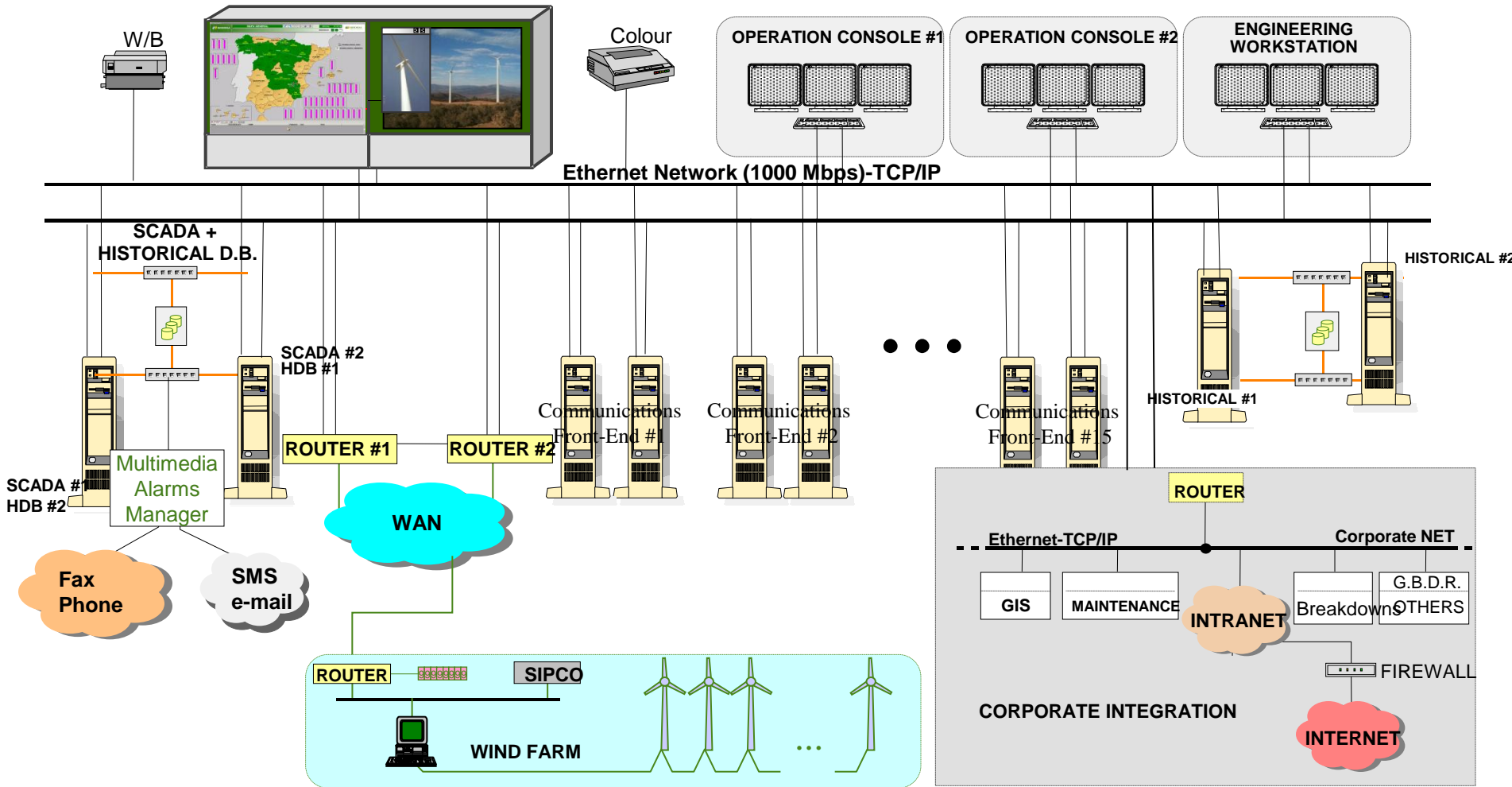
- Maintenance optimization system by standardization the process for WF: Centralized configuration and On-Line, object-oriented technology can reduce the configuration and commissioning of new facilities
- Based on a commercial SCADA, maintained and supported by the manufacturer for this application
- Ability to application development and integration
- Client / server distributed architecture, which ensures:
 - Availability and Reliability
 - High performance
 - Incremental growth according to needs
- Process data at different levels
- Web access to plant information



CORE of Iberdrola Renovables



Architecture



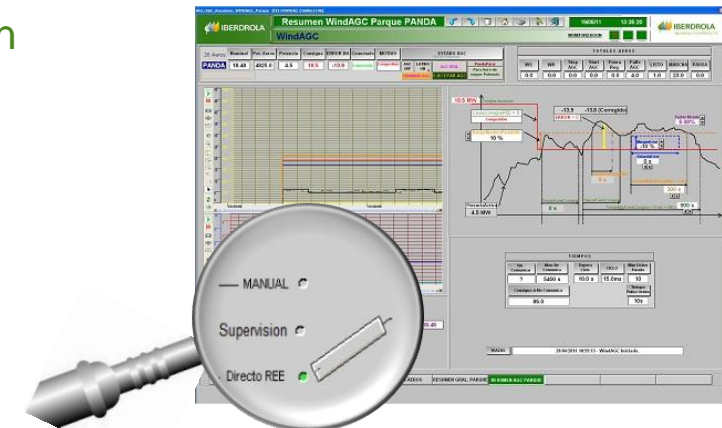
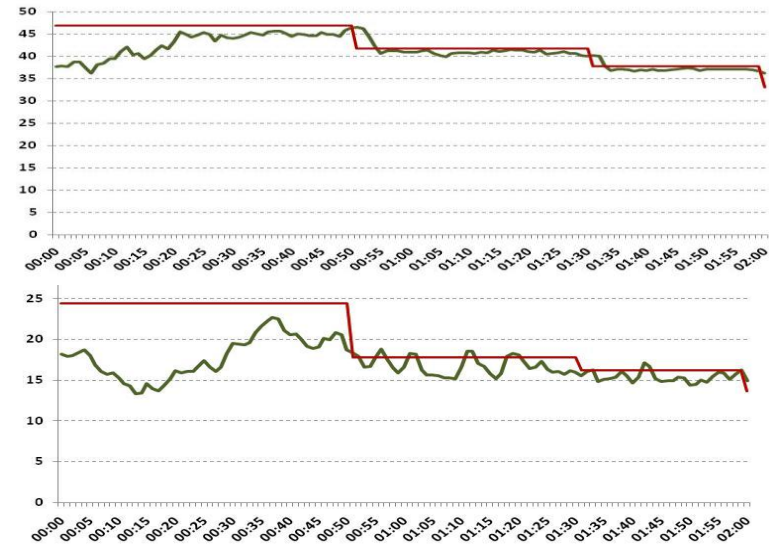
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Control functions for the integration of wind energy in the network

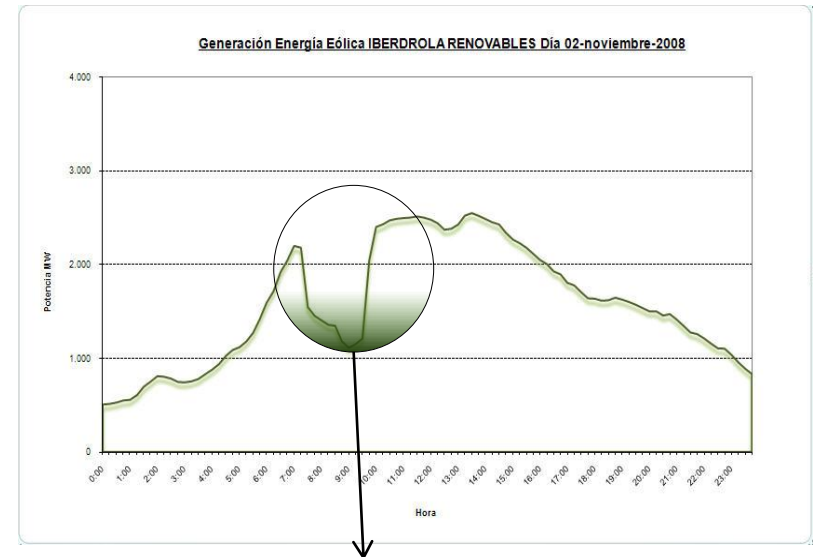
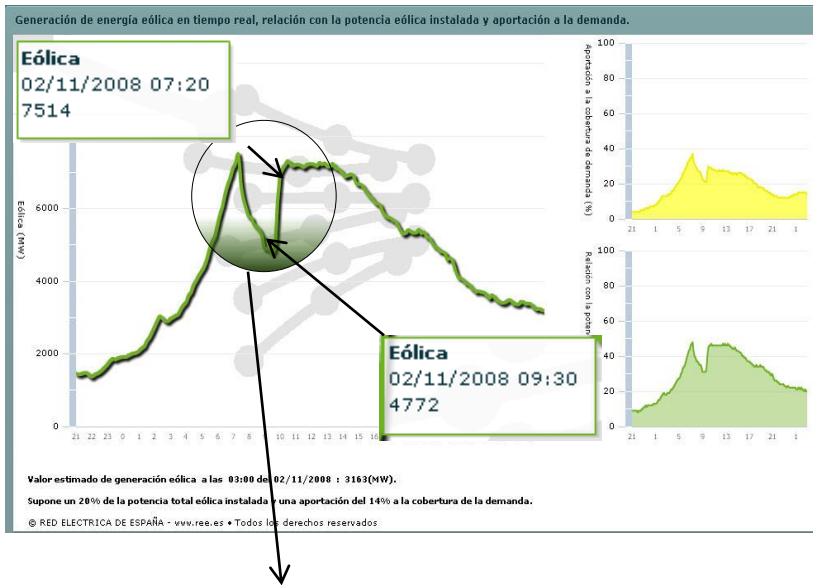
Active Power Control

- Existing Controls
 - Reduction of active power limitation with low pitch angle
 - Reduction through wind turbines stop
- Type of control:
 - Manual: The instruction may be fixed or set on a schedule
 - Automatic: the application implements the setpoint of an external system
 - Supervision: the logic is implemented but it doesn't send control setpoints



Control functions for the integration of wind energy in the network

Wind power massive surplus limitation in Spain on 02 November 2008



Total limitation of Spain (REE):

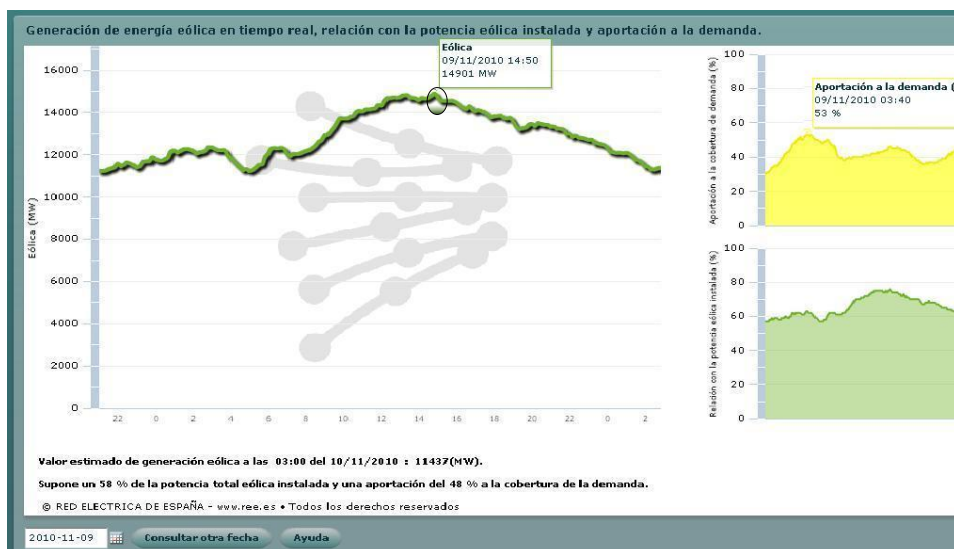
- At 07:24 h the reduction started to maintain the system safety.
- Wind power reached **37%** of contribution to cover the demand.
- REE sent a reduction of more than **2.742 MW** to the Renewable Energies Control Centres .
- The reduction ends at 9:35 h.

Limitation of IBERDROLA RENOVABLES:

- **127 Wind Farm** received a reduction or limitation.
- It was affected approximately 4.260 MW of installed power.
- IBERDROLA RENOVABLES received order to reduce about **1.000 MW**.

Control functions for the integration of wind energy in the network

Maximum wind power



Spain maximum wind power :
14,962 MW (09/11/2010 14:50 h)

Maximum coverage of demand in Spain:
54% (09/11/2010 3:35 h)

Iberdrola Renovables maximum wind power:
4.095 MW (09/11/2010)

Control functions for the integration of wind energy in the network

Reactive power control

Existing controls

- Power Factor Control
 - Manual or automatic setpoint to consume or generate reactive power
 - Setpoints Calendar
- Other elements can be used to adjust Voltage: SVCs, STATCOMS or transformers with on load tap regulations.
- Voltage-reactive control in substation or node: ensures optimal voltage profile in the network

Control functions for the integration of wind energy in the network

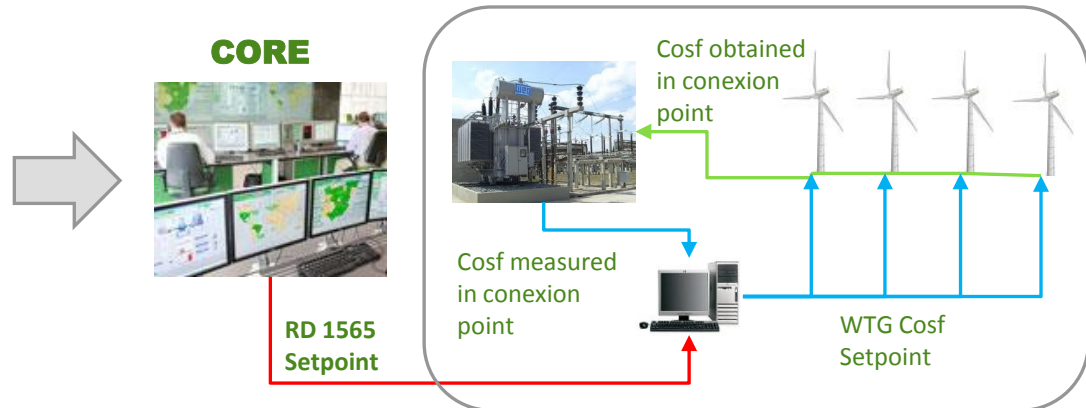
Supplement for reactive power RD1565/2010

Power factor range	Bonus for compliance %	Penalty for failure %
Required	0,00	3,00
Between 0,995 inductive and 0,995 capacitive	4,00	0,00

Establishing the mandatory power factor range between 0.98 inductive and 0.98 capacitive

Facilities must provide reactive power control, to receive a bonus (positive) or penalty (negative) on the appropriate fee, depending on the power factor obtained at the connection point to the network

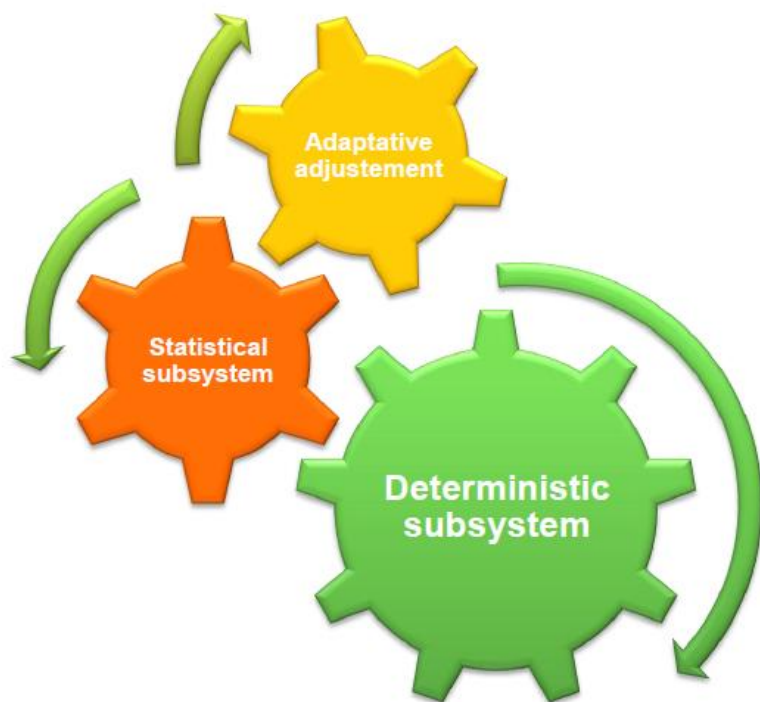
The reactive power is controlled through a closed loop algorithm



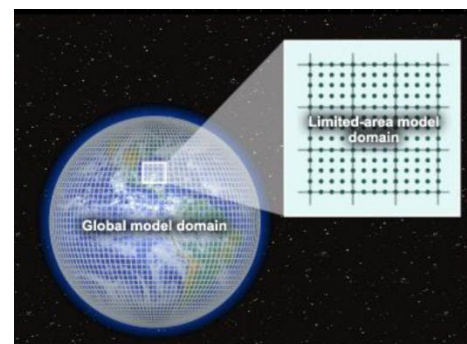
Control functions for the integration of wind energy in the network

Forecasting and planning system (METEOFLOW)

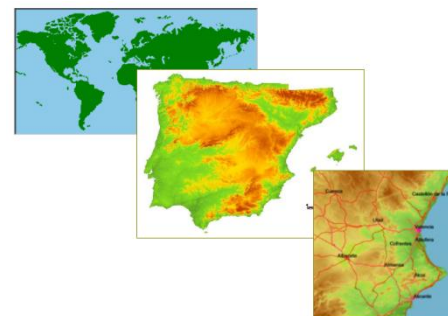
The METEOFLOW system calculates a wind production forecast for every day-ahead and an imbalanced market session



Deterministic global + LAM system



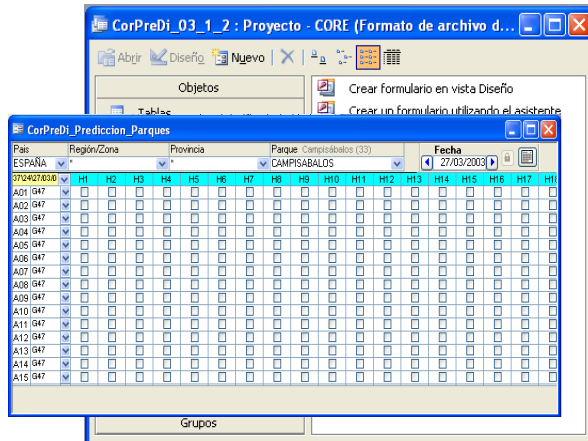
High resolution grid nesting capabilities



Control functions for the integration of wind energy in the network

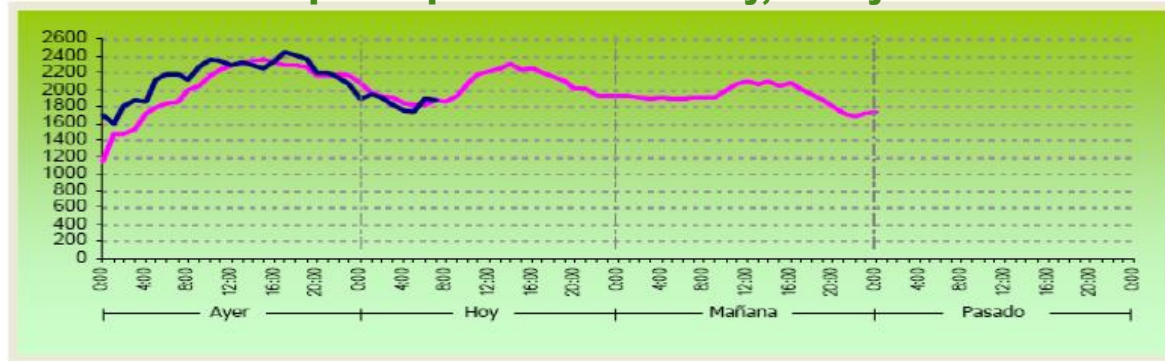
Forecasting and planning from a Control Center

- Modification model of the forecast by the facilities availability
- Periodic sending of information to the agent to sell the energy in the market.
- Real-time monitoring of the outcome of the prediction compared to real power



Pais	Región/Zona	Provincia	Parque	Campesitabales (33)	Fecha
ESPAÑA			CAMPISABALOS		27/03/2003
07U4270300					
A01 IG47					
A02 IG47					
A03 IG47					
A04 IG47					
A05 IG47					
A06 IG47					
A07 IG47					
A08 IG47					
A09 IG47					
A10 IG47					
A11 IG47					
A12 IG47					
A13 IG47					
A14 IG47					
A15 IG47					

Instantaneous power provided Yesterday, Today and Tomorrow

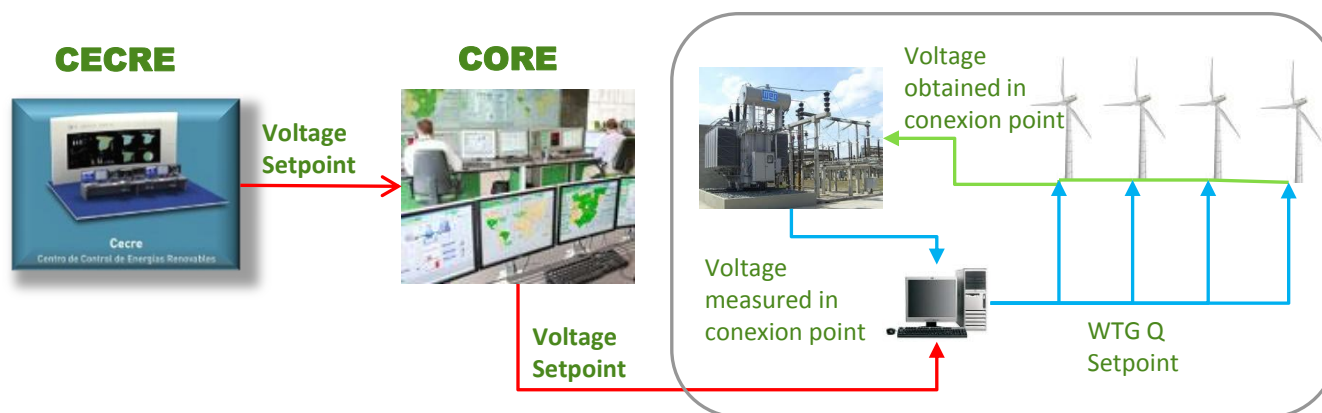


- Today there is forecast in countries such as Spain, Portugal, Mexico, Brazil, France, Germany, Poland, Hungary and Greece.

Control functions for the integration of wind energy in the network

Control Voltage level

The voltage control system that has evolved from reactive power control algorithm is a closed loop that receives a remote voltage setpoint.



Voltage control needs to demand enough reactive power of the turbines to keep the voltage level at the connection point

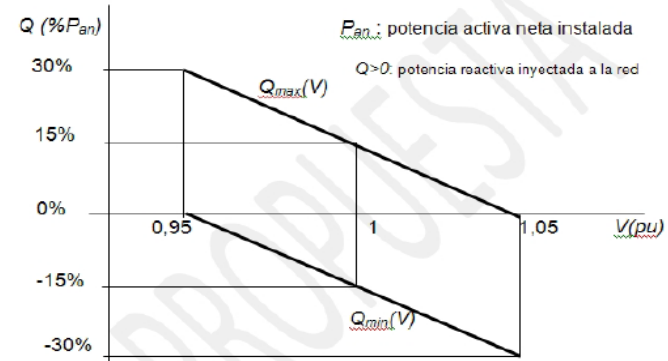
Compared to the control of reactive power, the voltage regulators get better control of voltage profiles and avoid unwanted shutdowns of turbines and greater network stability

Control functions for the integration of wind energy in the network

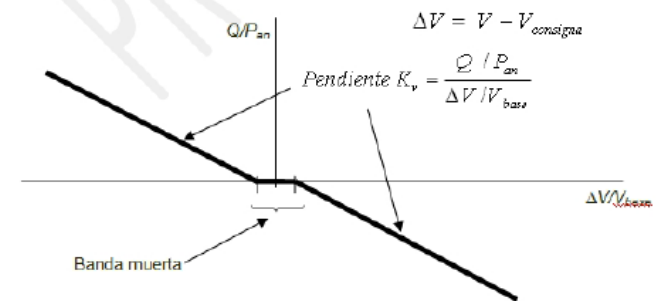
Tests on Voltage Control

For a voltage range of $V1 \leq V \leq V2$ pu (with $V1 \leq 1$ pu and $V2 \geq 1$ pu) wind power facilities must be able to produce or absorb an amount of reactive power according to the limits described in the Figures

The voltage control involves injecting reactive power in order to oppose the voltage error (which is the difference between the voltage setpoint and the measured voltage). The facility will produce/absorb reactive power at the busbar depending on the voltage deviation



Gráfica 2 Requisitos mínimos de generación/absorción de potencia reactiva en función de la tensión en barras de central³



Gráfica 1 Potencia reactiva unitaria en función del desvío unitario de la tensión.

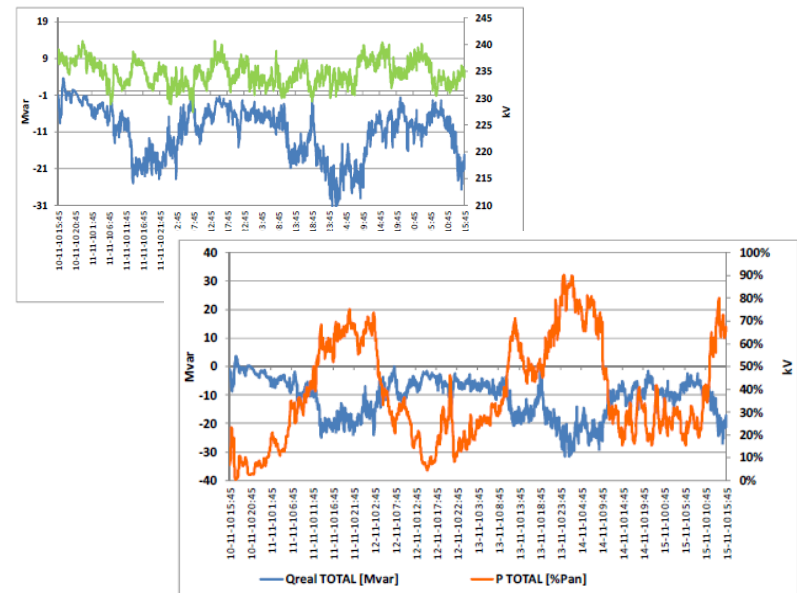
Control functions for the integration of wind energy in the network

Tests with SpainTSO on Voltage Control

The tests were conducted in three phases:

1. It sends a fixed voltage setpoint maintained over time
2. Setpoint changes are made (by varying the control variables)
3. It sends a fixed setpoint maintained over time, considering the most appropriate control parameters according to the results of phase 2.

In all tests the reactive power injected / absorbed by wind farms is in line to the reference voltage and therefore according to the needs of the network.



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Conclusion

- **The Renewable Energies Control Centers allow to control and integrate properly the wind power in the network.**
- **The results show that wind farms can cooperate with the stability of the network in a similar way as conventional generation facilities do.**
- **Iberdrola's wind farms are able to regulate active power, reactive power and voltage level, cooperating with the System Operator in order to ensure network stability**

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Thanks for your attention!



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