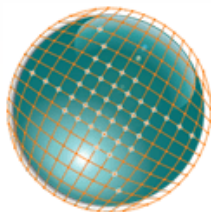


Operational procedures for RES generation in Spain

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4th International Conference on
**Integration of
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Speaker Information And Abstract

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Miguel de la Torre Rodríguez is a senior engineer in Red Eléctrica's Control Center Department where he has been working for the past 6 years. Since 2007 he is head of the Operation Support Area of the National Electrical Control Center (CECOEL). He has been actively involved in the development and commissioning of the Control Center for Renewable Energies (CECRE). At present he supervises and executes the day to day work of the CECRE.

He received a Master's degree in Industrial Engineering by the Universidad Politécnica de Madrid (Spain) in 2004 and a Master's degree in Electrical Engineering by the Technical University of Darmstadt (Germany) in 2003.

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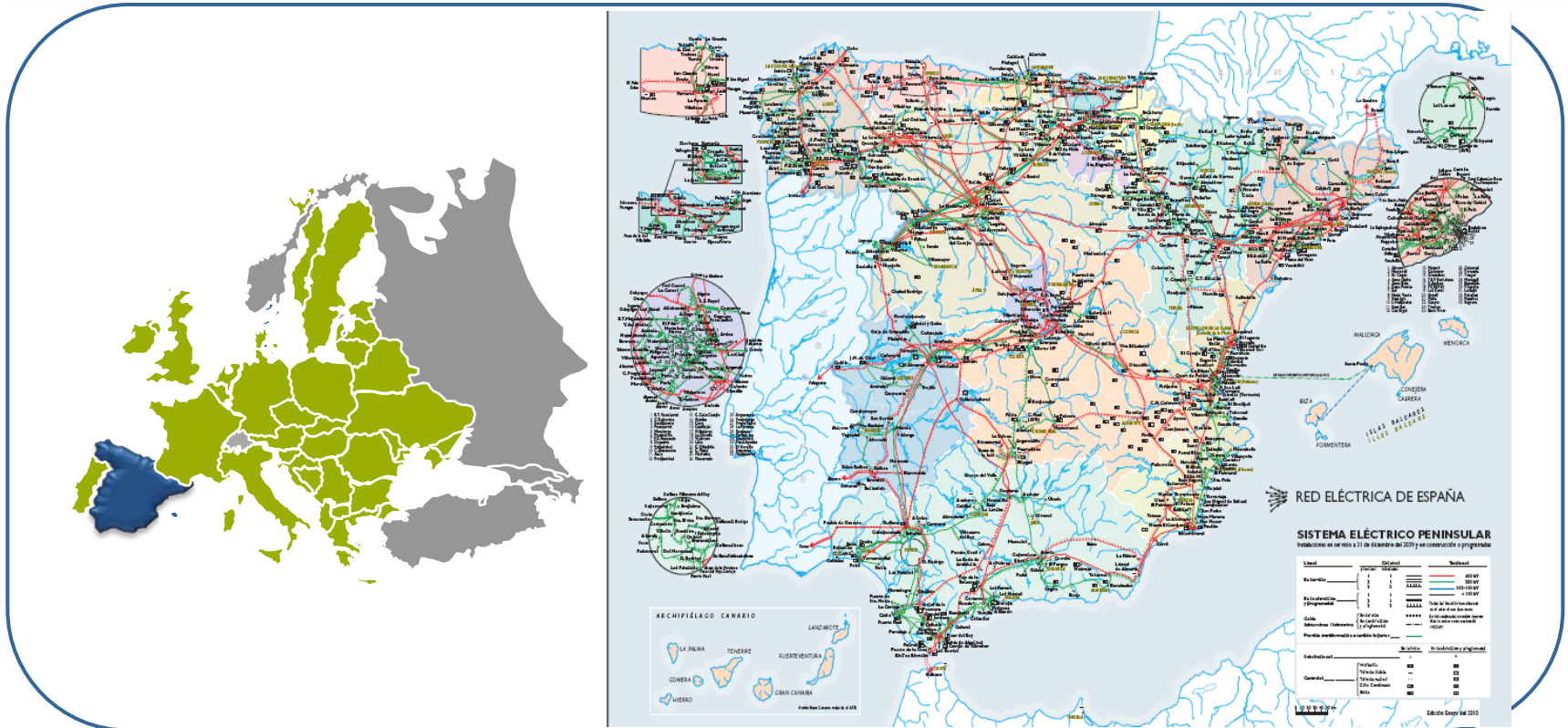
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Who is Red Eléctrica

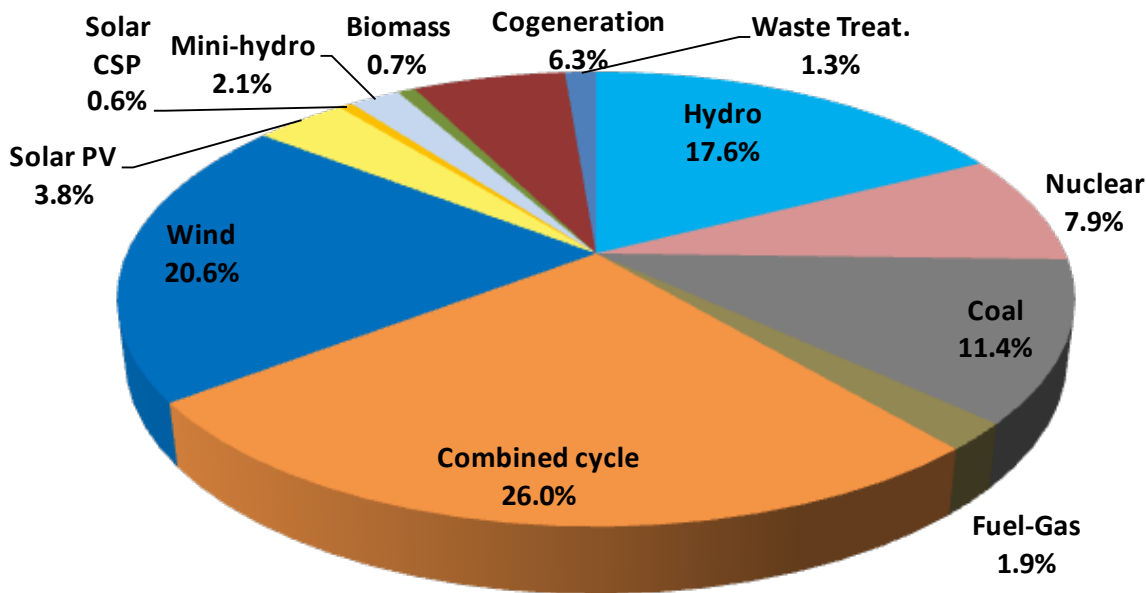
Red Eléctrica de España (REE) is the Spanish transmission system operator (TSO)

REE is operating the mainland system and the island systems

REE was the first company in the world dedicated exclusively to power transmission and the operation of electrical systems.



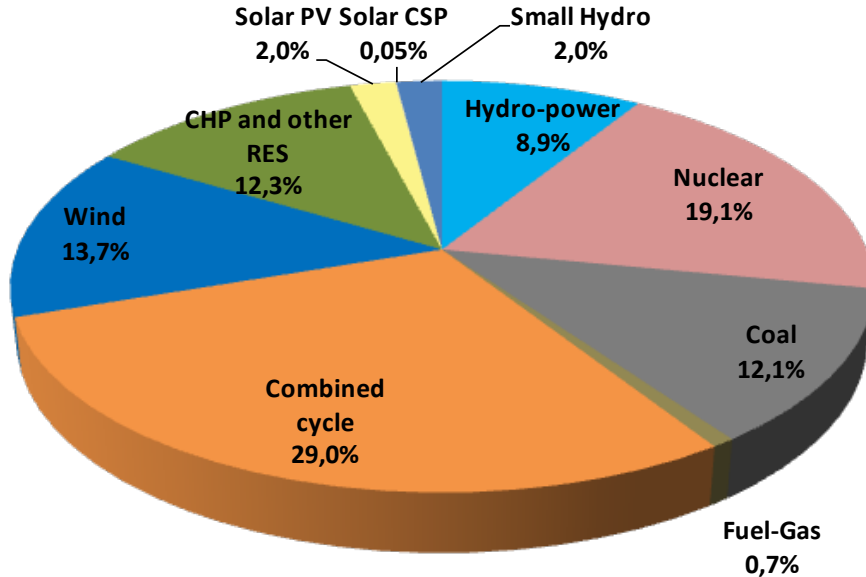
Installed capacity November 2010



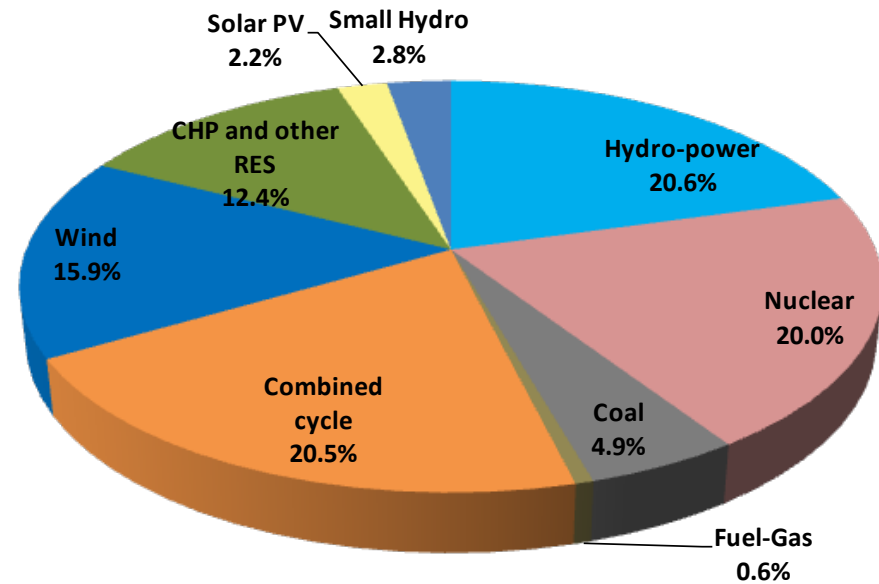
Technology	MW	%
Hydro-power	16 657	17.6
Nuclear	7 716	7.9
Coal	11 357	11.4
Fuel-Gas	1 849	1.9
Combined cycles	24 633	26.0
Total (ordinary regime)	61 383	64.8
Wind power generation	19 584	20.6
Solar PV	3 392	3.6
Solar CSP	531	0.6
Biomass	684	0.7
Special regime hydro	1 965	2.1
Cogeneration	5 946	6.3
Waste treatment	1 204	1.3
Total (special regime)	33 306	35.2
Total	94 689	

Demand supply

Year 2009



Year 2010 Q1+Q2



Requirements and grid codes in Spain

- ❑ Grid codes or operational procedures are approved by the Ministry with consultation to the CNE.
- ❑ Some of the Operational Procedures (PO) apply also to RES units:
 - PO 3.2. Technical constraint management (D-1, real-time...)
 - PO 8.2. System operation of generation and transmission
 - PO 9 Information exchanged with the System Operator (observability)
- ❑ Some are specific for RES generation:
 - RD 661/2007 Voltage control aspects
 - PO 3.7 Controllability of non-manageable RES generation
 - PO 12.3 Voltage dip ride-through capabilities of wind generation
- ❑ In the process of approval:
 - PO 12.2 Requirements for new generators.
 - PO 7.5 Voltage control by RES.
- ❑ ENTSO-e in process of elaborating “Requirements for Generators” which will be proposed to the European Commission.

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Observability and controllability

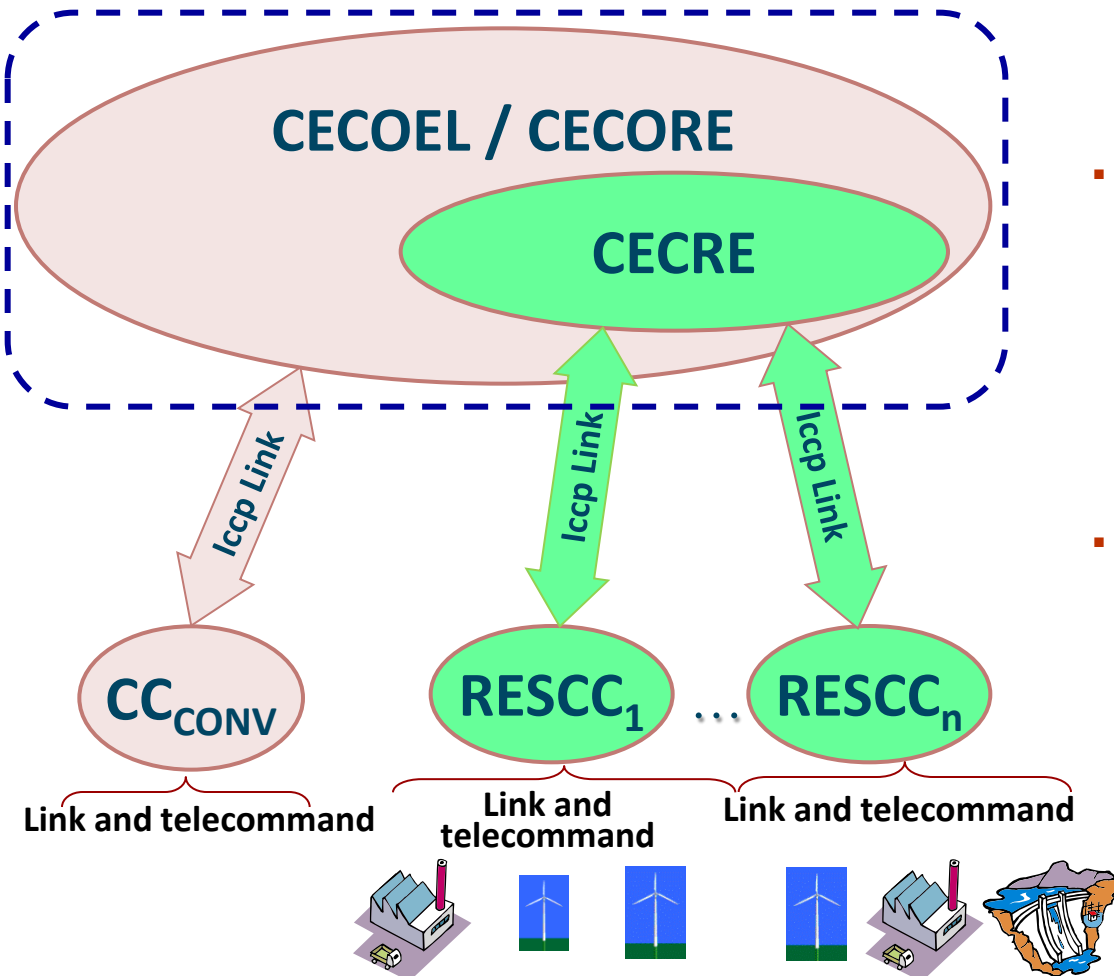
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Observability by the System Operator

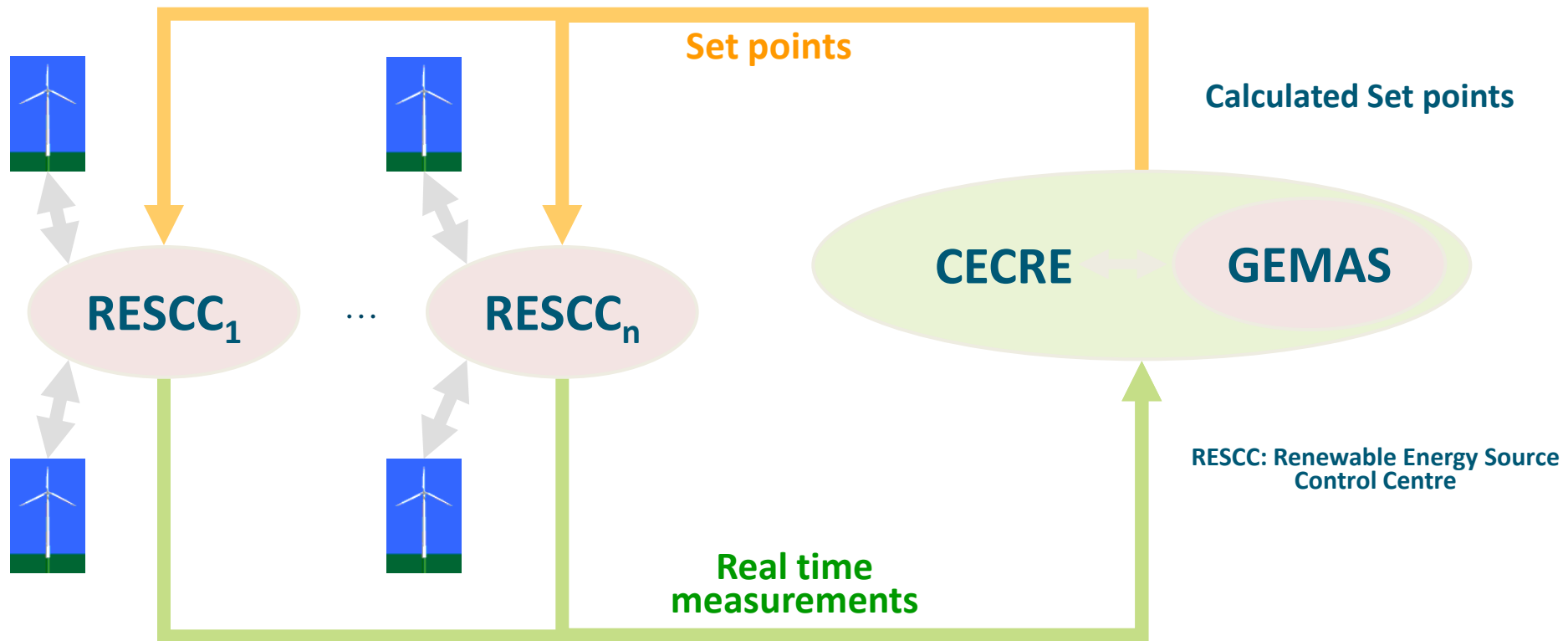


- According to RD661/2007 all special regime facilities >10 MW must be connected to a RESCC.
- RESCC must send in real time every 12 seconds:
 - P, Q and V
 - Wind speed, direction and T (only wind)
- Plants with $P > 1$ MW must send via the distribution control center the real-time measurement of P.

RESCC: Renewable Energy Source Control Centre
 CC_{CONV}: Control Centre for conventional generation

Controllability by the System Operator

- All plants with $P > 10$ MW must be controllable via the RESCC.
- In the case of wind generation, set-points are sent via the ICCP links and production must be adapted within 15 minutes.
- For other RES, instructions are issued by telephone.



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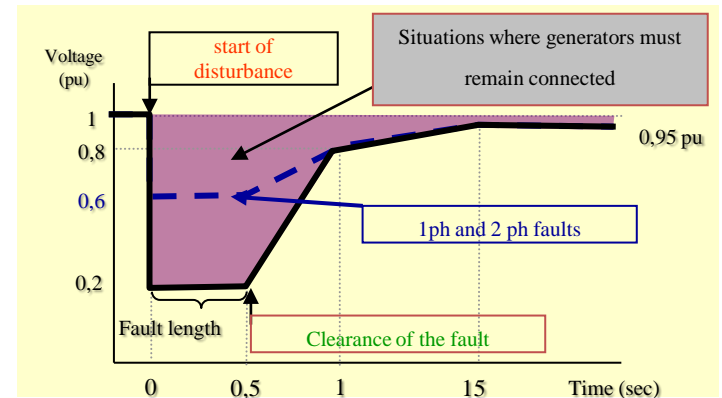
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Wind generation tripping due to voltage dips.



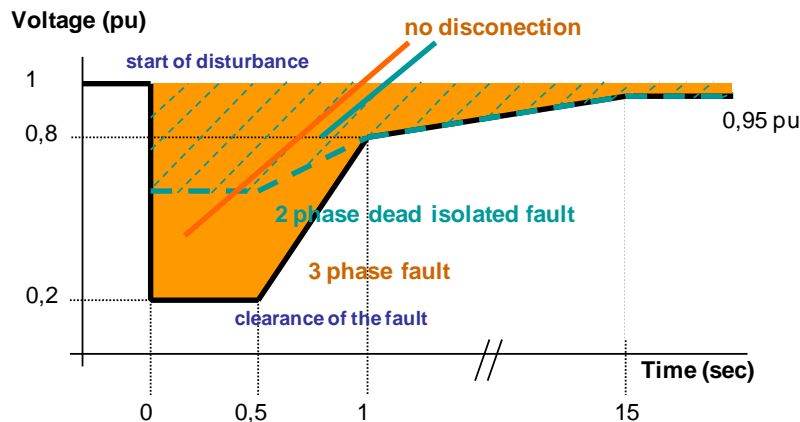
Grid code. Operational Procedure 12.3

- From January 1st 2008 all new wind facilities must comply with PO 12.3. Of the parks that were on-line prior to this date, more than 10 GW have been also certified.
- Still 750 MW of installed wind turbines have no fault-ride-through capabilities for faults shorter than 100ms and voltages lower than 85% p.u.
- RD 1578/2008 for solar PV: new and existing solar PV plants must comply with voltage dip ride-through requirements (In implementation process).

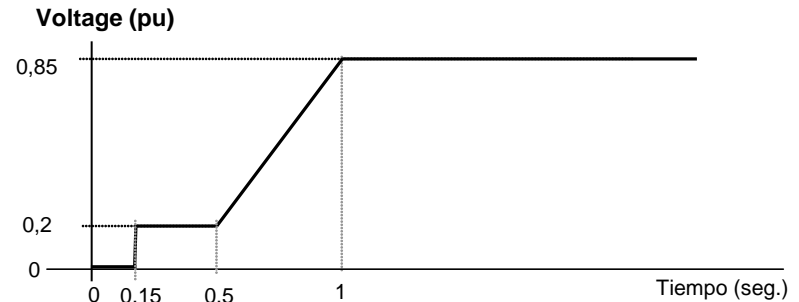
Ride-through capability for wind generation

- As more RES generation displaces conventional generation, the studies show that more strict requirements are needed to maintain system security.
- Comparison between PO 12.3 and PO 12.2 for ride-through capability:

Operational Procedure 12.3
Studies with 20 GW of wind for 2010.
In effect from January 1st 2008



Operational Procedure 12.2
Studies very high contribution of wind
and solar 2020
Pending approval



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Voltage Control (I)

- RD 661/2007 Art. 29: Reactive power bonus or penalization.
From +8 to -4% of 7.8441 c€/kWh depending on the power factor.
Periods do not distinguish between labor days or holidays so producers might behave contrary to system requirements.
- In reality it leads to simultaneous connection/disconnection of capacitors.
- SO may issue instructions to modify these table values for plants larger than 10 MW if voltage problems are detected. This is done regularly.

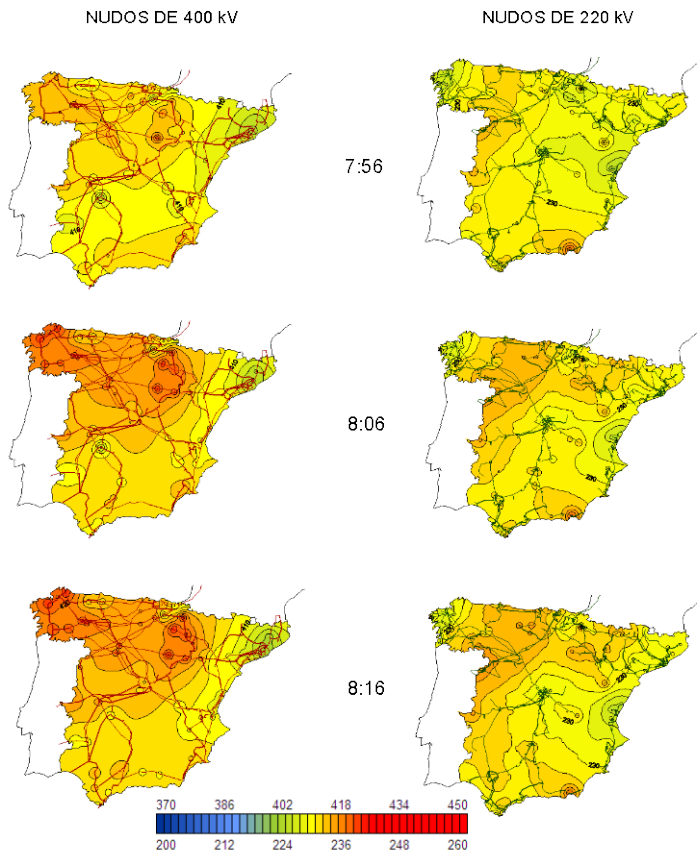
Reactive Power Bonus

Type of	Power Factor	Bonus (%)		
		Peak	Inter	Off-Peak
Inductive	< 0,95	-4	-4	8
	< 0,96 y \geq 0,95	-3	0	6
	< 0,97 y \geq 0,96	-2	0	4
	< 0,98 y \geq 0,97	-1	0	2
	< 1 y \geq 0,98	0	2	0
	1	0	4	0
Capacitive	< 1 y \geq 0,98	0	2	0
	< 0,98 y \geq 0,97	2	0	-1
	< 0,97 y \geq 0,96	4	0	-2
	< 0,96 y \geq 0,95	6	0	-3
	< 0,95	8	-4	-4

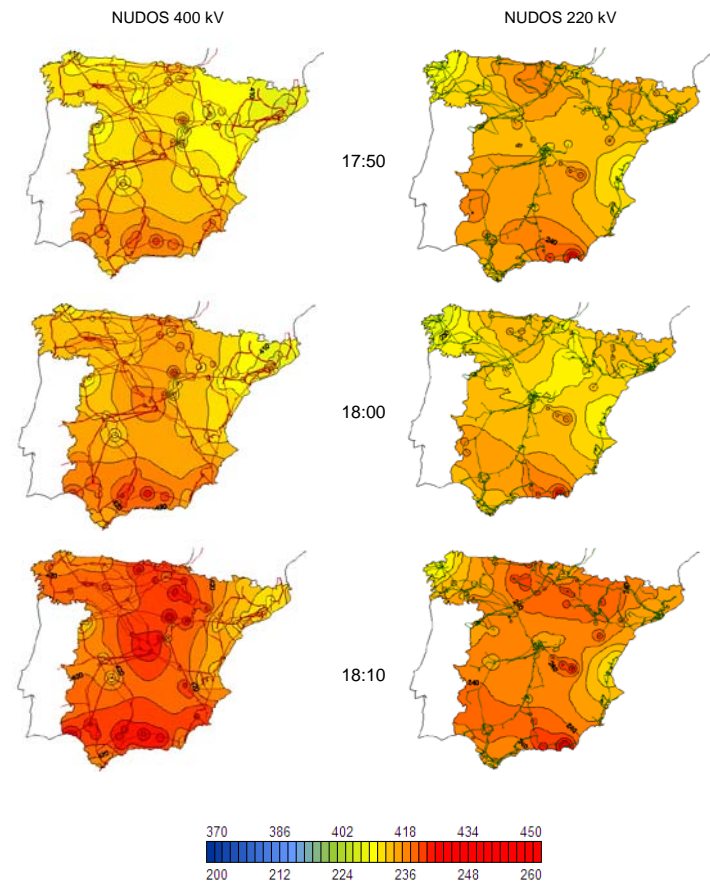
Zona	Invierno			Verano		
	Punta	Llano	Valle	Punta	Llano	Valle
Zona 1	16-22	8-16 22-24	0-8	8-14	14-24	0-8
Zona 2	17-23	8-17 23-24	0-8	9-15	8-9 15-24	0-8
Zona 3	16-22	8-16 22-24	0-8	9-15	8-9 15-24	0-8
Zona 4	17-23	8-17 23-24	0-8	10-16	8-10 16-24	0-8
Zona 5	16-22	7-16 22-23	0-7 23-24	17-23	0-1 9-17 23-24	1-9
Zona 6	16-22	7-16 22-23	0-7 23-24	17-23	8-17 23-24	0-8
Zona 7	17-23	8-17 23-24	0-8	18-24	0-1 9-18	1-9

Voltage Control (II)

- Voltage variations during off peak to peak periods (9/3/2009)

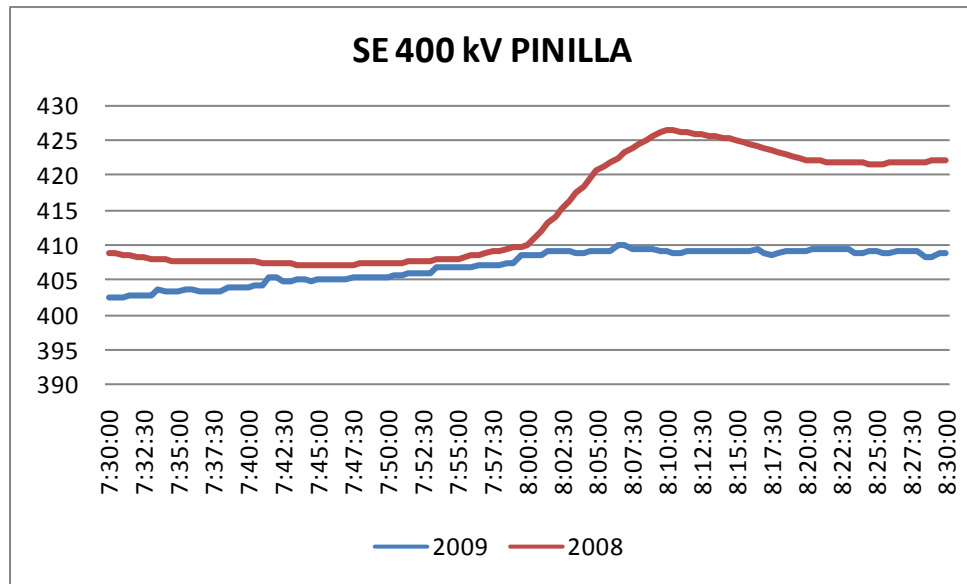


- Voltage variation during intermediate to peak periods. (7/2/2009)



Voltage Control (II)

- From 1/4/2009, all the special regime installations higher than 10 MW are obliged 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.
 - In order to avoid high voltage problems in the system.

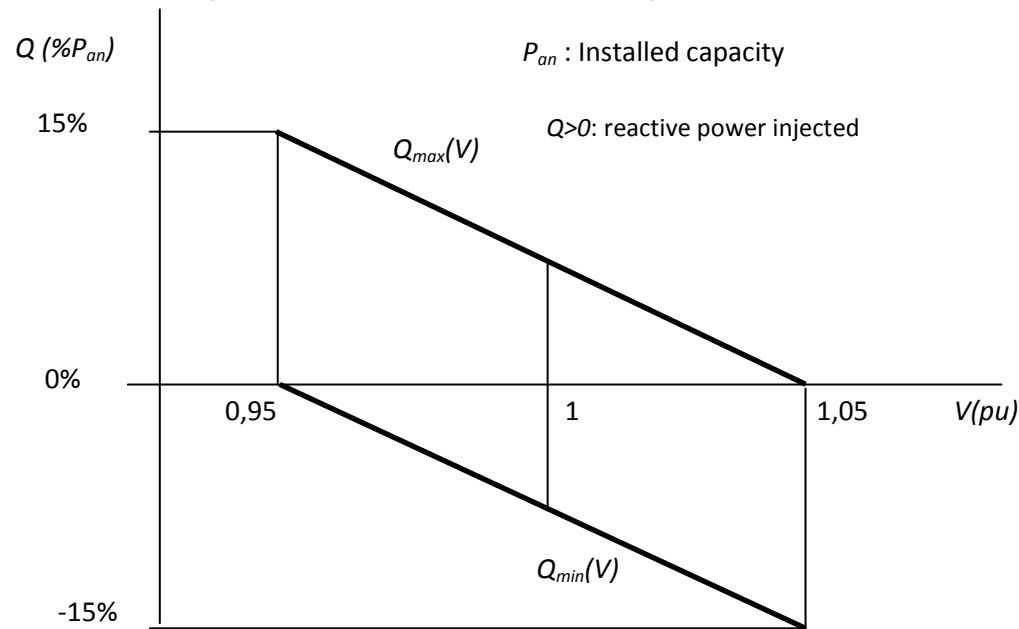


- Final Solution: continuous voltage control through the CECRE. New regulation already proposed to the Ministry.

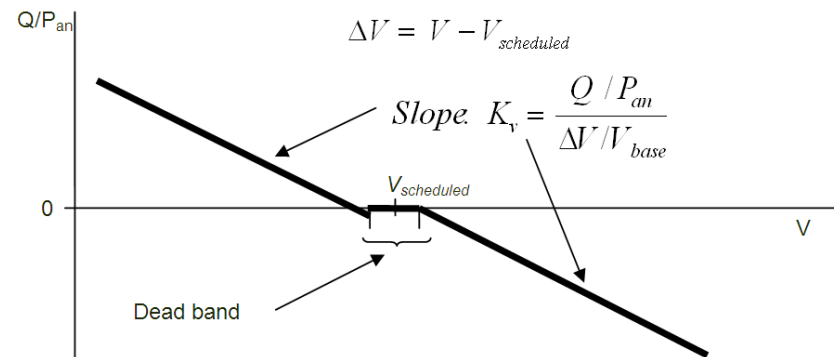
New proposed voltage control

- New proposal of continuous voltage control for $P > 10$ MW.
- The SO will issue voltage set-points at the generation bus-bar. The generation facility must produce/consume reactive power up to 15% of active power to maintain these set-points.
- The set points can change each minute.

Limits for reactive power production/consumption.



Control strategy depending on ΔV with respect to voltage set-point.



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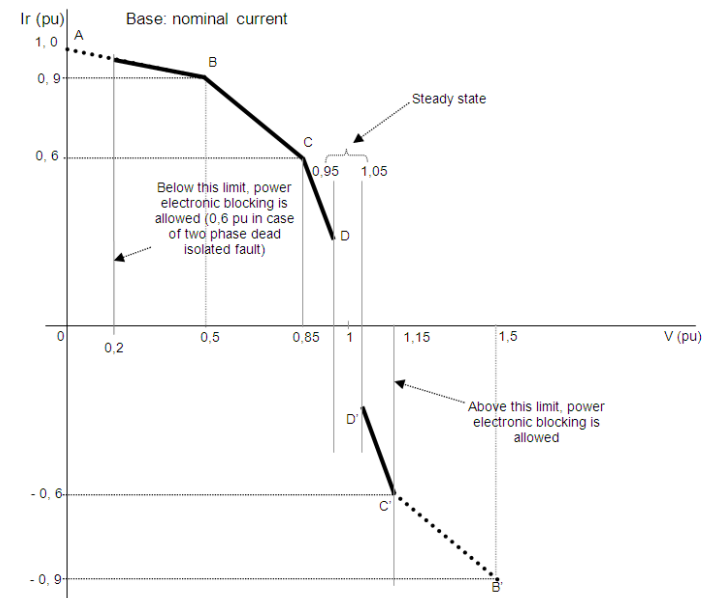
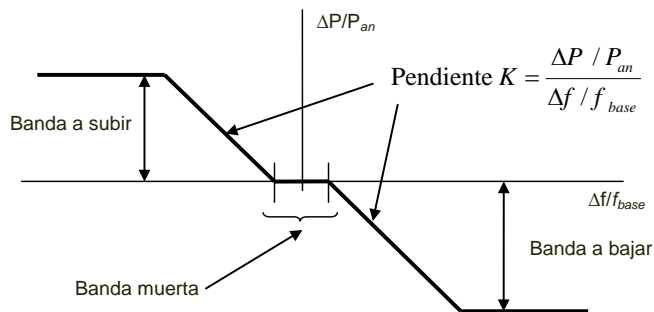
Voltage control

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New requirements in proposal P.O. 12.2

- Specific requirements for plants connected synchronously or with power electronics.
- For plants with $P > 10$ MW of connected to the transmission grid
 - Possibility of providing frequency control
 - Permanent regime voltage control
 - Disturbed regime voltage control
 - Voltage ride-through capabilities
 - Inertia emulation
 - Oscillation damping
- New Operational Procedures will be developed or updated to use these future capacities.



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- ❑ RES in Spain have reached high penetration levels and will continue to rise for several years.
- ❑ Thanks to the approval of regulation and grid codes that apply to RES generation we can speak of successful integration.
- ❑ Control and supervision of RES generation needed to maximize RES integration maintaining security of supply.
- ❑ As the installed capacity increases RES generators must be prepared to be the main generation in the system during certain times. New requirements needed.
- ❑ Requirements should be harmonized as much as possible in neighbouring areas.

Thanks for your attention!



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