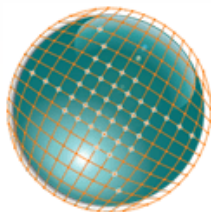


Large-Scale Renewable Energy Integration in Spain

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4th International Conference on
**Integration of
Renewable and Distributed
Energy Resources**
December 6-10, 2010
Albuquerque, NM, USA

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Speaker Information And Abstract

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Control Center Department
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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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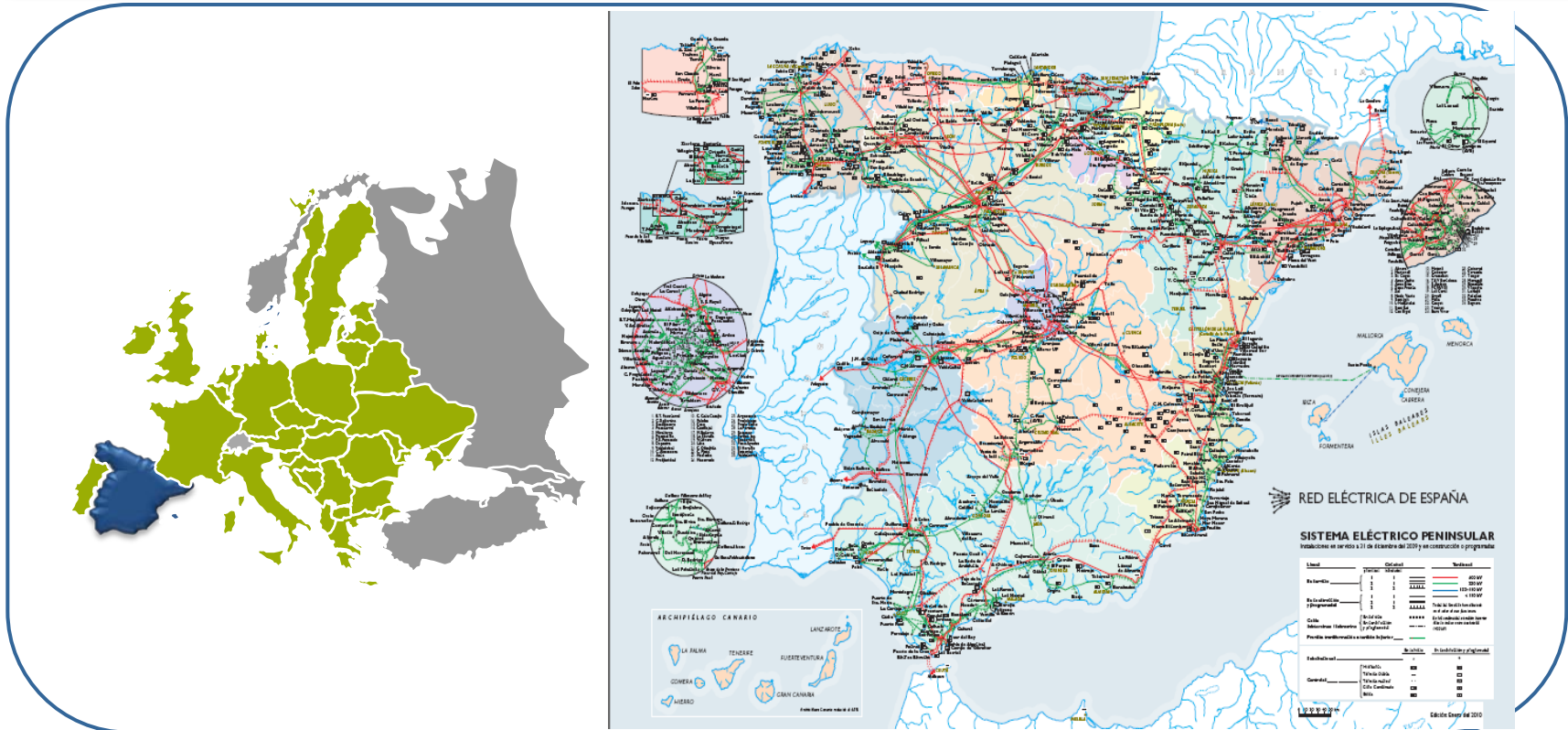
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Who is Red Eléctrica

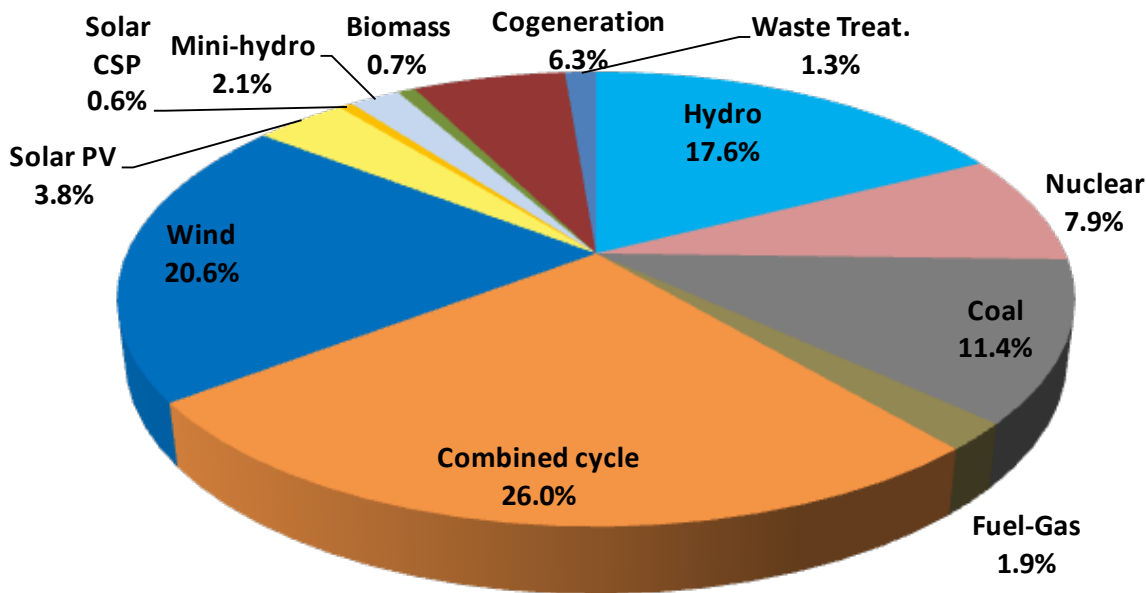
Red Eléctrica de España (REE) is the Spanish transmission system operator (TSO)

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.



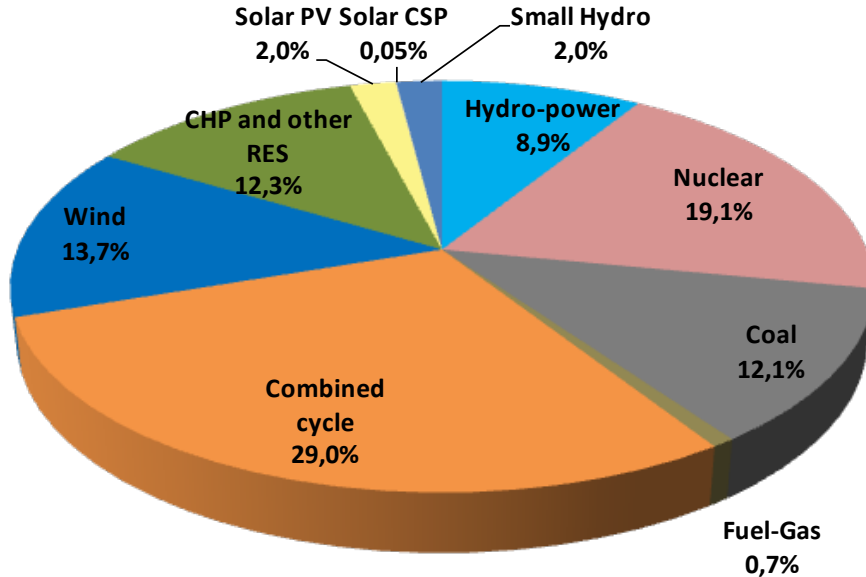
Installed capacity November 2010



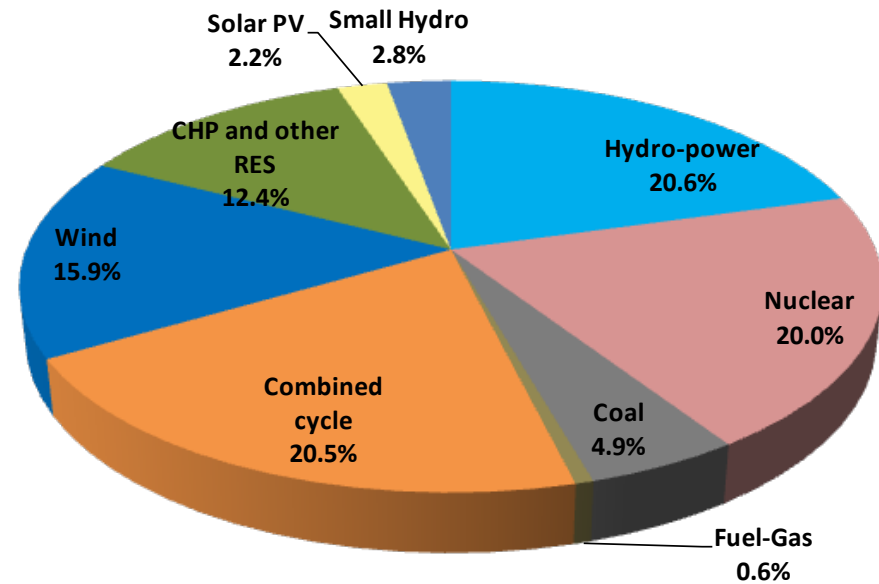
Technology	MW	%
Hydro-power	16 657	17.6
Nuclear	7 716	7.9
Coal	11 357	11.4
Fuel-Gas	1 849	1.9
Combined cycles	24 633	26.0
Total (ordinary regime)	61 383	64.8
Wind power generation	19 584	20.6
Solar PV	3 392	3.6
Solar CSP	531	0.6
Biomass	684	0.7
Special regime hydro	1 965	2.1
Cogeneration	5 946	6.3
Waste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

Demand supply

Year 2009



Year 2010 Q1+Q2



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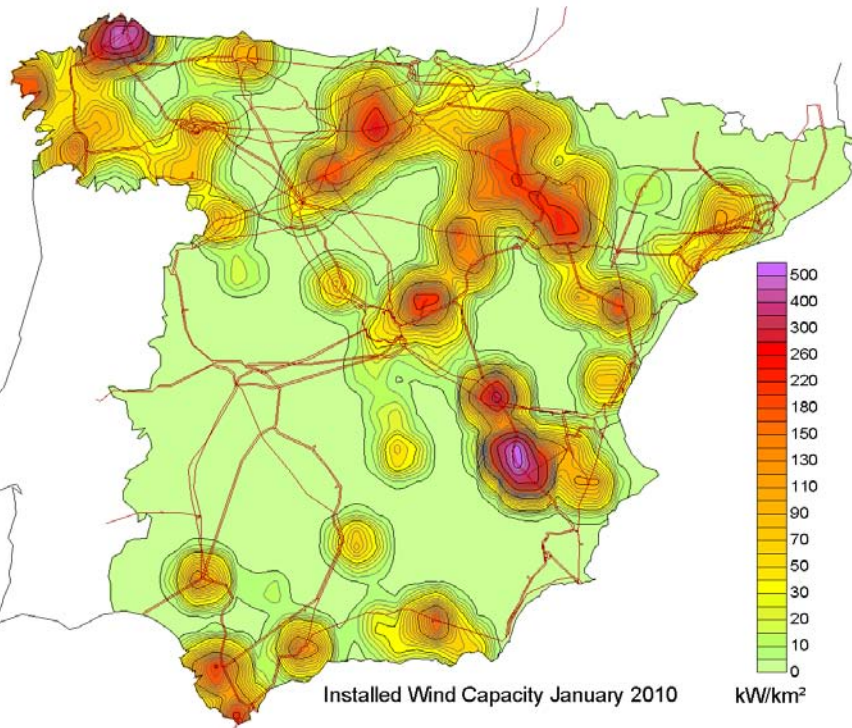
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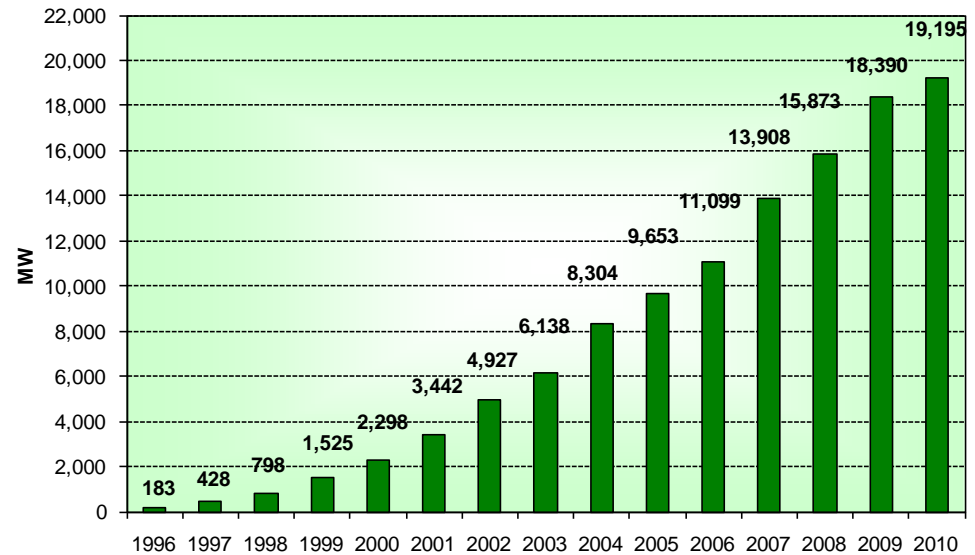
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Wind power capacity and evolution

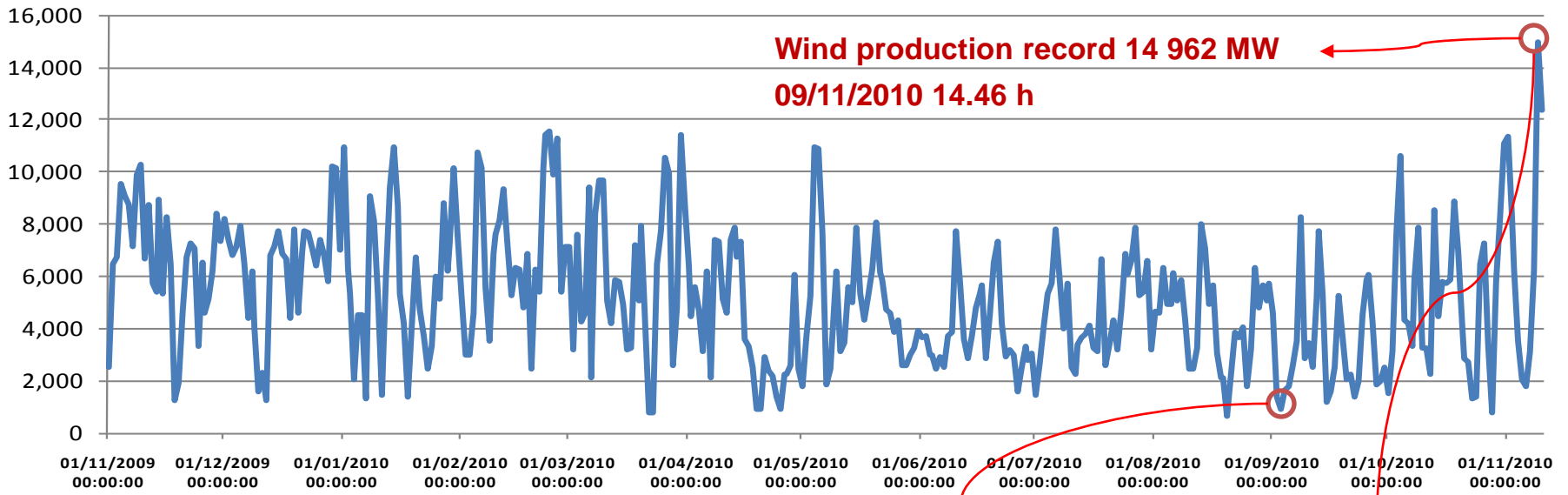


Installed Wind power generation evolution 1996-2010

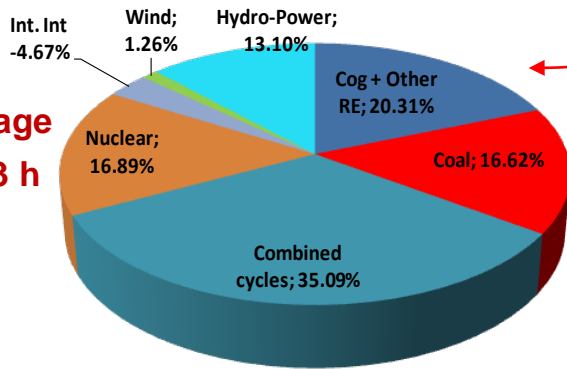


- ❑ Renewable Energies' Plan for Spain (August 2005): ~20,000 MW by the year 2010.
- ❑ Official Network Planning for 2016 contemplates ~29,000 MW.
- ❑ Renewable Energies Plan for Spain 2010-2020 ~38,000 MW.

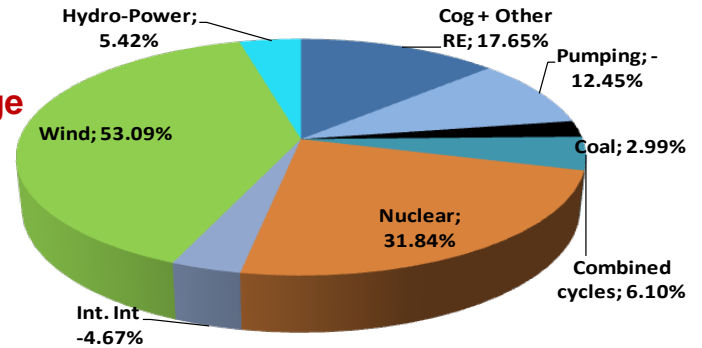
Wind production variability



Minimum coverage
03/09/2010 12.33 h



Maximum coverage
09/11/2010 3.35 h



Influence of solar photovoltaic in system operation

- ❑ 2% of the total energy demand in 2009 (5 347 GWh).
- ❑ Present installed capacity: 3 392 MW.
- ❑ Reduced observability by the SO. Must be solved.
- ❑ Behavior in summer in accordance to demand requirements.
- ❑ In winter, peak demand is in the evening. No contribution.
- ❑ Connection to Transmission/Distribution: 2/98%

YEAR	SOLAR PV PRODUCTION (GWh)
2005	40
2006	103
2007	466
2008	2 477
2009	5 347

Source CNE



Integration of solar CSP in system operation

- ❑ Present installed capacity 531 MW.
- ❑ In the short term: increase of ~500 MW per year.
- ❑ Two technologies: parabolic trough and tower.
- ❑ Connection to Transmission/Distribution: 63/37%

- ❑ Year 2007: first commercial solar thermoelectric plant installed (PS-10)
 - Installed capacity: 11 MW (as a part of the Solucar project with expected 300 MW en 2013).

- ❑ Energy in Q1+Q2+Q3 2010 : 487 GWh.
- ❑ Planning 2010-2012: 500 MW per year of new installed capacity.
- ❑ Positive correlation with demand in summer.
- ❑ In winter molten salt storage allow production during the daily load peaks becoming mostly manageable generation.



Planta PS-10

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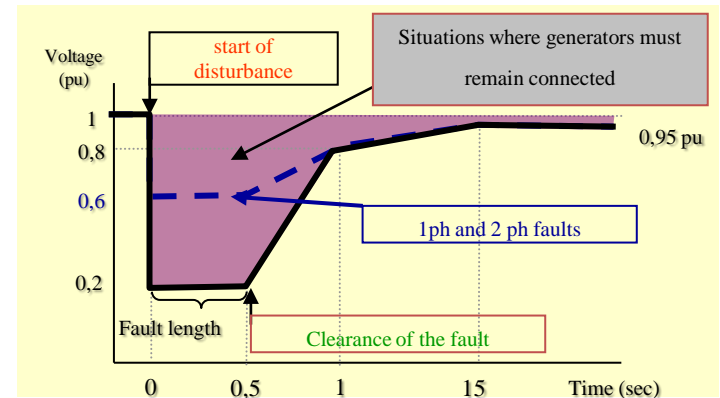
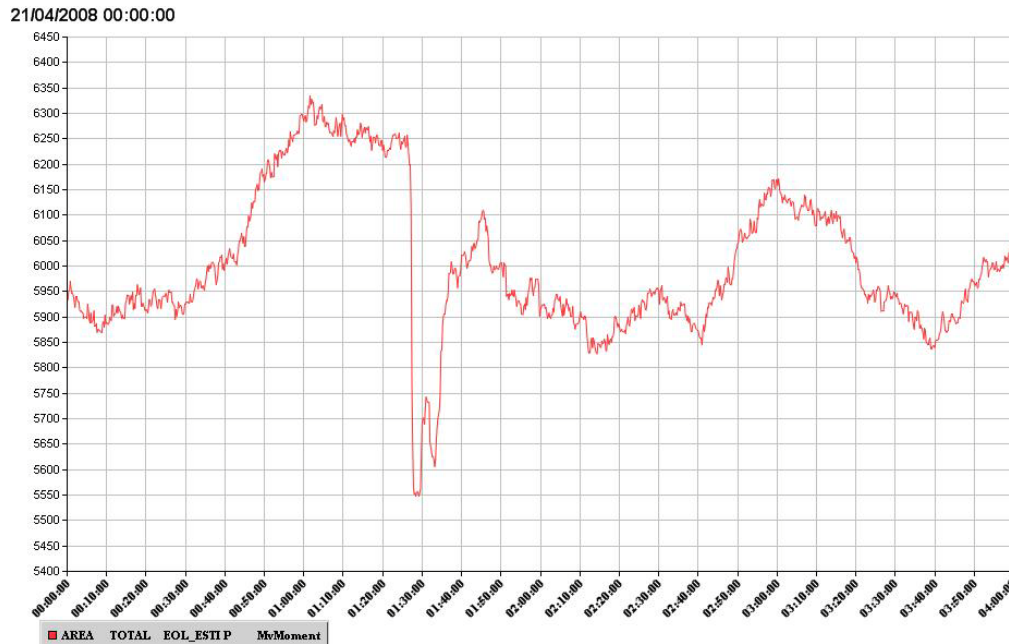
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Wind generation tripping due to voltage dips.



Grid code. Operational Procedure 12.3

- Monitoring of wind generation tripping due to voltage dips since June 2005.
- 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 9 800 MW have been also certified.
- Still 1 500 MW of installed wind turbines have no fault-ride-through capabilities for faults shorter than 100ms and voltages lower than 85% p.u.
- REE runs real-time monitoring of highest generation tripping that may occur by means of simulating three-phase solid faults in 70 different 400 kV substations.

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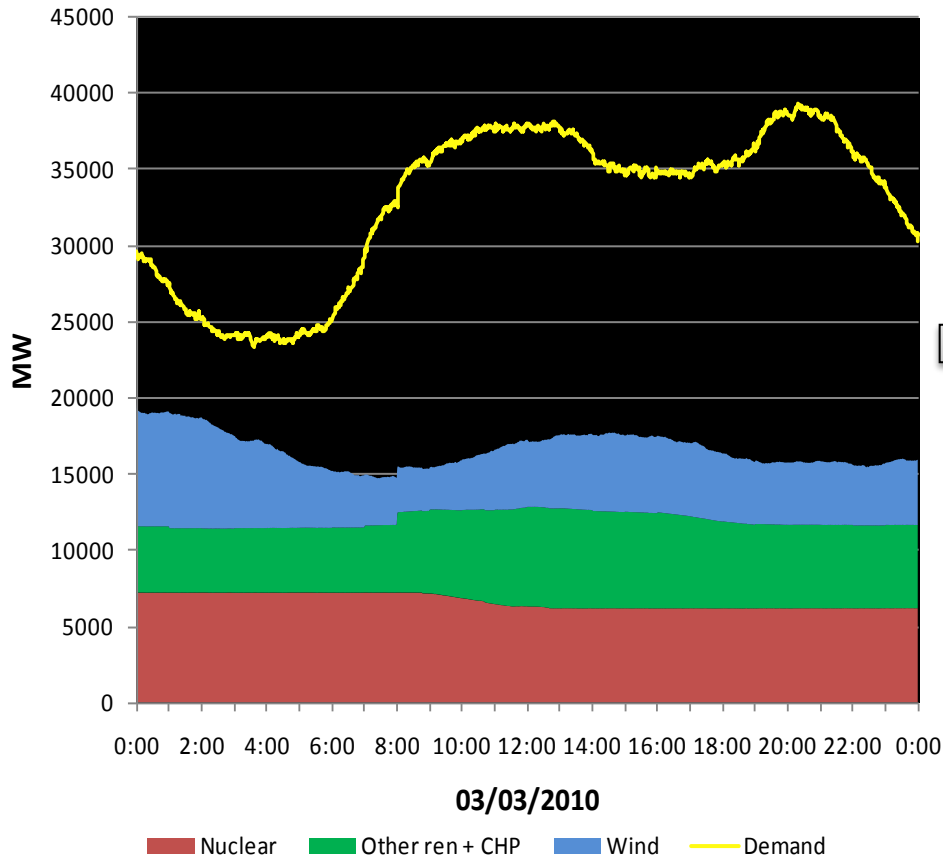
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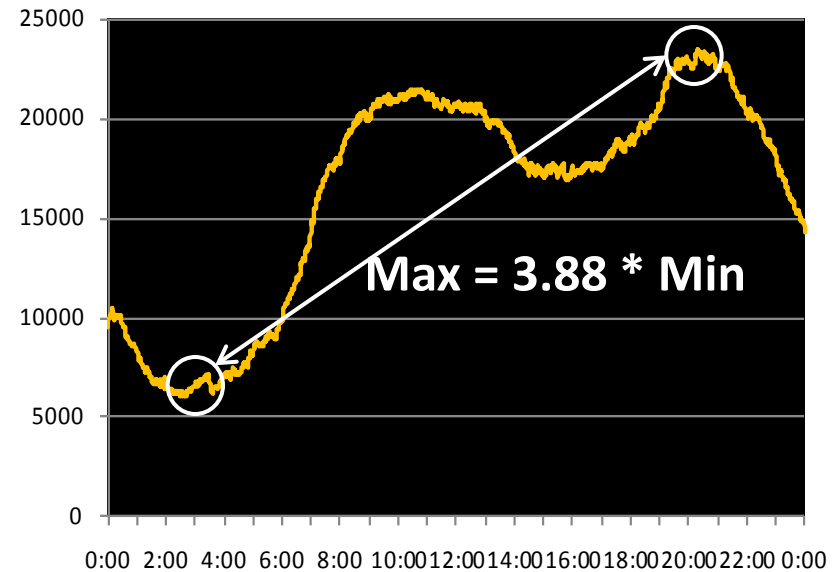
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Requirement for manageable generation (I)

Demand vs requirement



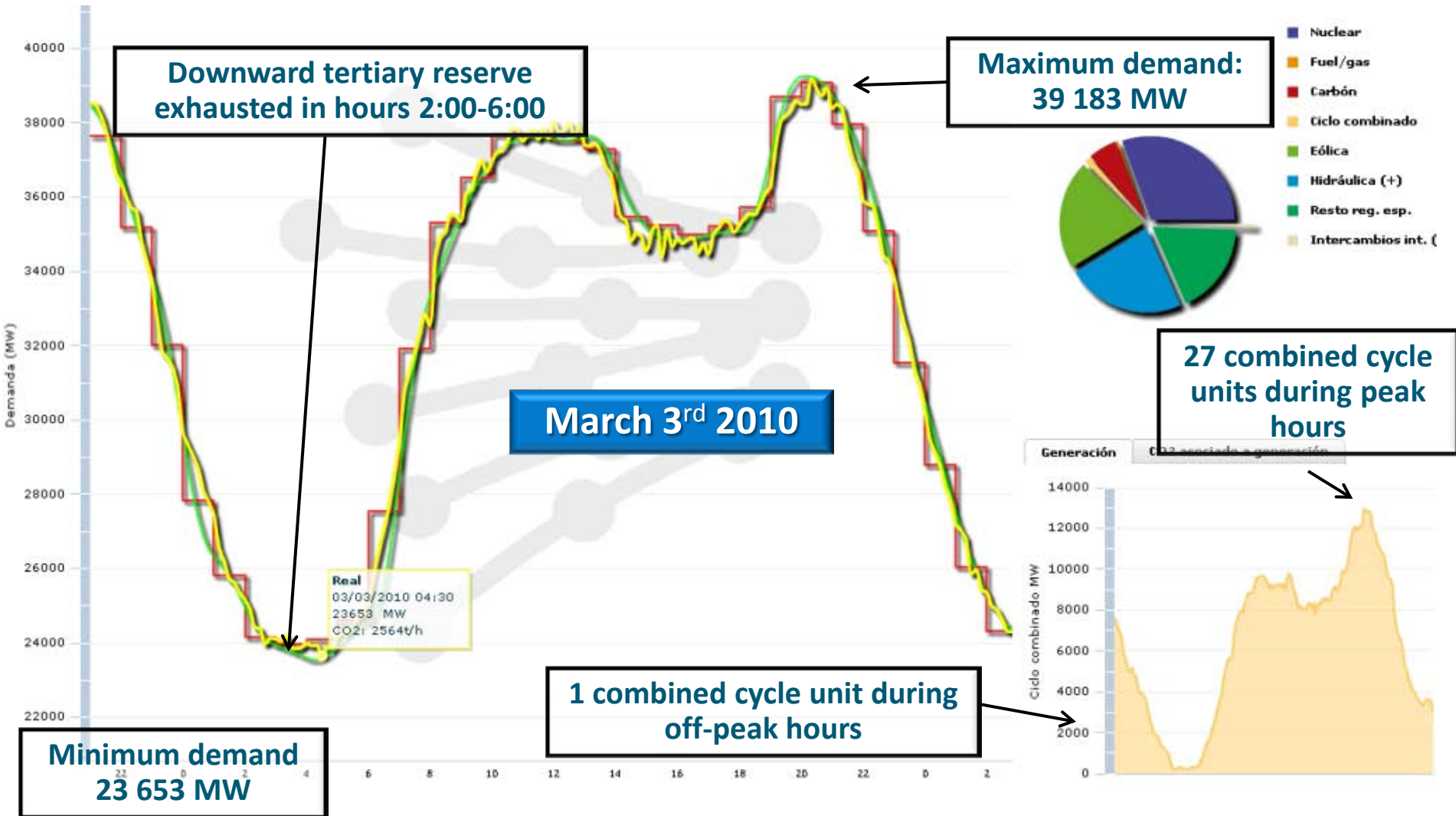
Requirement



- ❑ Thermal groups must be disconnected during off-peak hours.
- ❑ Some thermal plants maybe needed for local constraints.

Energy Storage facilities and flexible CCGTs are the key technologies to manage wind variability

Requirement for manageable generation (II)



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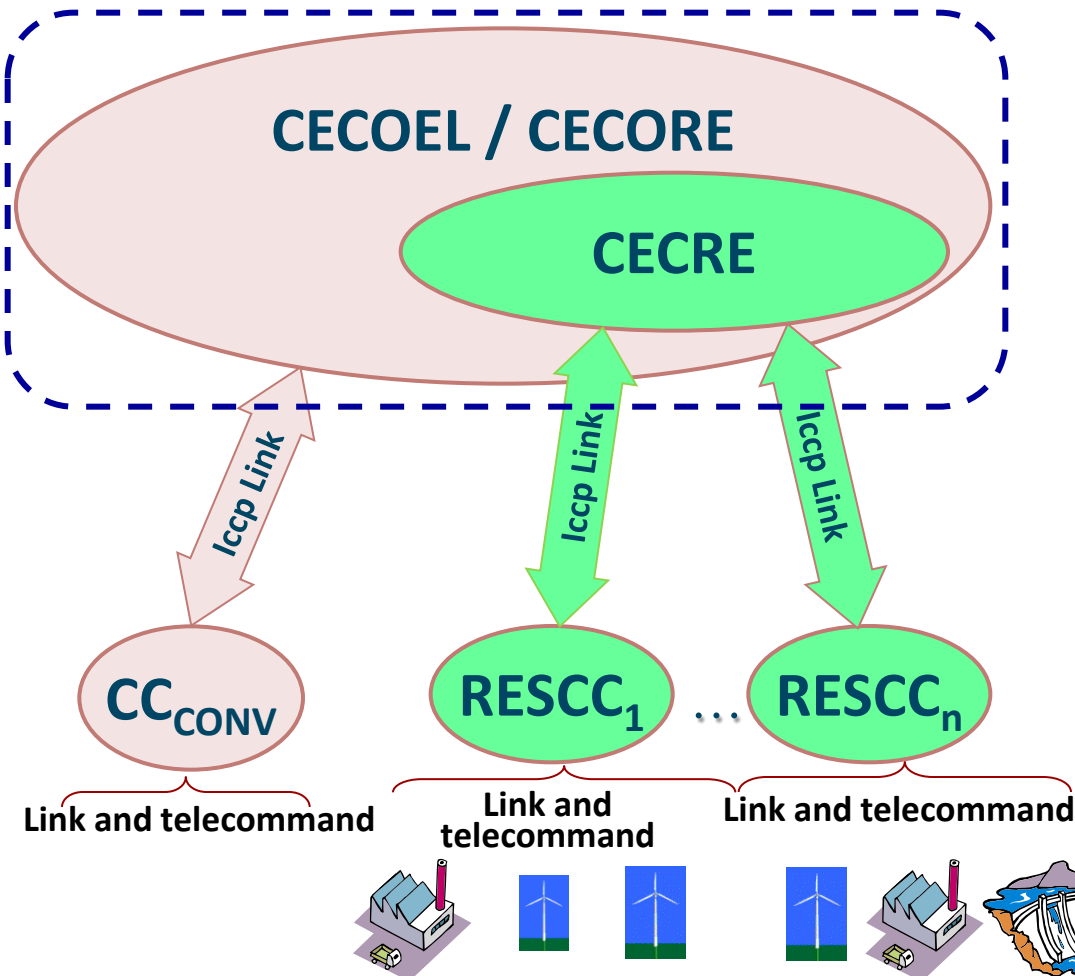
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The Control Center for Renewable Energies

- REE's goal: Integrate the maximum possible renewable generation integration while maintaining security of supply.
 - Creation of the Control Centre for Renewable Energies (CECRE)
 - Control and supervision of RES generation and CHP.
 - Coordination with RES and CECOEL.



CECRE: functional scheme



CECRE is a control centre devoted to special regime generation and specially to wind power:

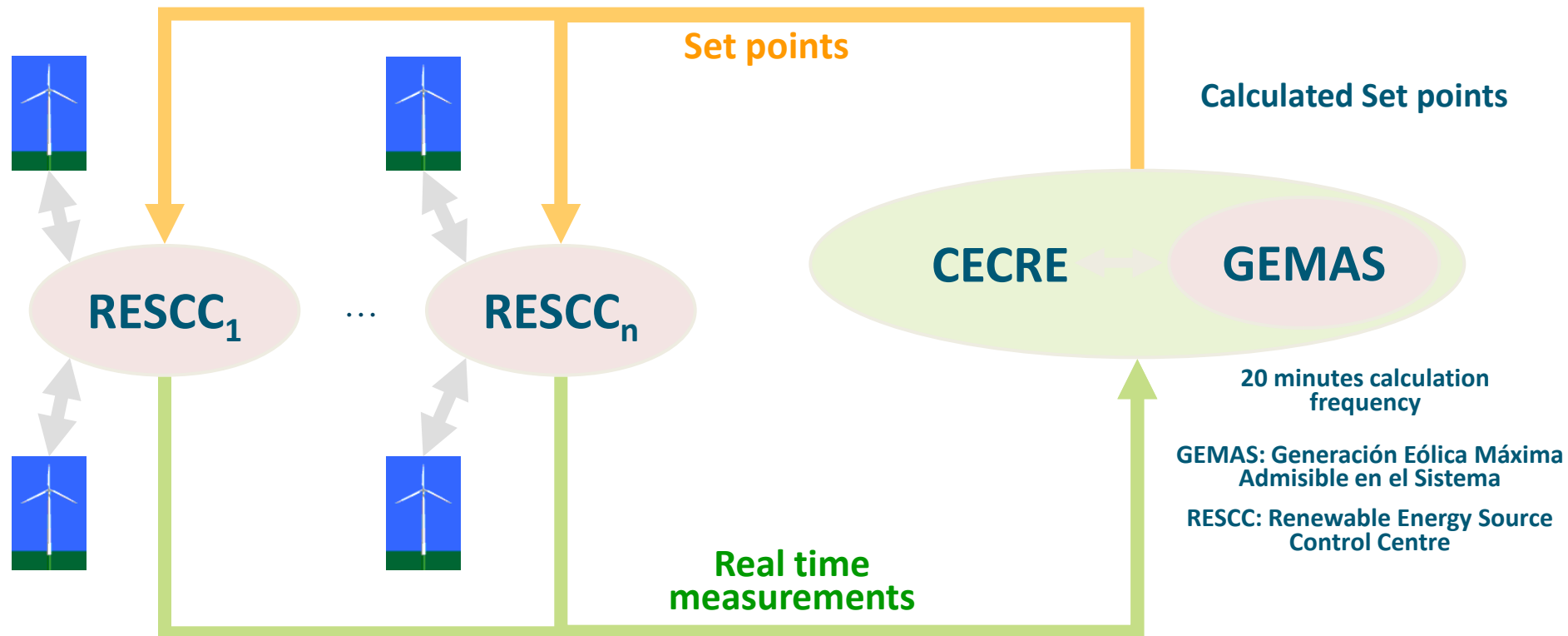
- Integrated in REE's control structure
- Communication with generation Control Centres for supervision and control instructions.
- According to RD661/2007 all special regime facilities >10 MW must be connected to a RESCC.
- CECRE issues generation limitations through the SCADA system to the Control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

RESCC: Renewable Energy Source Control Centre

CC_{CONV}: Control Centre for conventional generation

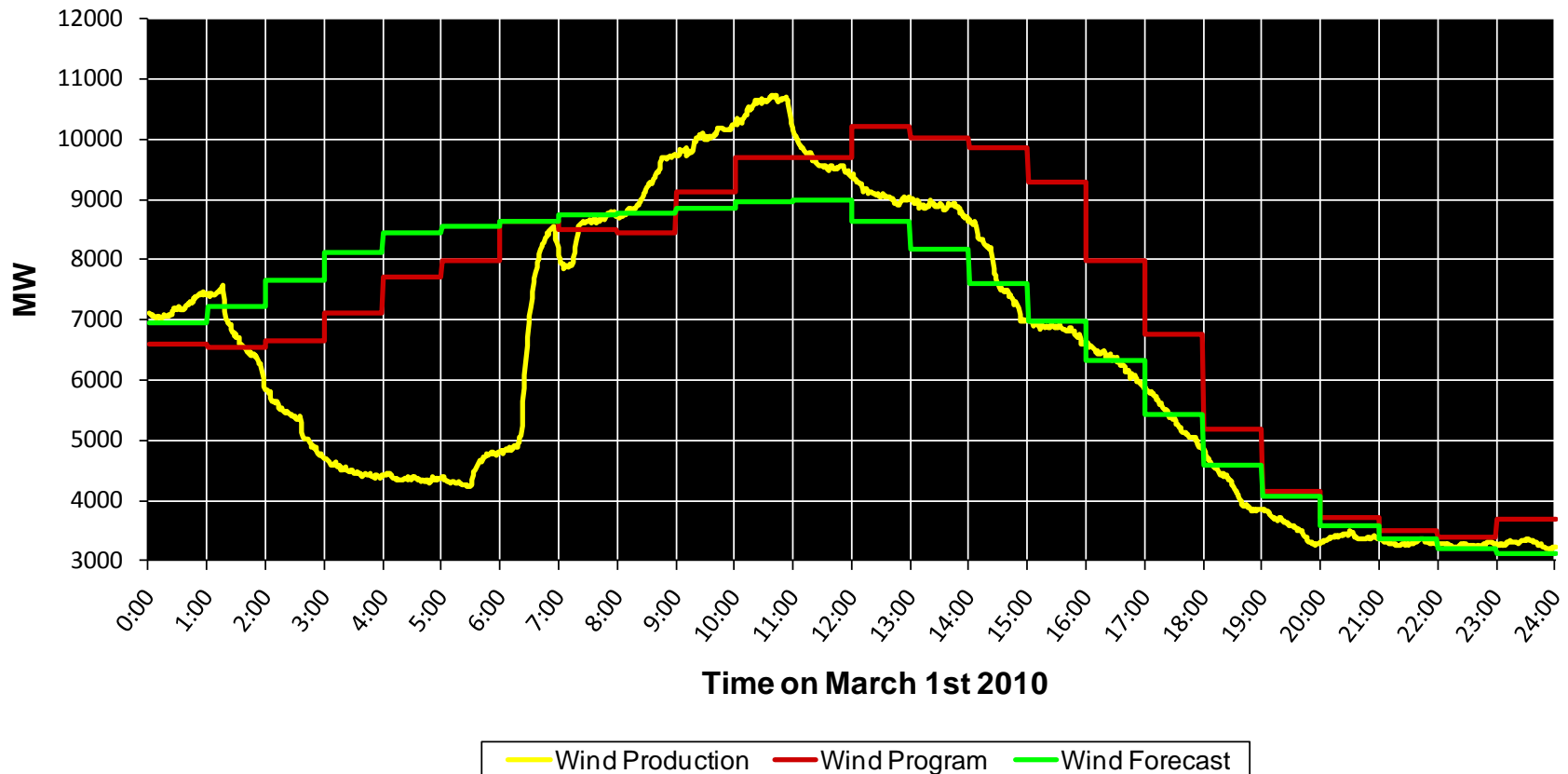
CECRE's control and supervision scheme

- ❑ CECRE checks if with the real-time wind scenario the System is safe due to voltage dips, congestions or balancing.
- ❑ If not, set-points are calculated and sent to the RESCC.
- ❑ Presently only done for wind generation, but a similar methodology can also be applied for all renewable energy sources.



CECRE may issue wind generation curtailments

- ❑ Wind and demand forecast error during off-peak hours.
- ❑ System ran out of tertiary reserve. Low secondary downward reserve during some instants.
- ❑ Wind generation curtailments issued from 1:12 to 6:19 h.



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- ❑ RES in Spain have reached high penetration levels and will continue to rise for several years.
- ❑ Control and supervision of special regime generation needed since it is already a large portion of the Spanish generation mix.
- ❑ RESCC and the CECRE improve the integration of special regime generation in the System Operation making these technologies compatible with security of supply.
- ❑ Better and safer integration means that more renewable energy may be installed at the same risk level.
- ❑ CECRE provides a fast and automatic way of curtailment in case of emergency maximizing generation while keeping the system safe.

Thanks for your attention!



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