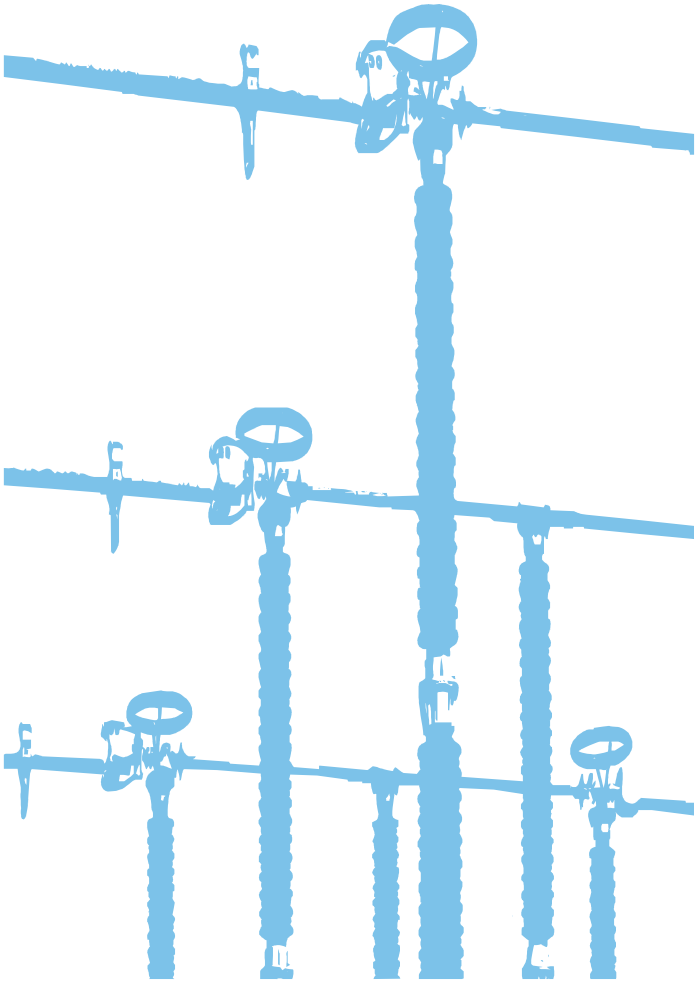
RED ELÉCTRICA DE ESPAÑA

Ancillary Services in Spain: dealing with High Penetration of RES

Ignacio de la Fuente

1985-2010 25 años



Brief review of Spanish Ancillary services scheme

Renewable energy in Spain today

Challenges integrating renewable energy nowadays

Wind forecast and use in reserve calculation

Influence of wind power on balancing reserves

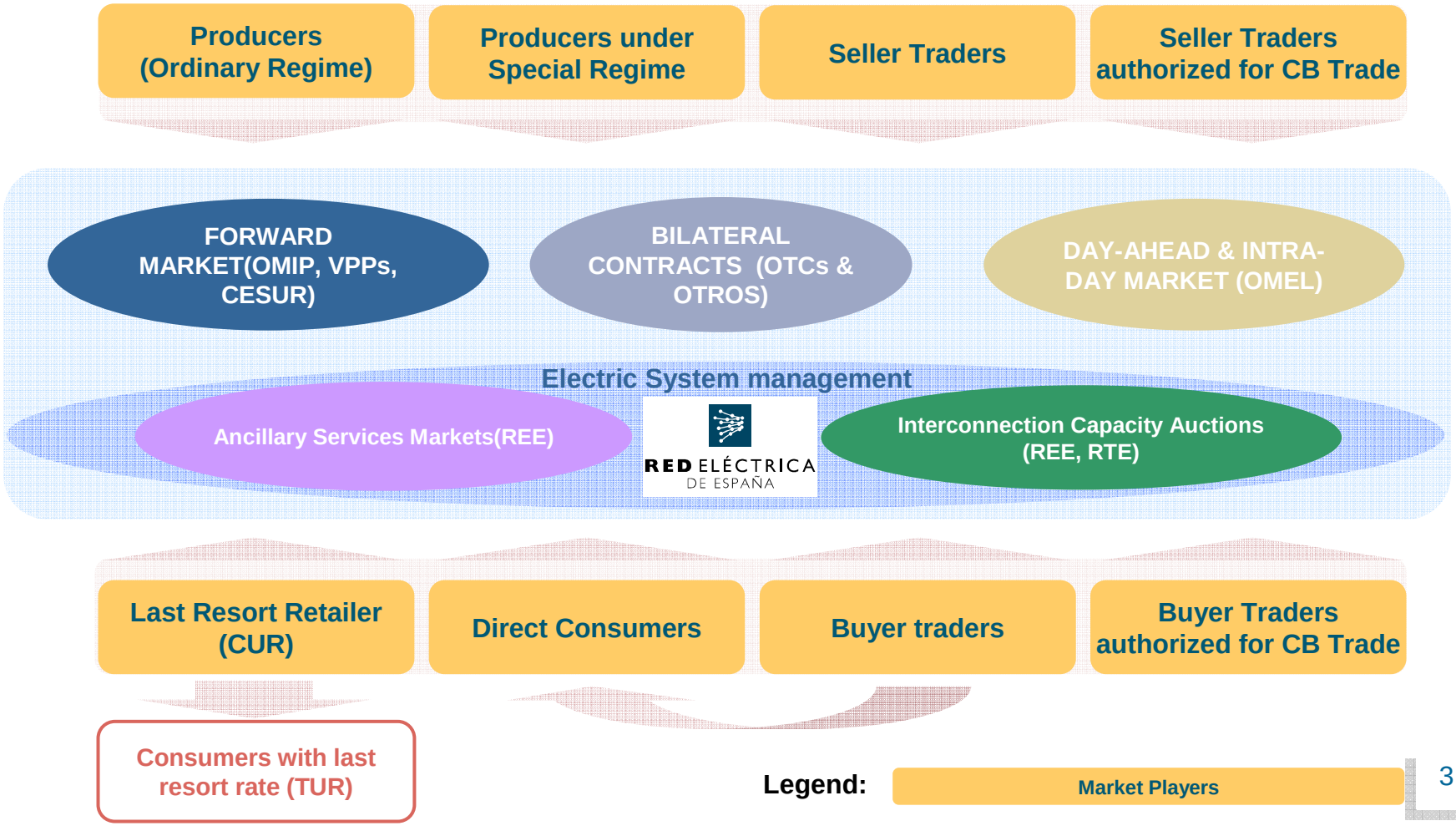
Real time actions to restore system reserves

Control centre for renewable energies (CECRE)

Challenges integrating renewable energy for tomorrow

Conclusions

General scheme of the electricity market



System balancing services

Type	Definition
Primary Regulation	Action of speed regulators from generator units responding to changes in system frequency (<30 s to 15 minutes)
Secondary Regulation	Automatic and hierarchical control that faces changes in system frequency and power deviations with respect to France-Spain exchange program. (≤100 s to 15 minutes)
Tertiary Regulation	Manual power variation with respect to a previous program in less than 15 minutes. (<15 min to 2 hours)
Slow reserve	Running reserves of connected thermal units (30 min. to 4-5 hours)

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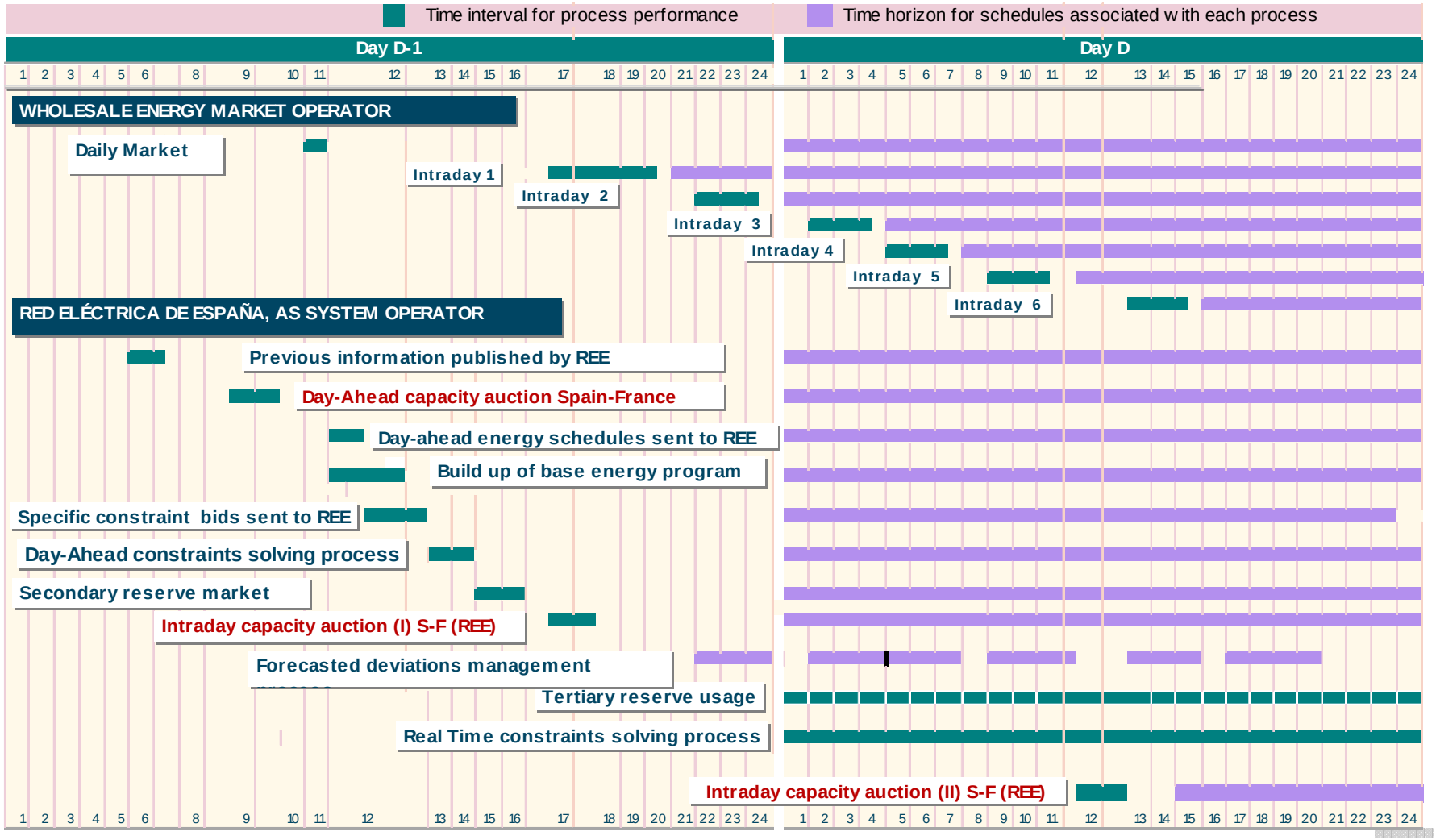
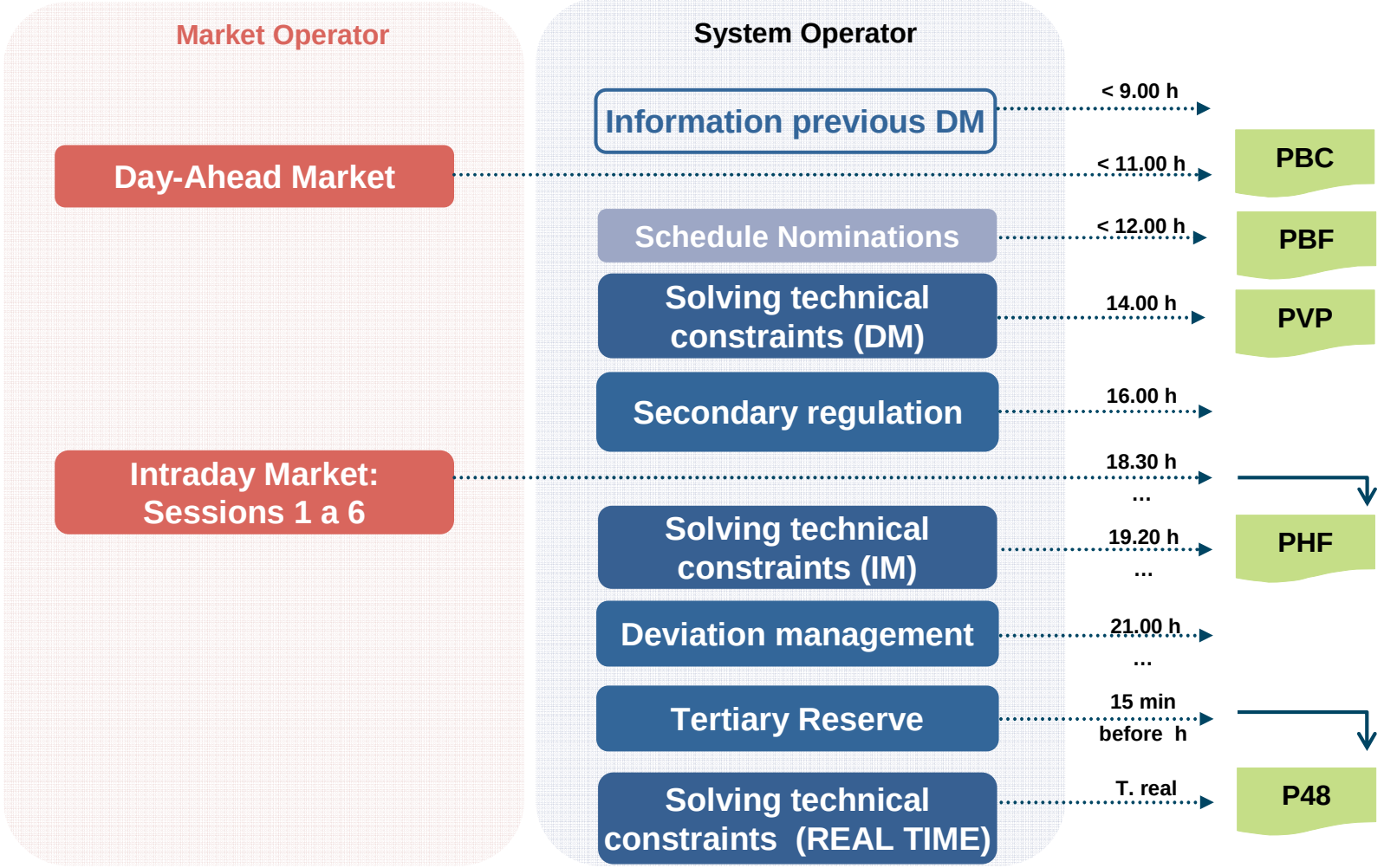
Generation Scheduling (I)



Generation Scheduling (II)



Primary Regulation

Objective:
- Maintain the frequency system stability

Providers:
- Generation units: Mandatory and non-paid service

Ancillary service provided by the automatic modification of the power generated: Generation unit speed regulators facing frequency system deviations.

- Load variation: 1,5% of the nominal power
  - t ≤ 15 sec. with frequency deviations ≤ 100 mHz
  - Lineal variation 15 ≤ t ≤ 30 sec. with frequency deviations between 100 y 200 mHz

Requirements
- Established by UCTE rules

Secondary Regulation

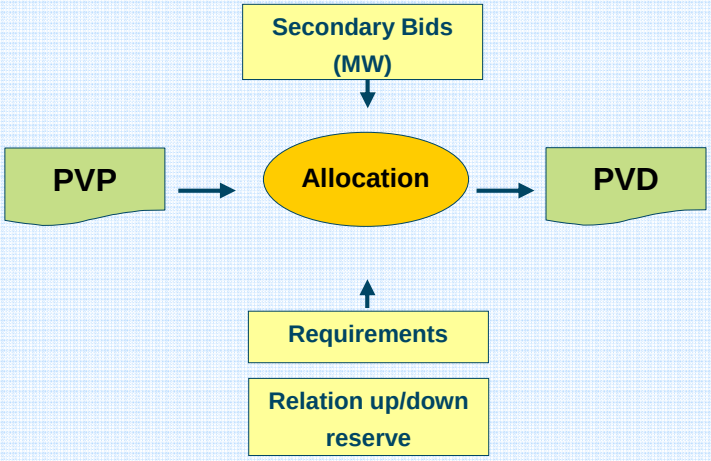
General

- Bids:
  - Licensed generation units: Power band to be increased and reduced (MW) and power band price (€/MW)
- Reserve allocation:
  - Economic merit order
- Operation:
  - The regulation deviation is measured by the TSO Regulation Master and the requirement for each Regulation Area is distributed (every 4 sec.) according to the reserve allocation
- Service fulfilment control by Regulation Area

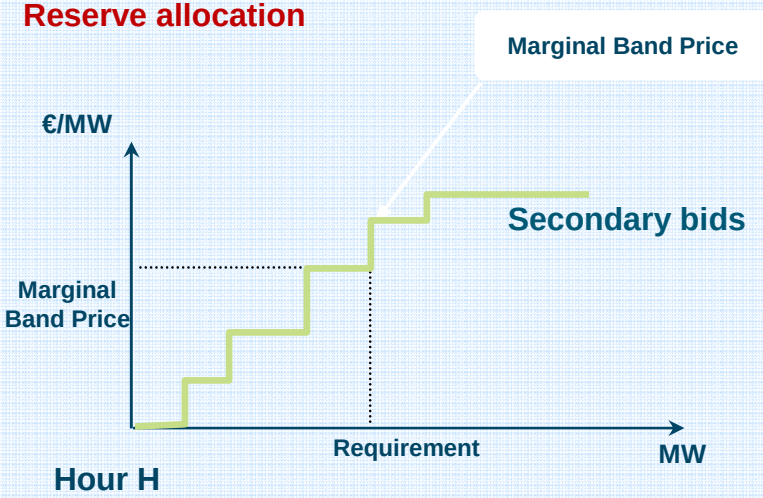
Provider remuneration and overcost

- Service remuneration prices:
  - Power band: Hourly marginal price
  - Penalty / Bonus depending on real time fulfilment
  - Used energy: Marginal price for tertiary regulation that would have been necessary to use instead (using tertiary bid ladder)
- Overcosts:
  - Power band cost paid by demand proportionally to metered energy (except pumping consumption and exports)
  - Energy over-cost paid by generation and demand units which deviate from their programmes

Process



Reserve allocation



Tertiary Regulation:

Face unforeseen deviations and short term foreseen deviations

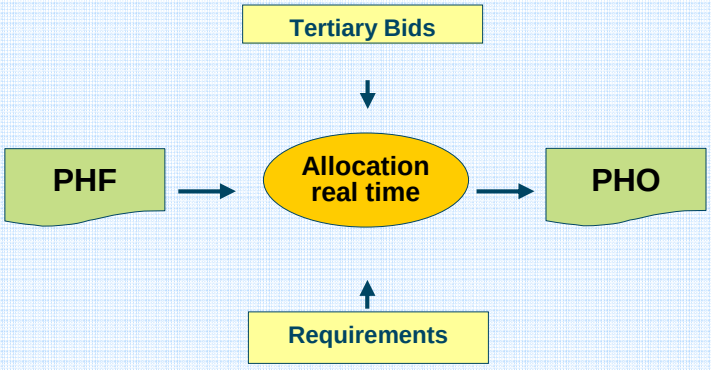
General

- Bids:
  - Obligation to offer available power
  - Bids are sent at 23:00 the day before and can be updated till 25 min before the beginning of the hour
- Allocation:
  - Economic merit order. Constraints must not happen
  - 15 min before the beginning of the programming hour and, if necessary in the programming hour

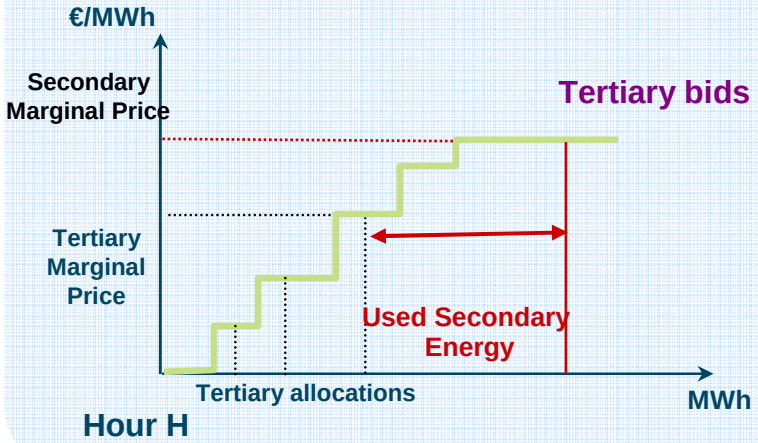
Provider remuneraion and overcost

- Service remuneration price:
  - Marginal price of allocated bids each hour
- Overcost:
  - Service overcost paid by generation and demand units which deviate from their programmes

Process



Tertiary Allocation



Deviation management:

Face foreseen deviations maintained during several hours

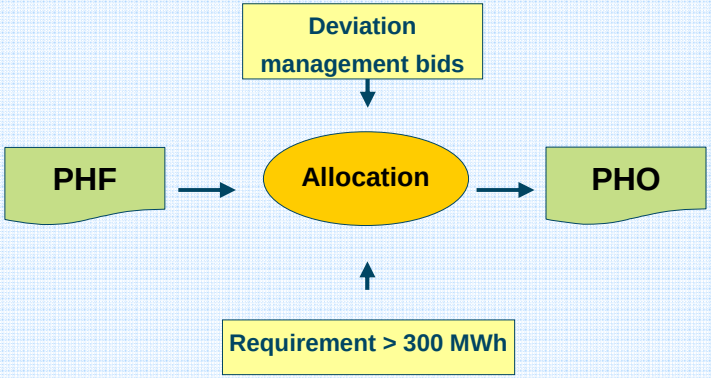
General

- Process subsequent to the intraday market sessions to balance big differences (≥ 300 MWh) between scheduled generation and forecasted demand
- Foreseen deviations: unavailabilities or justified changes communicated from generation
- It covers the period between Intraday market sessions
- Offers: Optional to Generation and pumping units authorized
- Allocation:
  - Economic merit order

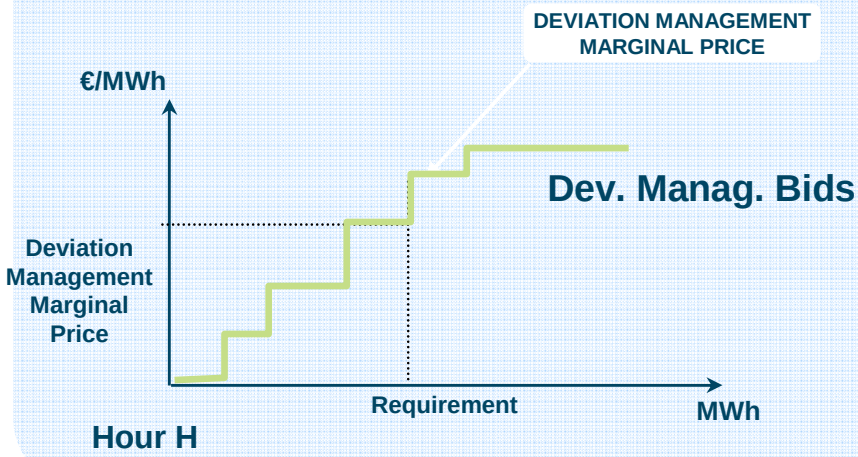
Provider retribution and over cost

- Service remuneration:
  - Hourly Marginal Price
- Overcost :
  - Paid by generation and demand units which deviate from their programmes

Process



Deviation Management allocation



Payment of Technical Services

TECHNICAL CONSTRAINTS

SECONDARY RESERVE

Final demand depending on the metered energy

(excepting pumping units and exports)

SECONDARY ENERGY

TERTIARY ENERGY

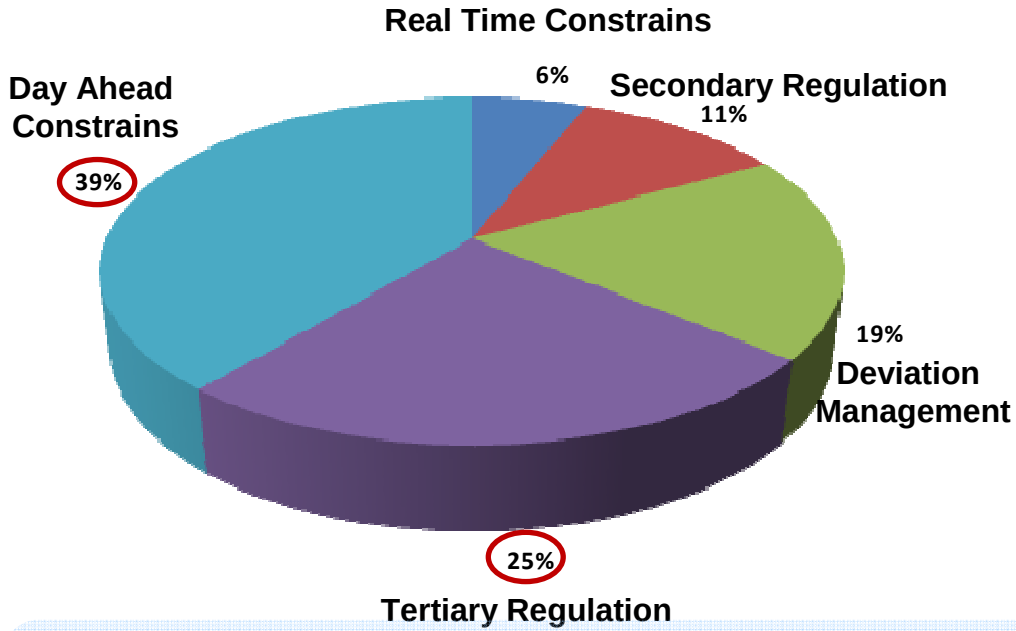
DEVIATION MANAGEMENT

Units which deviate from their programs

	IN FAVOUR OF THE SYSTEM	IN OPOSSITION TO THE SYSTEM
UPWARD UNBALANCES (less consumption, more generation)	**Receive DMP**	Receive minimum of: •DMP •Average price of DOWNWARD energy used (SR + TR + DM)
DOWNWARD UMBALANCES (more consumption, less generation)	**Pay DMP**	Pay Maximum of: • DMP • Average price of UPWARD energy used (SR + TR + DM)

Deficits and surpluses are paid by final demand proportionally to metered energy (excepting pumping units and exports)

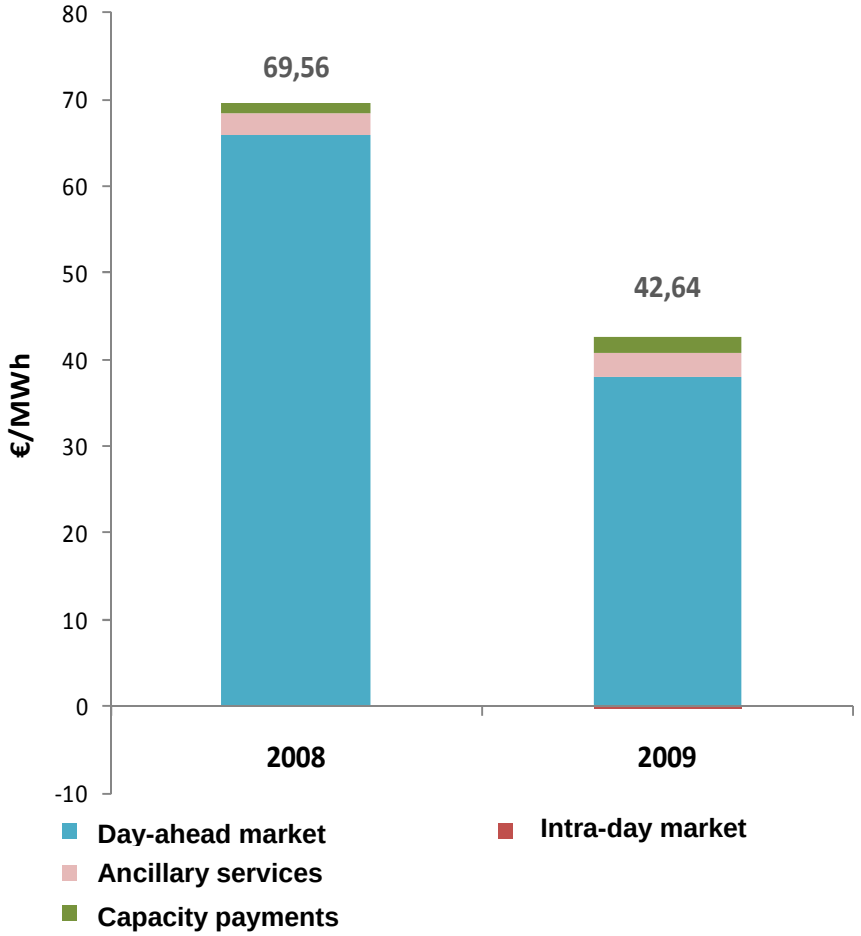
Annual energy managed at ancillary services markets: 2009 (I)



	Energy (GWh)	
	Upwards	Downwards
Day Ahead Technical Constraints (Fase I)	9,475	707
Secondary Regulation Band (upwards & Downwards GW)	10,896	
Secondary Regulation	1,071	1,406
Tertiary Regulation	2,238	3,287
Deviation Management	1,253	3,018
Real Time Technical Constraints	821	638
TOTAL	14,858	9,056

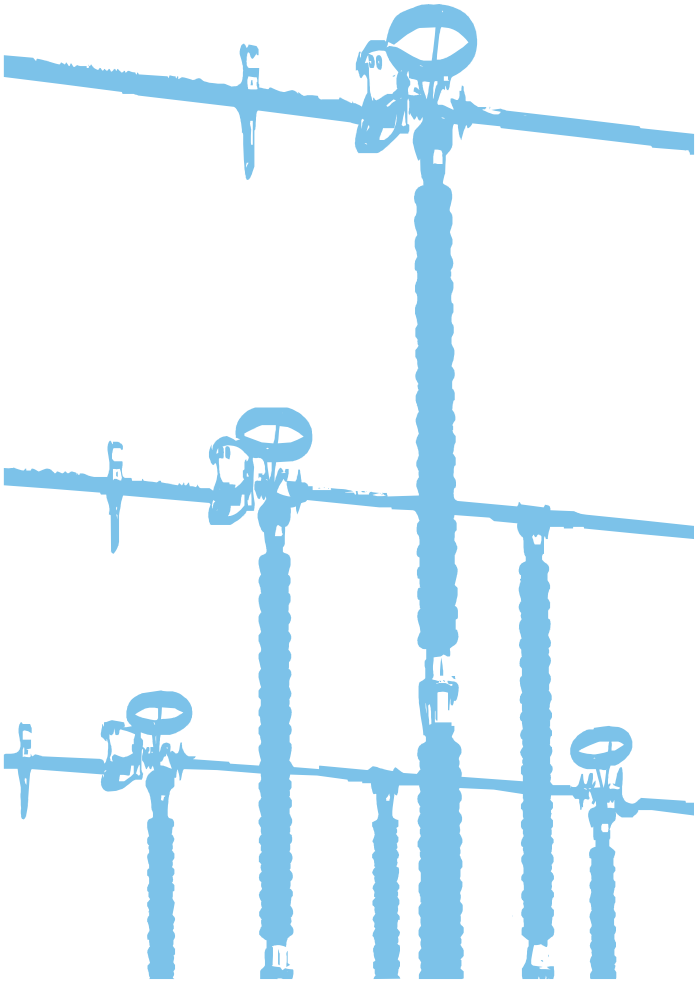
- The total amount of energy management at ancillary services during 2009 was 22.501 GWh, that means the 8,95% of the total energy supplied (251.305 GWh).
- Day-Ahead Technical Constraints solution process (39%) and Tertiary Regulation (25%) were the ancillary services that manage more amount of energy.

Final electricity price (€/MWh)



€/MWh	2008	2009	2009%	%2009/2008
Day-ahead market	65.91	38.06	89.3%	↓ -42.3%
Intra-day market	0.00	-0.02	0.0%	-
Ancillary services	2.60	2.69	6.3%	↑ 3.5%
Capacity payments	1.05	1.91	4.5%	↑ 81.9%
FINAL PRICE	69.56	42.64		↓ -38.7%

Ancillay services				
€/MWh	2008	2009	2009%	%2009/2008
Technical constraints	1.55	1.84	58.4%	↑ 10.8%
Secondary regulation band	0.81	0.56	20.8%	↓ -30.9%
Deviation management	0.36	0.43	16.0%	↑ 19.4%
Deviation surplus	-0.23	-0.14	-5.2%	↓ -39.1%
TOTAL	2.60	2.69		↑ 3.5%



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Installed capacity and demand supply 2009

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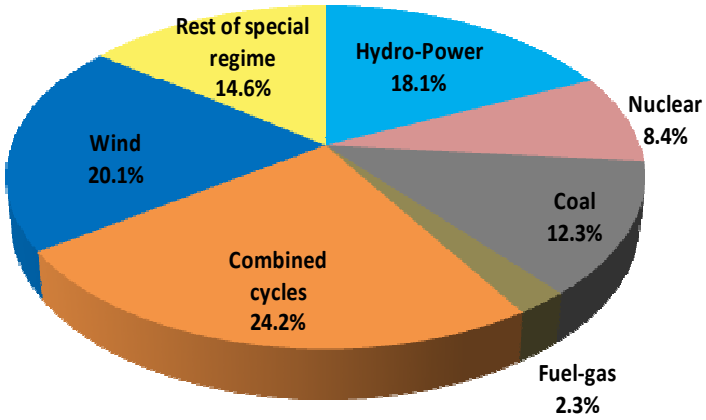
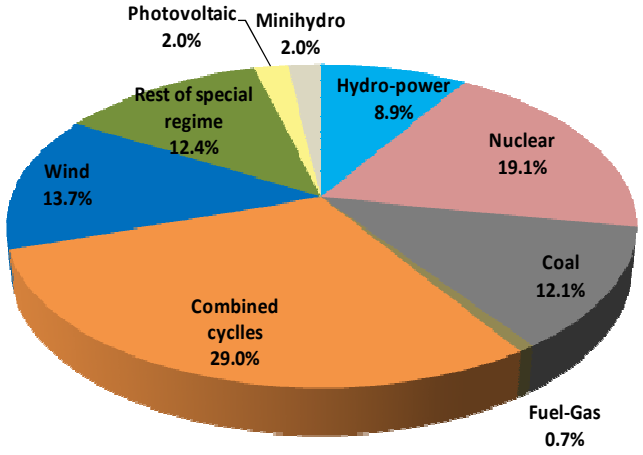
Installed capacity February 2010



Technology	MW	%
Hydro-power	16.657	18,1
Nuclear	7.716	8,4
Coal	11.359	12,3
Fuel-Gas	2.087	2,3
Combined cycles	22.243	24,1
Total (ordinary regime)	60.872	65,3
Wind power generation	18.458	20,1
Rest of special regime	13.471	14,6
Total (special regime)	31.861	34,7
Total	91.991	

Demand supply 2009

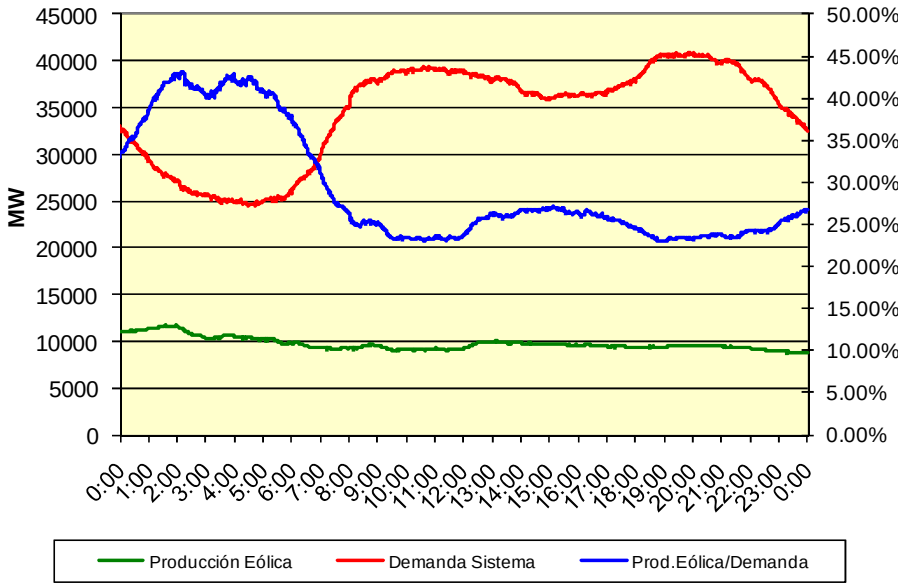


+181.614 GWh Net Ordinary Regime
+ 81.785 GWh Net Special Regime
- 3.770 GWh Hydro-pump storage
- 8.120 GWh International exchange

251.509 GWh

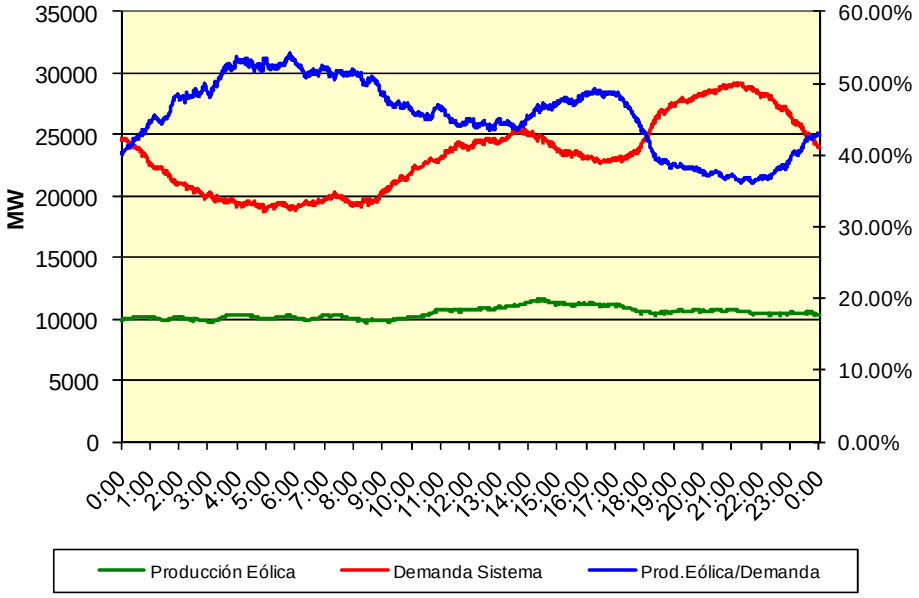
Wind energy production records

MAXIMUM PRODUCTION



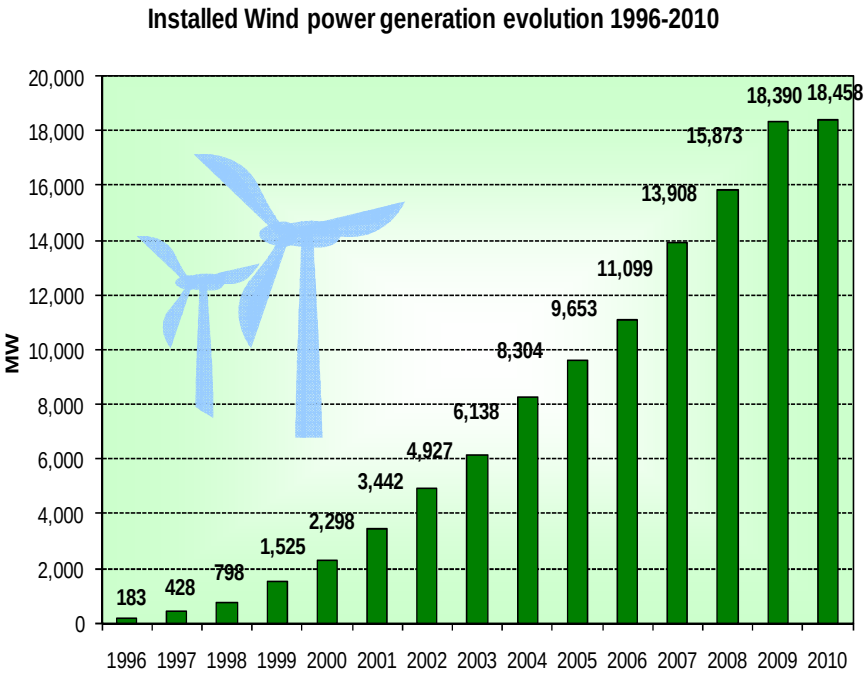
- Maximum production: 12.916 MW (24/02/2010).
- Minimum production in one year: 164 MW (03/06/2009).

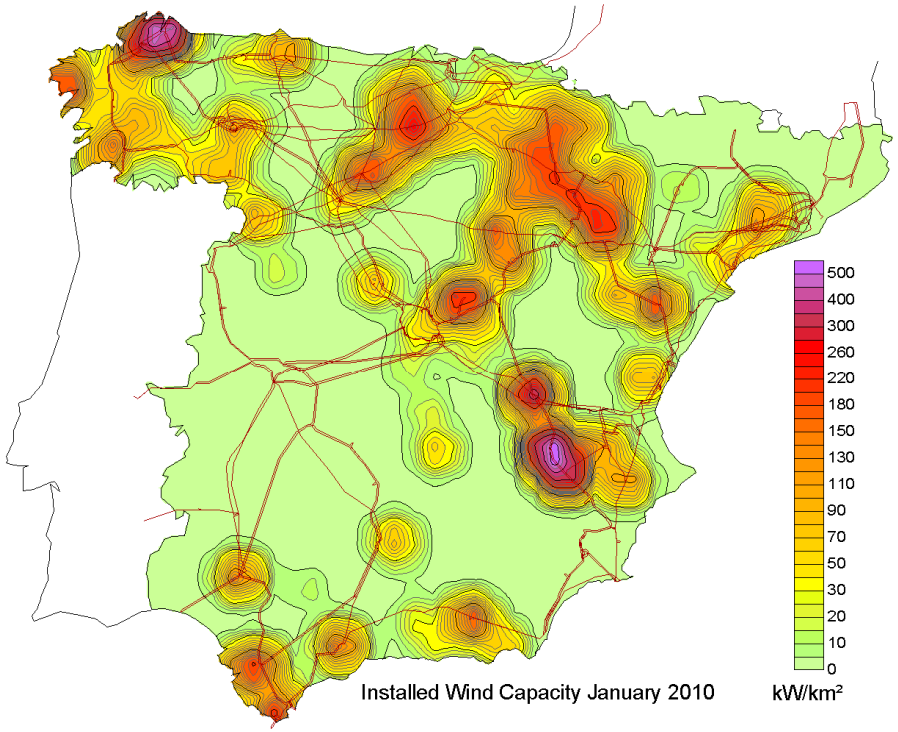
DEMAND vs. WIND PRODUCTION



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

Wind power capacity: Present and evolution



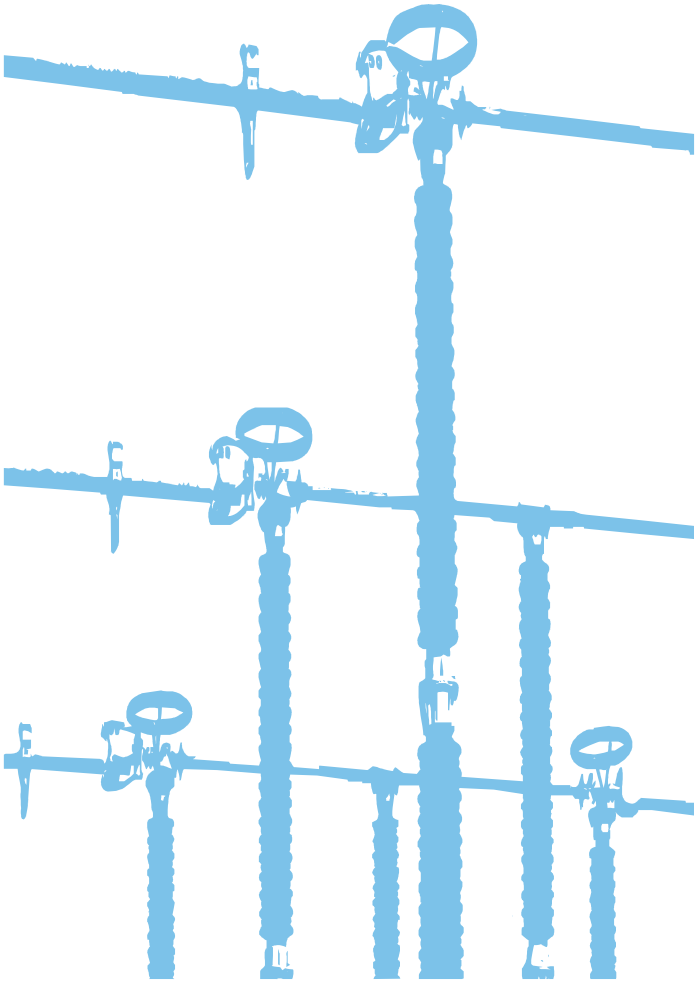


Installed Capacity Expected for 2016:

- **Wind: 29 000 MW**
- **Solar: 4 500 MW**

Spanish regulatory framework (20/20/20)

Further increase expected for compliance with approved EC initiatives (20% of primary energy must come from renewable).



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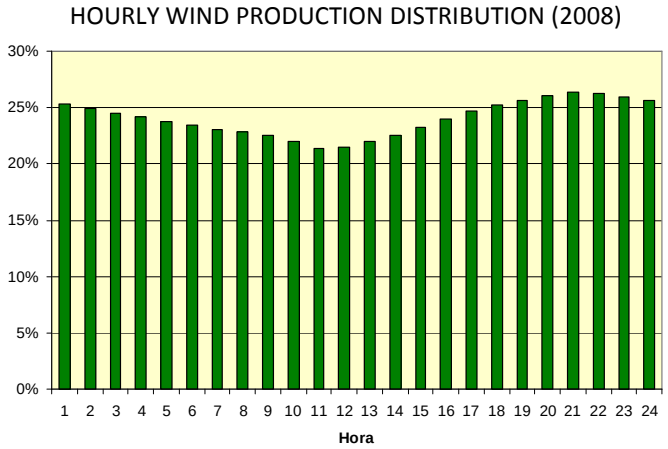
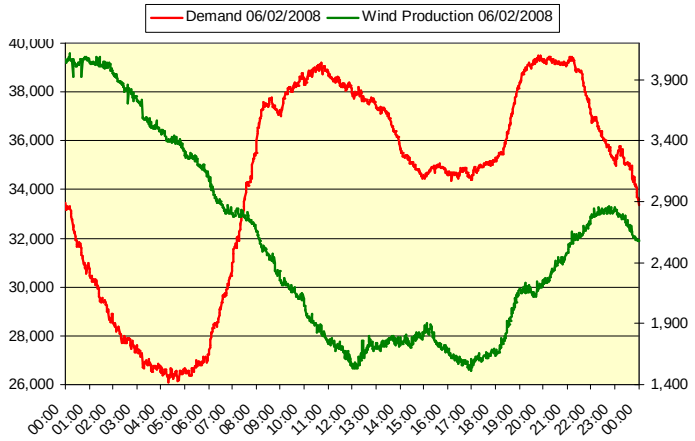
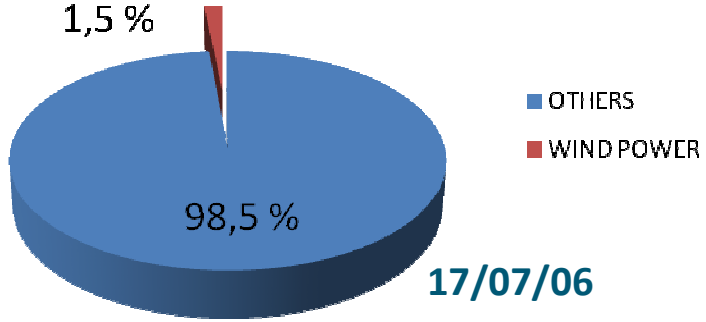
Production not correlated with consumption



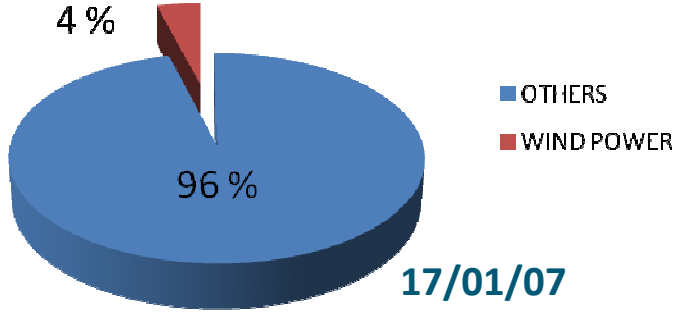


Demand supply: summer maximum demand Max. peak load = 40.730 MW



17/07/06

Demand supply: winter maximum demand Max. peak load = 45.450 MW

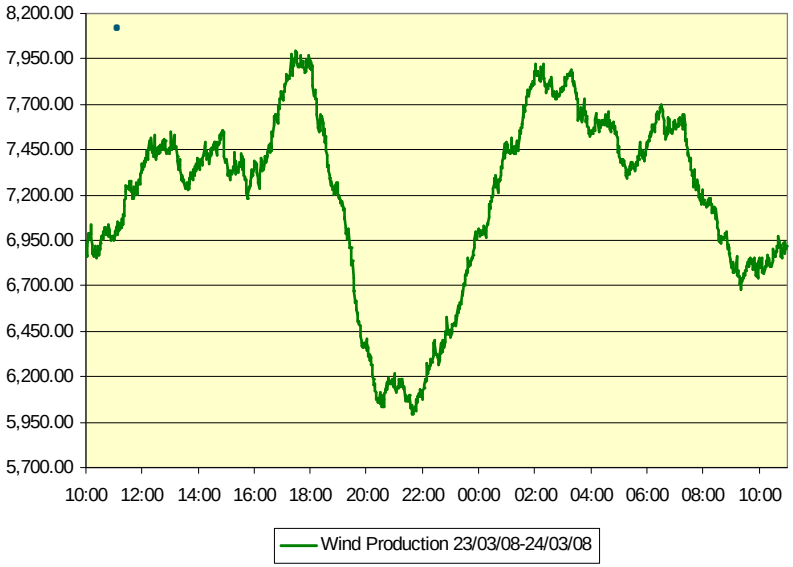


17/01/07

- **Downward ramps in wind production in the mornings often increase morning ramps of conventional generation.**
- **Wind production differs sometimes from demand requirements, specially in summer.**

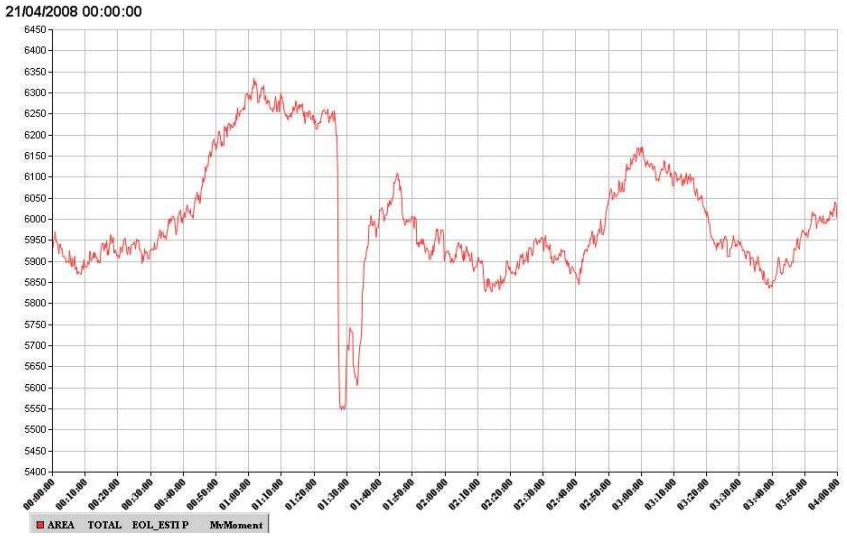
Wind turbines technology

Wind generation tripping due due to their over-speed protection



- Wind generation trips if wind speed higher than 25 m/s.
- Wind power variation on this day: 1.800 MW.

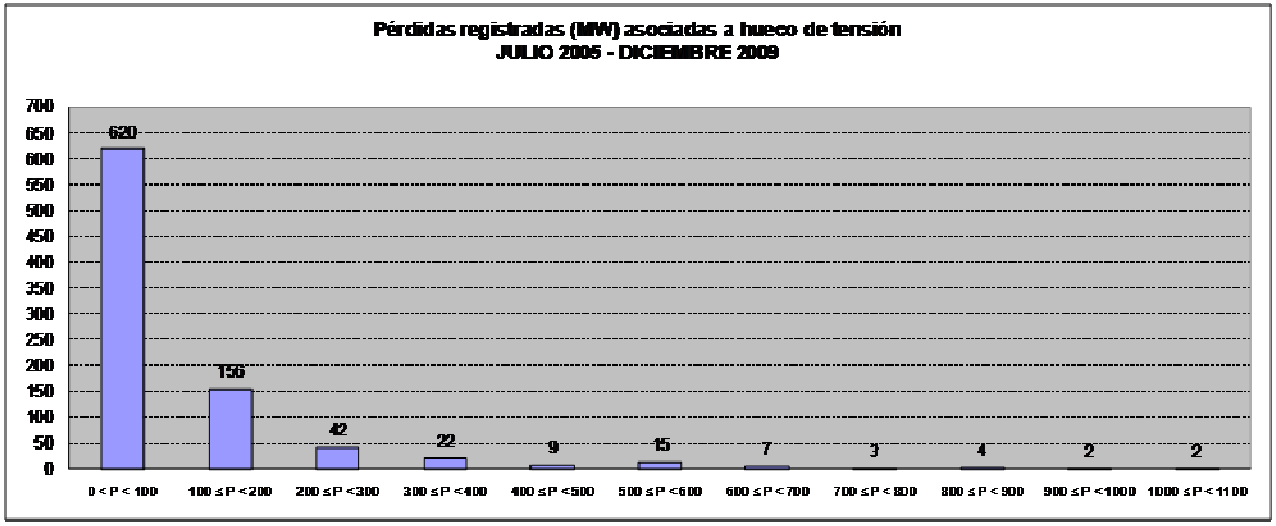
Wind generation tripping due to voltage dips

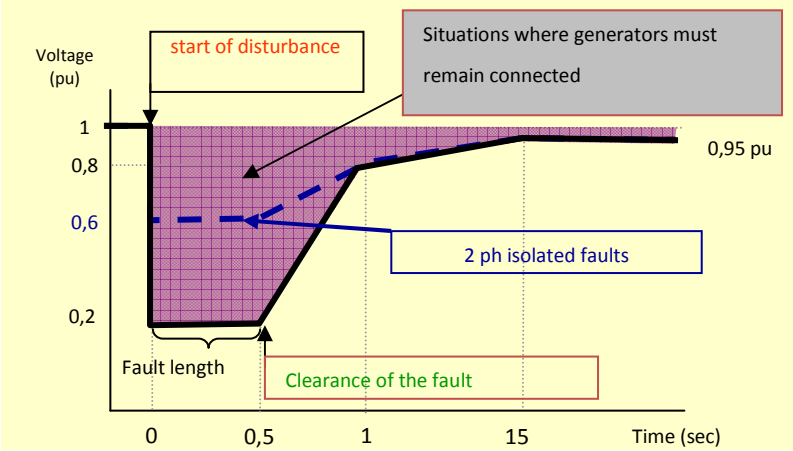


- From January 1st 2008 all new wind facilities must comply with PO 12.3.
- Of the installed wind turbines:
  13.906 MW have been certified.
  1.500 MW have currently no fault-ride-through capabilities*

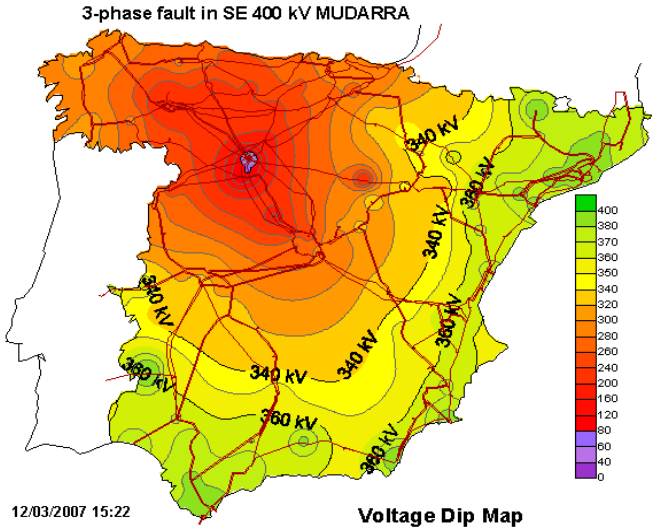
* Faults shorter than 100ms and voltages lower than 85% p.u.

Observation of wind generation trips





New “grid code”. Operational Procedure 12.3

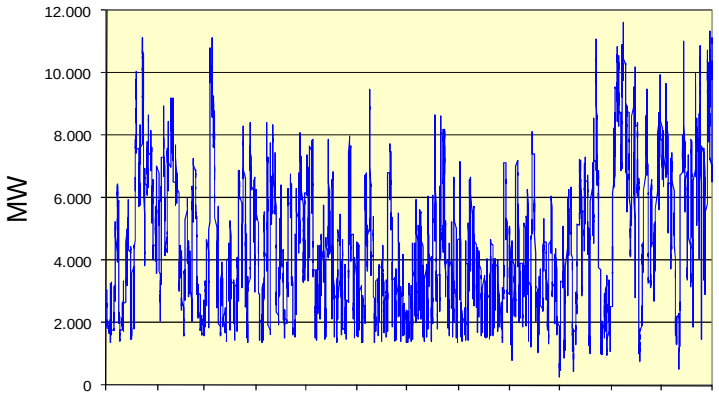


Real Time Risk Assesment

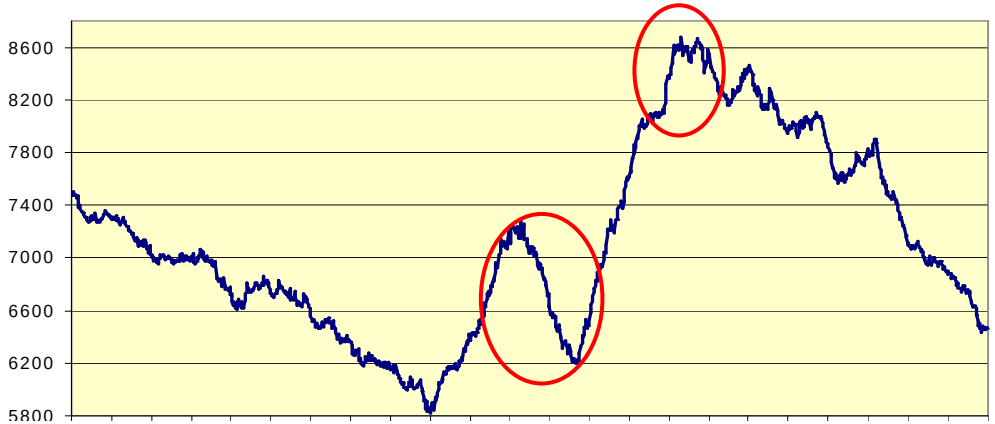
Wind production variability

- Non manageable primary energy.
- Very variable production output.
- Increase of 586 MW in 30 min. Gradient: 1172 MW/h
- Decrease of 1110 MW in 1 h 25 min. Gradient: -785 MW/h

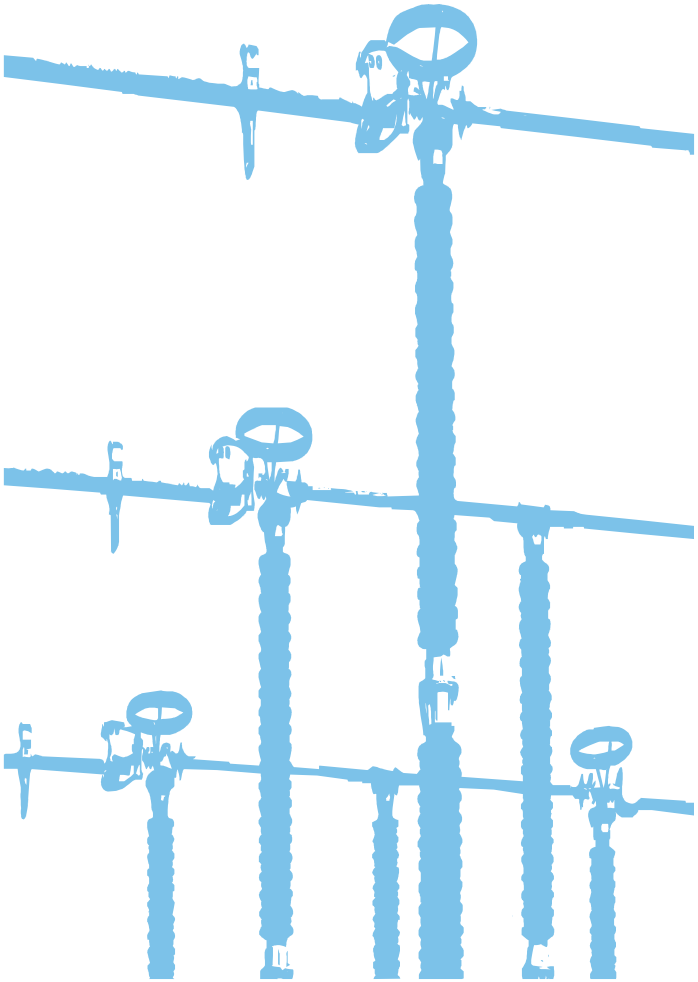
WIND PRODUCTION DURING A YEAR



WIND PRODUCTION VARIABILITY



- At present wind downward/upward ramps may reach ±1500 MWh.
- Wind forecast can mitigate the effects of wind variability for System Operation, but errors must be taken into account and additional reserves must be provided to overcome them.
- Larger forecast errors imply more provision of reserves increasing system costs.



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Wind forecasts available to the CECRE

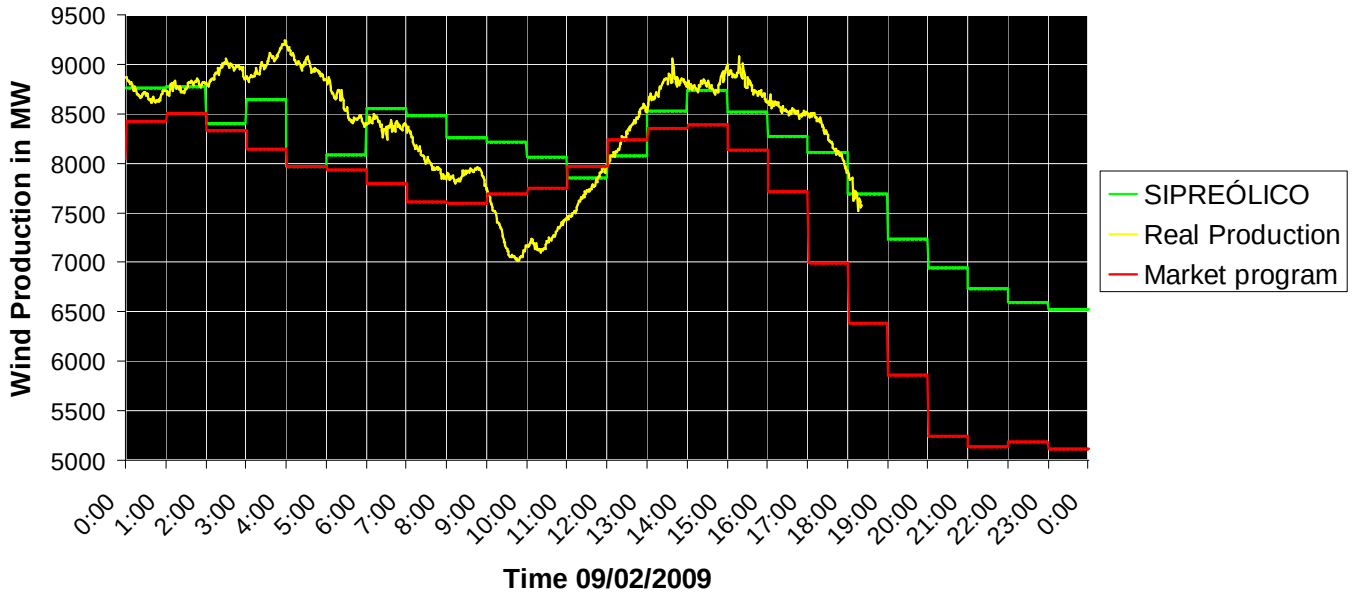
- In order to size reserves and to check the instantaneous need for manageable generation wind forecast becomes crucial for system balancing.
- REE has an internal forecast of all wind parks: SIPREÓLICO

Total hourly forecast for next 10 days (update 1 hour).

Hourly forecasts for next 48 hours by region or transmission system node (update 15 min.)

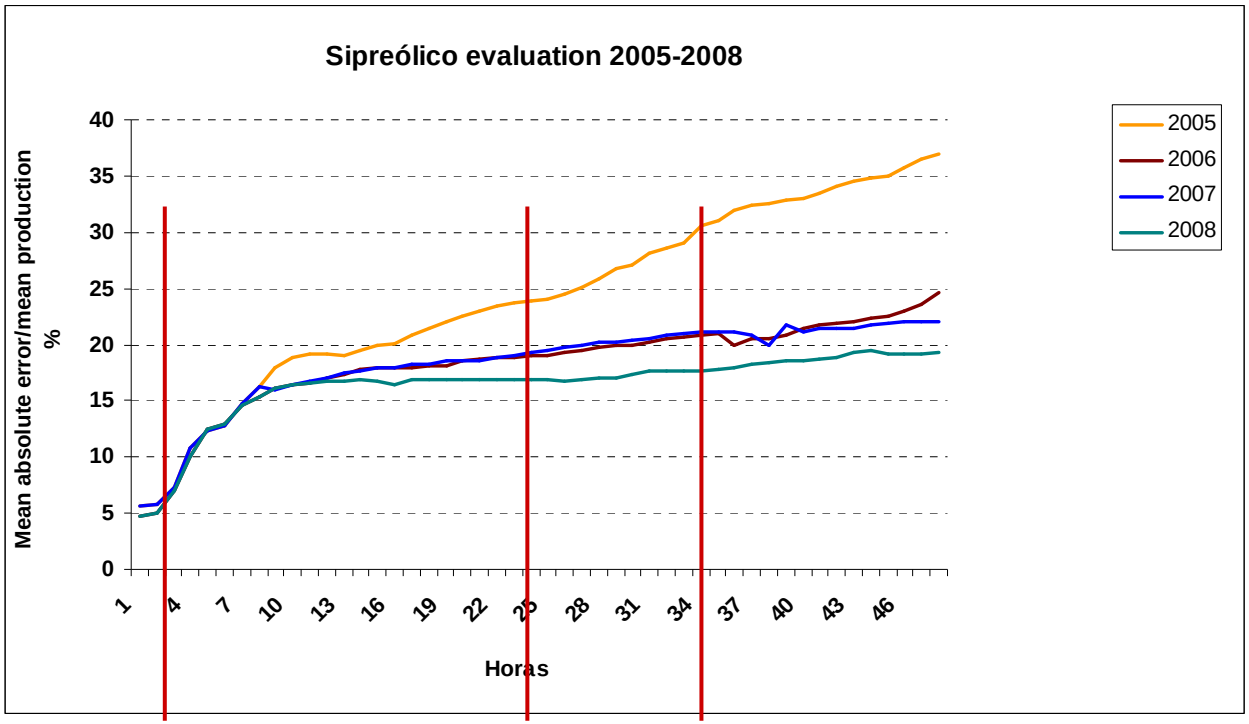
Hourly stochastic forecast of total production: percentiles 15, 50 and 85.

- Wind park programs matched in the daily market. Agent's forecast.

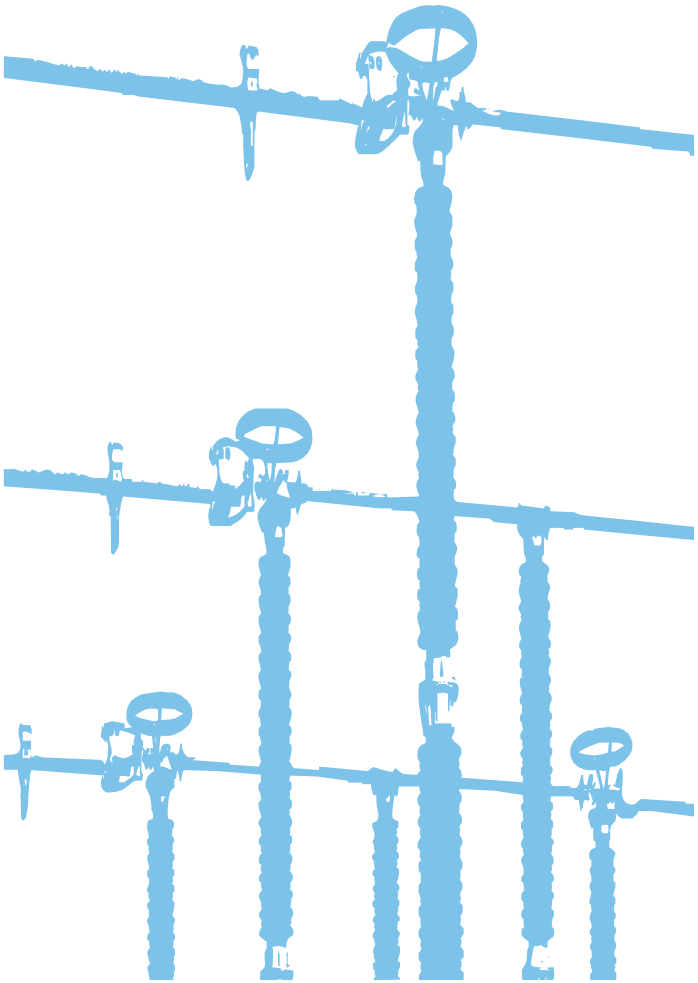


Hourly forecasts error based on production for the next 48 hours

- Critical time horizons are 24 or 32 hours in advance for D-1 reserve evaluation and 5 hours for real-time evaluation.



- Positive evolution in forecast error in the last years has resulted in fewer need for reserves to cover wind forecast errors, specially in D-1.



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Primary Regulation	Action of speed regulators from generator units responding to changes in system frequency (<30 s to 15 minutes)	**Currently a very low and decreasing impact** due to nowadays very few RES generation without fault-ride capability (and less expected in the future)
Secondary Regulation	Automatic and hierarchical control that faces changes in system frequency and power deviations with respect to France-Spain exchange program. (≤100 s to 15 minutes)	Nowadays, no need to contract further reserve bands.
Tertiary Regulation	Manual power variation with respect to a previous program in less than 15 minutes. (<15 min to 2 hours)	Only slightly affected by wind generation ramps when these ramps are opposite to system demand.
Slow reserve	Running reserves of connected thermal units (30 min. to 4-5 hours)	Significant influence of wind power. Reserve provision must be increased to take into account wind power forecast errors. Reserves are checked from day D-1 once market results are received until real time.

Tertiary energy scheduled

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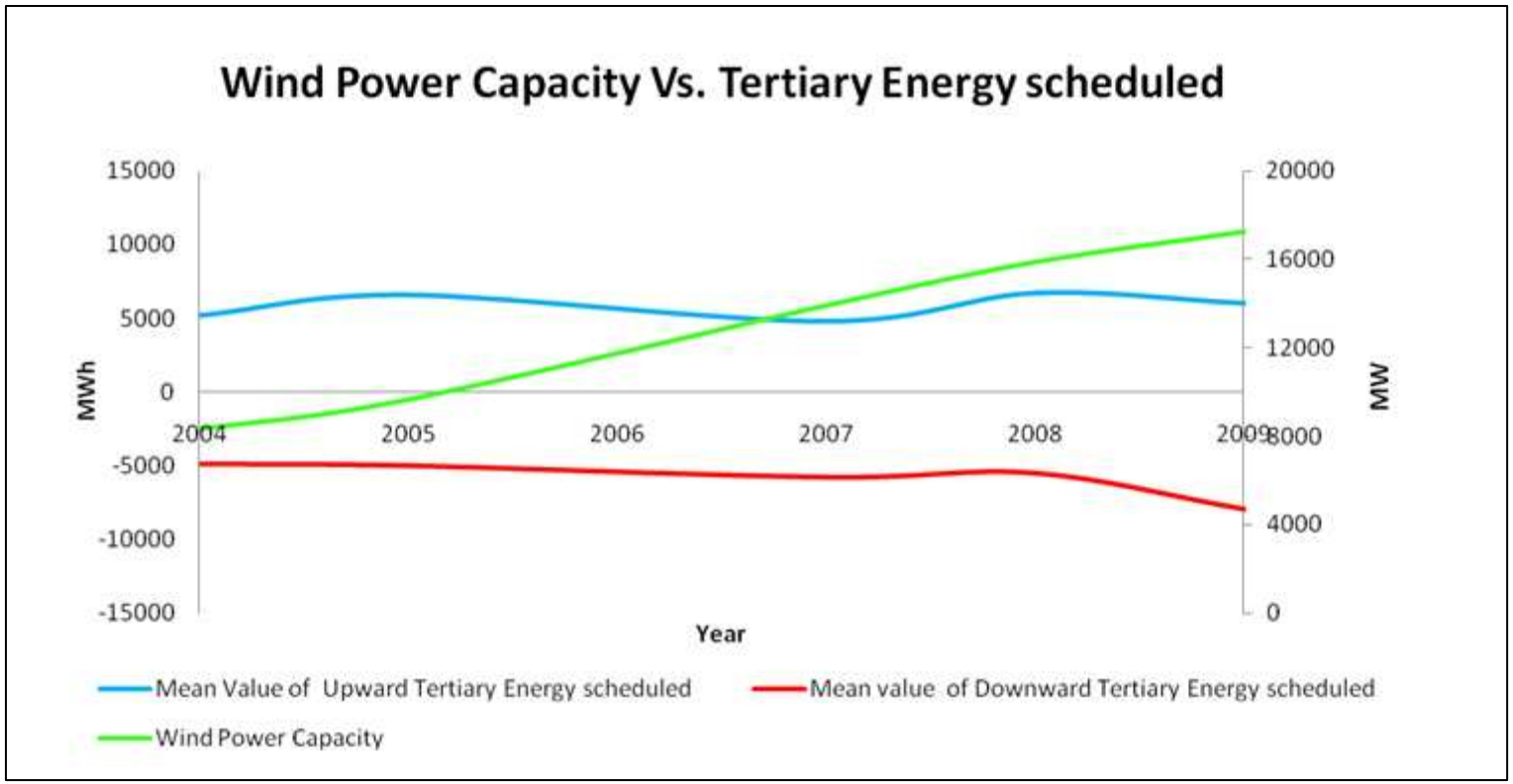
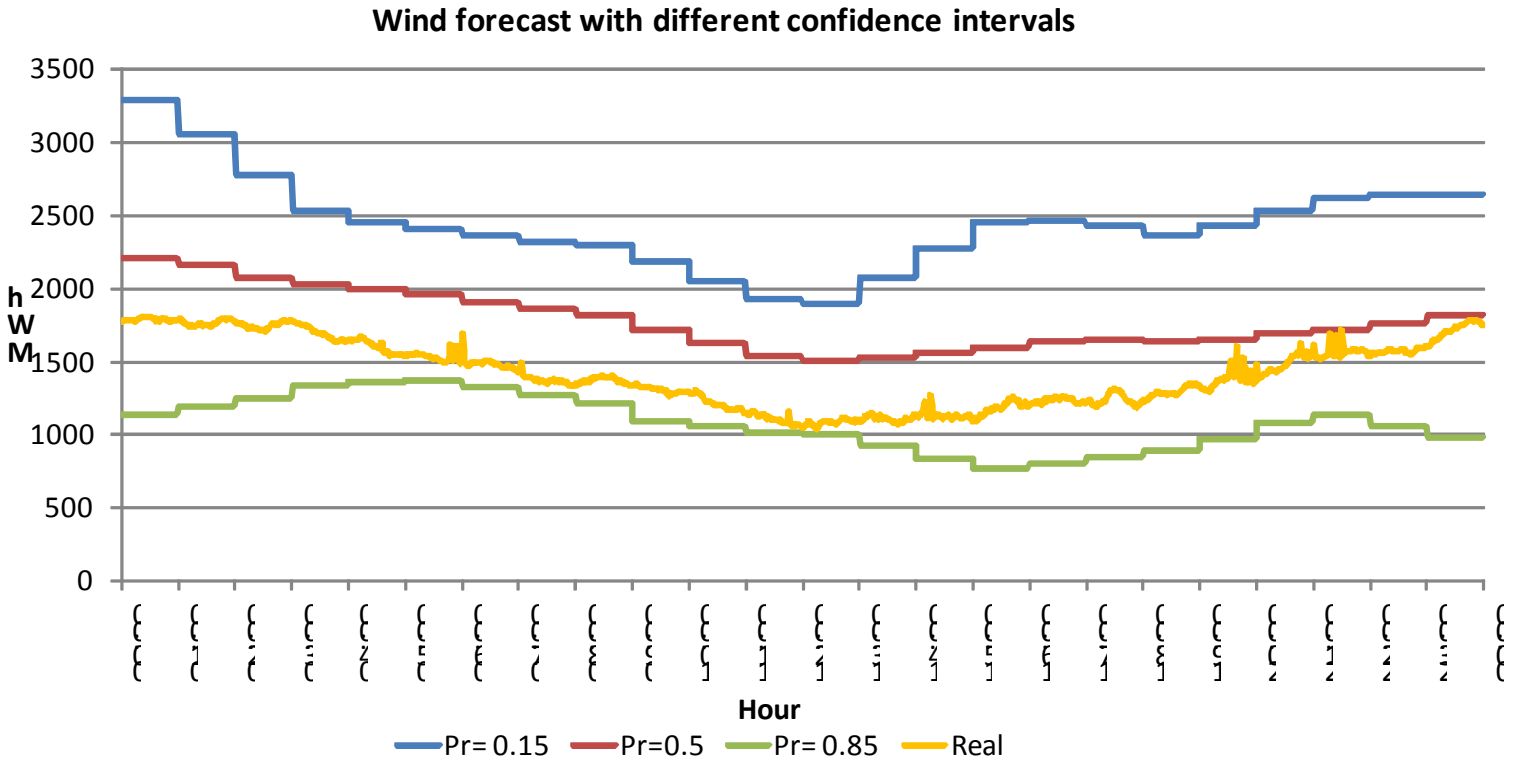
- **Tertiary energy scheduled is only slightly affected by wind generation ramps when these ramps are opposite to system demand.**

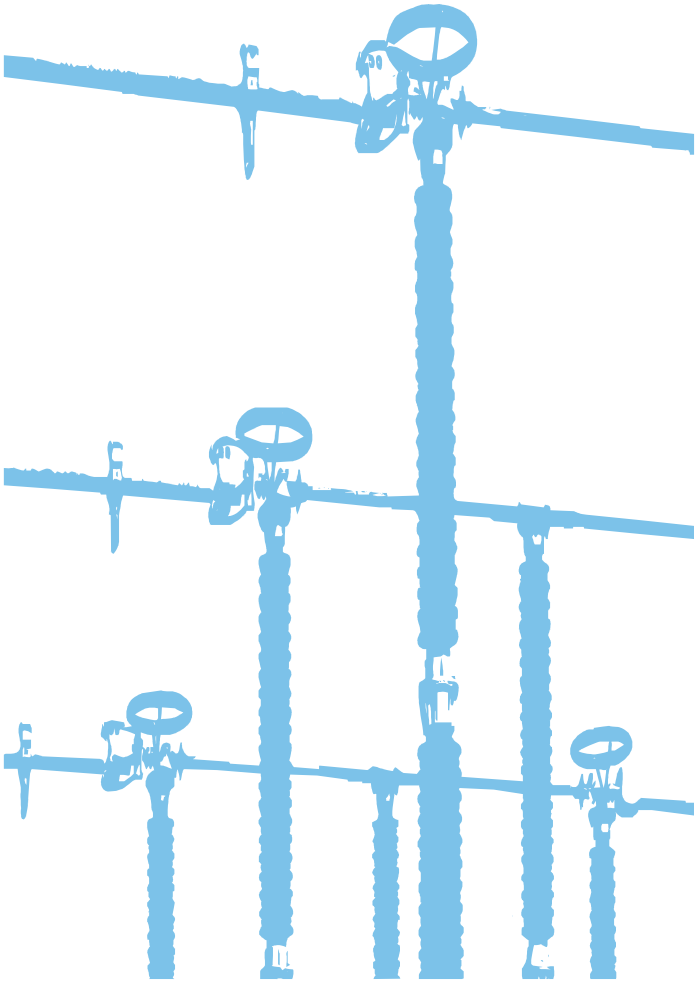


Running reserves scheduled

Wind forecast use for reserve evaluation in D-1

- At 11:00 h in D-1 after market and bilateral contract programs are received, REE checks if there are enough available running reserves for the next day.
- Probabilistic wind forecast: confidence intervals used for both upward and downward reserves
- If reserves are not sufficient more thermal plants must be connected to the grid.





Brief review of Spanish Ancillary services scheme

Renewable energy in Spain today

Challenges integrating renewable energy nowadays

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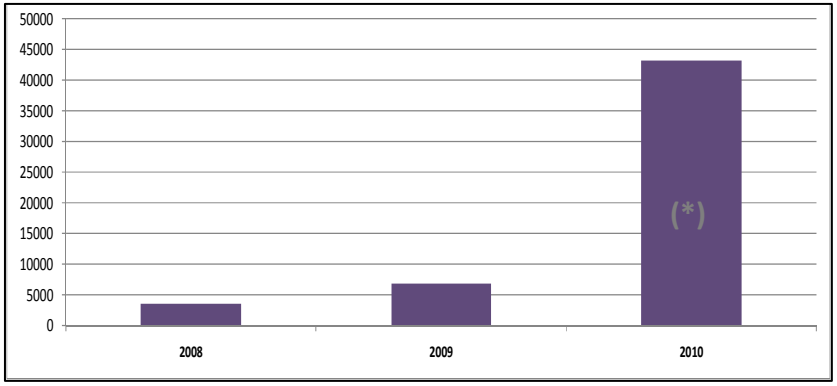
- **Hot reserves will run out due to the combined influence of:**
  - Tripping of conventional generation plants.
  - Demand prediction errors.
  - Wind or solar forecast errors.
  - Wind generation tripping due to over-speed.
  - Not enough manageable generation connected the grid (face peaks & deliver ancillary services)

Wind Energy reduced due to integration problems (MW)



* Datos provisionales a 31.01.10.

- **In the case of running out of:**
  - Upward reserves during peak demands, additional thermal units may be switched on with a real-time re-dispatch.
  - Downward reserves during off-peak, thermal units may be switched off in real-time. If not done enough time in advance (wind prediction errors increasing rapidly) or more manageable generation could not be retired from the system, the TSO, as a last resort, may issue maximum wind production nodal instructions.

Number of maximum wind production nodal instructions:

- 2 times in 2008
- 14 times in 2009
- 17 times in the two first months of 2010

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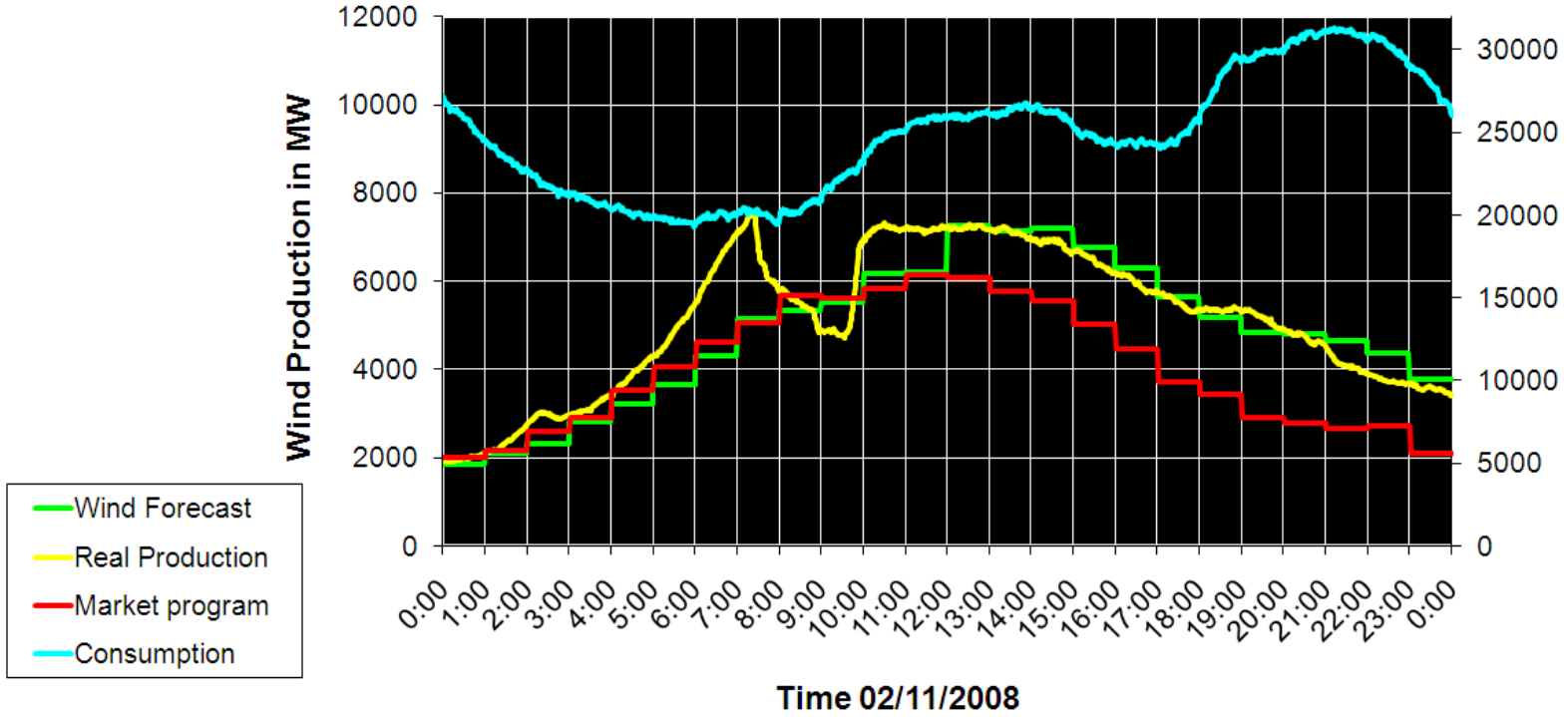
Running out of downward reserve due to wind forecast errors

Maximum wind production nodal instructions, November 2nd 2008 (I)

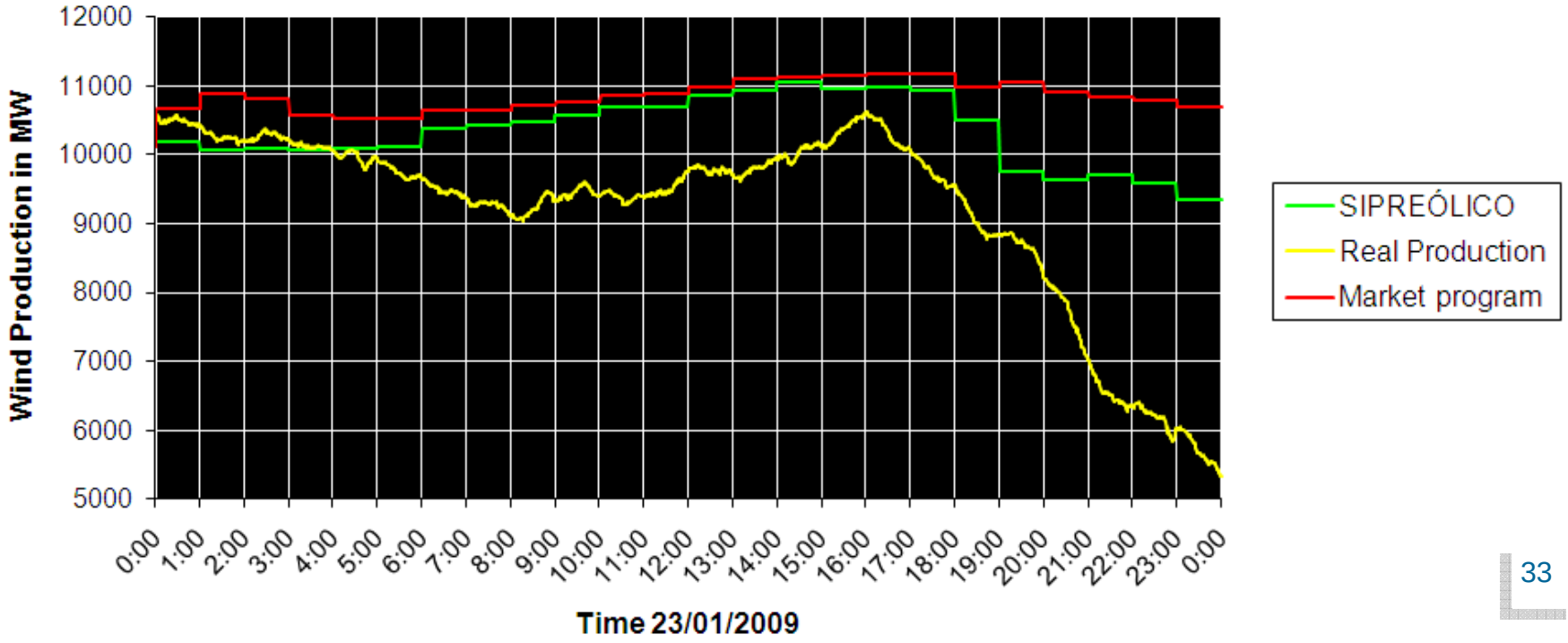
- On the morning of Sunday November 2nd at 8:00 h with one of the lowest demands of the year (~20 000 MW), wind prediction error hit 3 200 MW.
- Increase in error from 5:00 to 7:00 h too fast to have time to shut down thermal plants.
- Spanish system ran out of downward reserves very rapidly and the only solution to balance the system was to decrease wind production from 7:22 to 9:30 h.

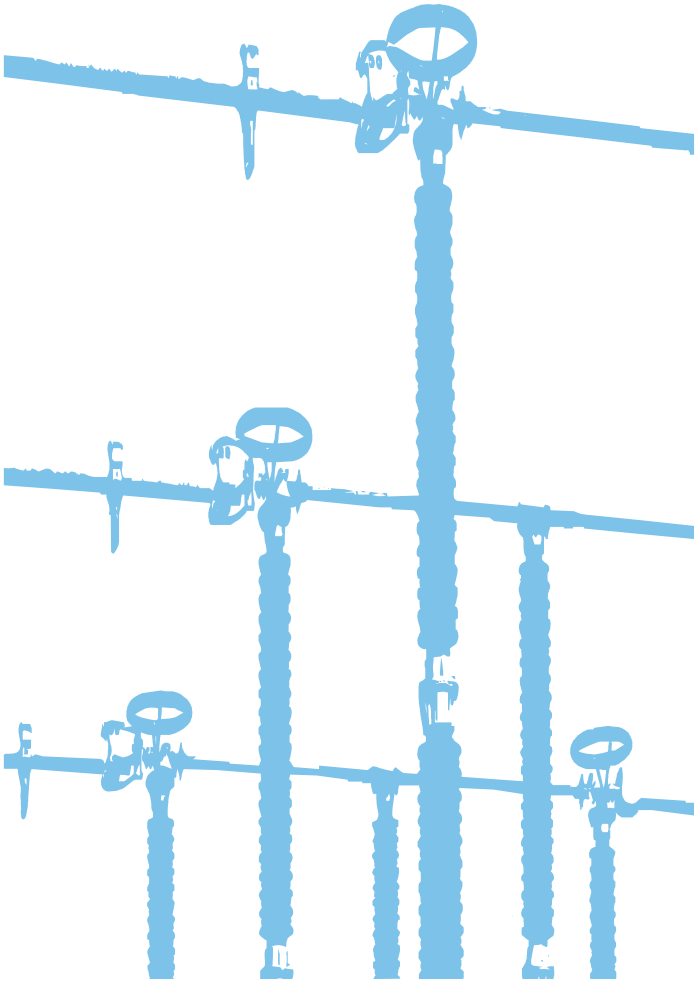


Running out of upward reserve due to wind generation tripping

Wind reduction instructions, January 23rd and 24th 2009

- January 23rd and 24th 2009: The storm Klaus. Winds up to 220 km/h hit the Iberian peninsula.
- Most turbines in the north of Spain shut down due to their over-speed protection.
- Difference between real and forecasted wind production was greater than 6 000 MW on some hours, but since demands were low and thermal plants were connected in real time due to alert situation there was enough upward reserve to deal with these errors.





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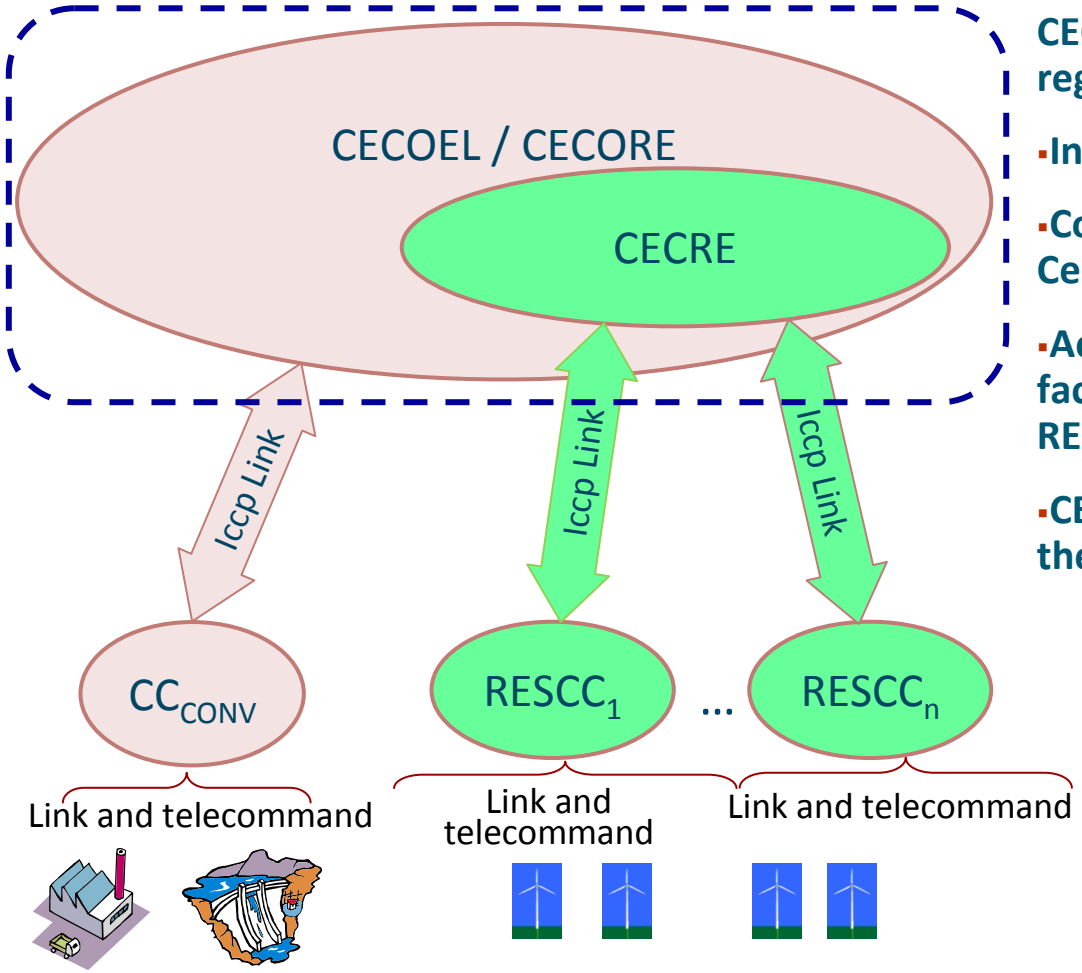
Control Centre for Renewable Energies (CECRE)

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

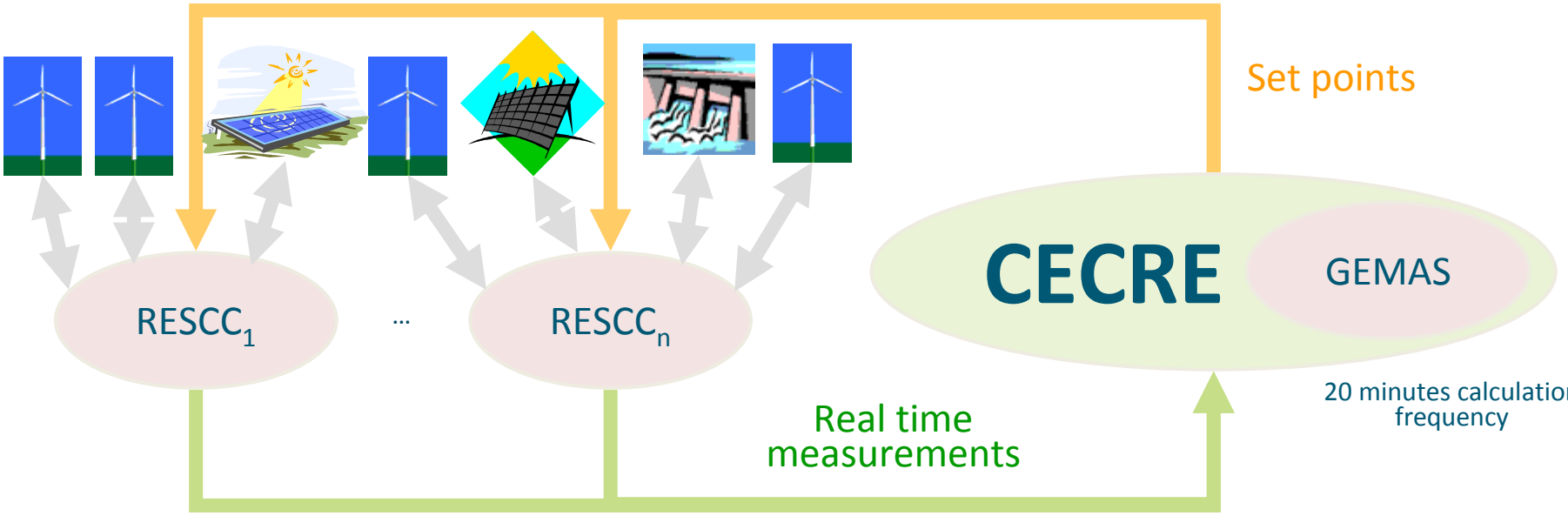
CC$_{CONV}$: Control Centre for conventional generation

Special Regulation Regime

Renewable:	Non Renewable:
Minihydro	Cogeneration
Biomass	Coal
Wind	Fuel - Gas oil
Industrial waste	Refinery gas
Urban waste	Natural gas
Solar	

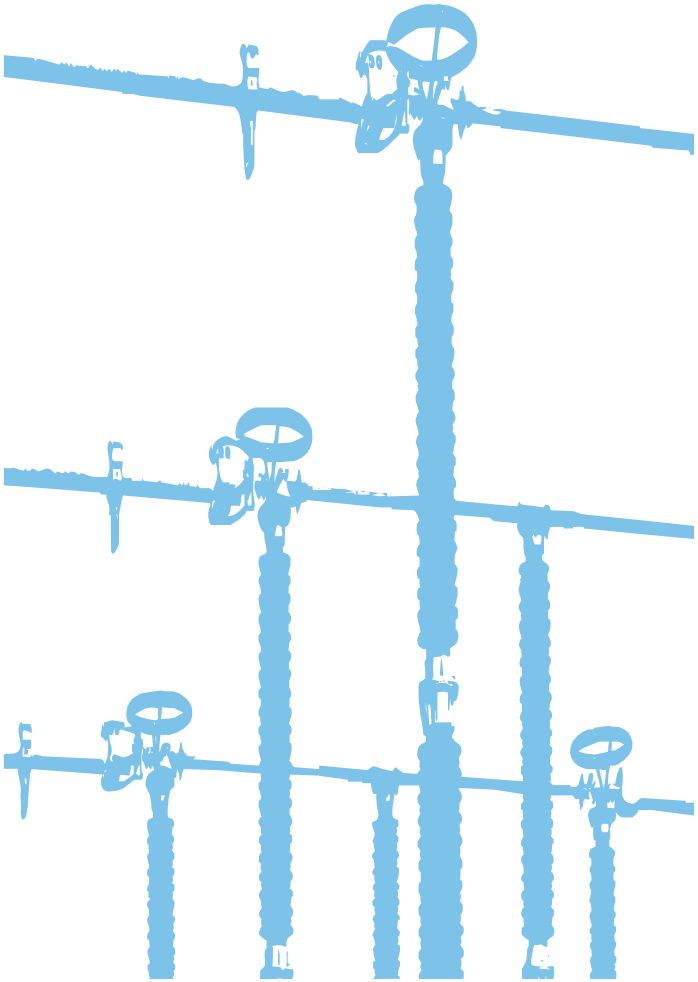
Checking the security with the real-time wind scenario

- CECRE analysis in real time the maximum wind generation supported by the system.
- If curtailments are needed, wind generation set-points are calculated and sent.
- Wind parks must adapt their production to the given set-point within 15 minutes.



- Presently only done for wind generation, but a similar methodology can also be applied for all renewable energy sources.

GEMAS: Analysis in real time the maximum wind generation supported by the system.



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Facing the future (i)

- **Challenges 2011: 20 000 MW wind installed capacity:**
  - Balance in off-peak hours → downward reserve management is an issue
  - Voltage dip tripping should no longer be a problem due to compliance with the grid code
  - Active voltage control with set-points (instead of load factors keeping)

- **Challenges beyond 2011: Up to 40 000 MW wind installed capacity. Safe integration will depend on several factors:**
  - Need for wind generation to provide frequency control (primary reserve, inertia emulation,…).
  - Increase of storage capability: more hydro-pump units
  - Need of more flexible and fast thermal plants (open cycle gas turbine)
  - Interaction between wind and solar production will be an issue
  - Improvement of wind forecast tools
  - More Flexible market mechanisms and regulatory measures

Facing the future (ii): more flexible market mechanisms and regulatory measures

- **Encourage flexible and fast conventional generation throughout adequate economic signals:**
  - Open cycle gas turbines
  - Household isolated operation of conventional units
  - To encourage more pump storage units and other storage facilities
- **Introduction of negative pricing (balancing markets/energy markets):**
  - Adequate for manage deep off-peaks and high wind production
- **Inter-TSO balancing actions:**
  - Need of compatibility of ancillary services to exchange
  - Need of compatibility of gate closures associated
  - Usage of ATC
- **Encourage RES to change from user towards providers of system services**

Conclusions

- Integrating non manageable generation is a challenging task: Low availability, production not correlated with consumption, lack of firmness of generation programs and power balance difficulties.
- Spanish RES control center (CECRE) has helped to reach a high penetration of special regime generation in the System making these technologies compatible with security of supply.
- There is not a significant influence of the present wind capacity on primary, secondary or tertiary reserves.
- Wind forecast has been improving in the last years, being now a basic tool for hot reserve evaluation. Its accuracy for time scopes from 24 to 32 hours in advance affect required levels of reserve and helps dispatching manageable generation to counteract wind fluctuations.
- Some days , due to the lack of downward reserve wind energy reduction are unavoidable in order to keep system balance. Thanks to the CECRE curtailments take less time to be done so we could plan and place less stricter limitations increasing RES production and installation.


Thank you for your attention!
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