Japan Renewable Energy Foundation

Spanish experience on technical integration and incorporation of wind energy into the electric market

Technical Department
Spanish Wind Energy Association

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THE ELECTRIC SECTOR AS A WHOLE SHOULD BE ADAPTED TO THE NEW ELECTRIC SCENARIOS

Traditional concepts:

- Centralized supply by large power plants.
- Power flow from high to low voltage levels.

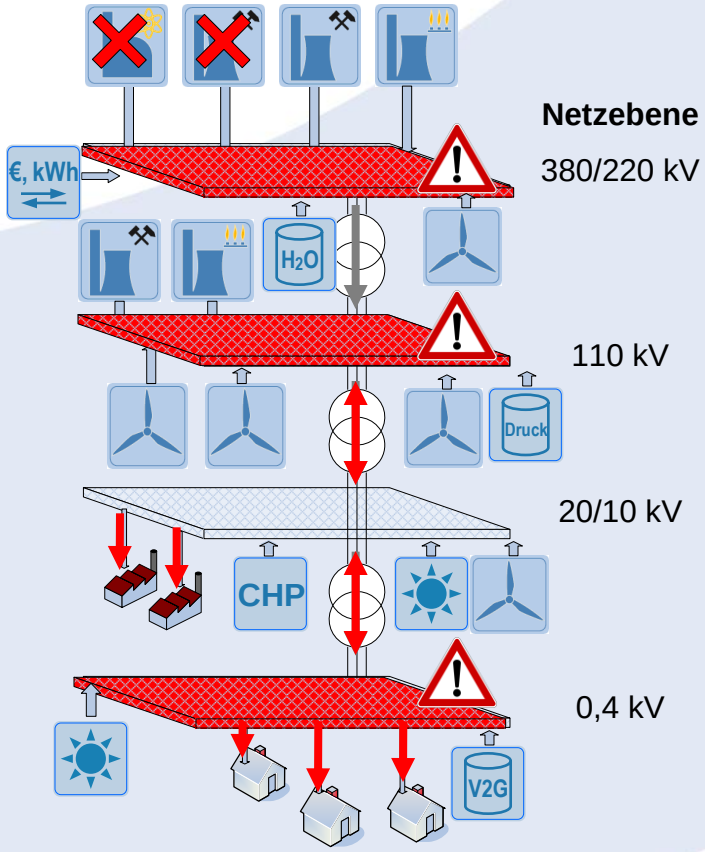
Future scenarios:

- Increasing distributed power generation.
- Progressive substitution of conventional power plants.
- Bi-directional power flows.

➔ Upgrading and reinforcement of the electrical grid: generation away of the consumption.

➔ REs should be involved in regulation and ancillary services.

➔ Technical requirements should take into consideration the technical characteristics of the equipments and the installations.



It is important to have standards and no retroactive GRID CODES.

Source: FHG/AEE

CRITICAL ELEMENTS OF THE INTEGRATION OF WIND POWER INTO THE ELECTRIC GRID, SYSTEM AND MARKET OPERATIONS

TECHNICAL REQUIREMENTS TO CONNECT WIND FARMS TO PUBLIC MAINS:
-Power quality: flicker, harmonics, …
- Safety.
- Minimum requirements for later technical operations: permanent voltage control, f/P, LVRT, …

TECHNICAL SYSTEM OPERATION:
- Local voltage control.
- Contribution to grid stability.
- Regulation and balancing power costs as low as possible.

WHOLESALE ELECTRIC MARKET:
- Wind power increases market liquidity.
- Day-ahead offers are based on weather forecasting.
- Deviations can be compensated in the intra-day markets.

NEVERTHELESS, WIND INTEGRATION CAN BE SEEN FROM DIFFERENT POINTS OF VIEW

TRANSMISSION SYSTEM OPERATOR (TSO)

Grid Security
Technical risk: GRID CODES

MANUFACTURER

Standardization, costs, …
Technical risk: certification, ...

DEVELOPER

Economic feasibility
Technical risks: contracts

TRANSMISSION AND SYSTEM OPERATORS NEEDS TO INCOPORATE POWER FROM RES

Increasing penetration of RES

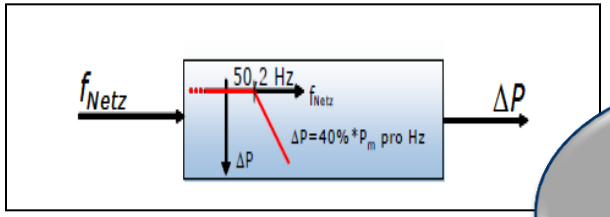
Problems of the system operator: are they real?

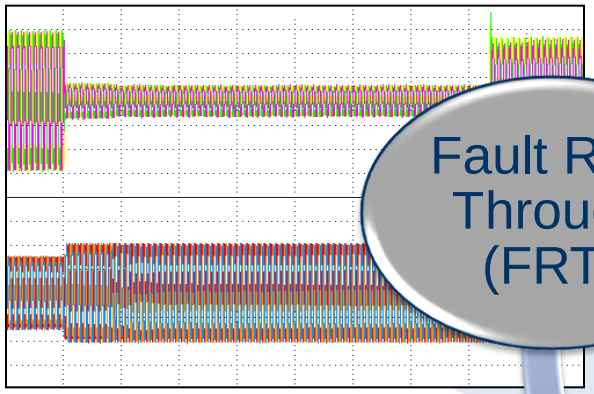
Frequency stability	Voltage regulation	Dynamic stability
• Lacking involvement of RES in balancing power regulation	• Substitution of conventional power plants with voltage control availability	• Risk of voltage unstability in case of sudden low voltage

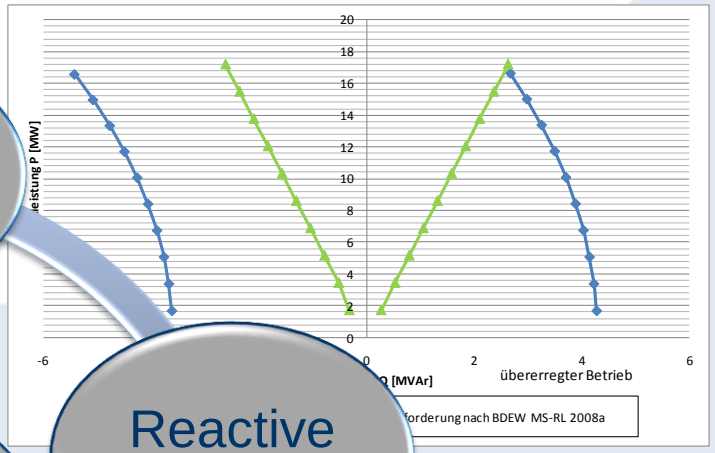
NEW GRID CODES/
Postulation of system services is mandatory

Source: FGH /AEE

CURRENT GRID CODE REQUIREMENTS FOR WIND POWER







Active Power

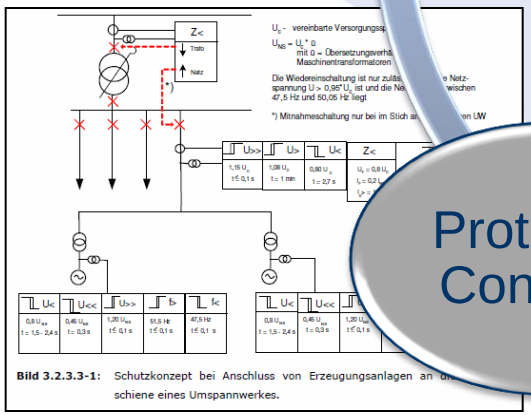
Fault Ride Through (FRT)

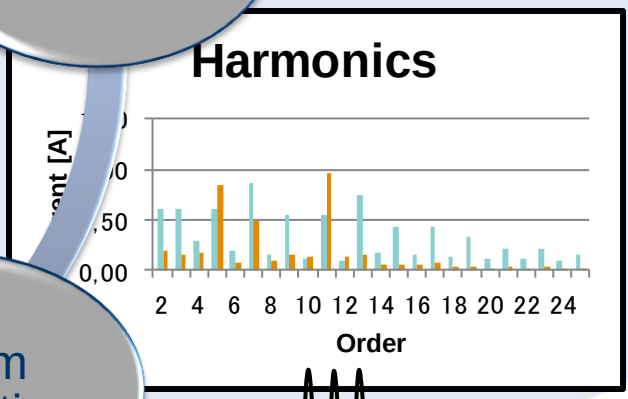
Reactive Power

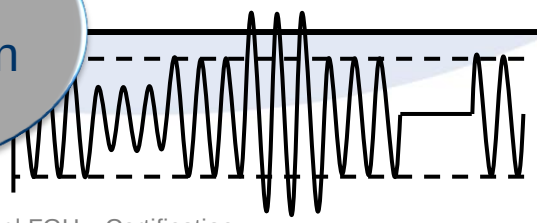
Grid Code requirements:

Protection Concepts

System perturbation

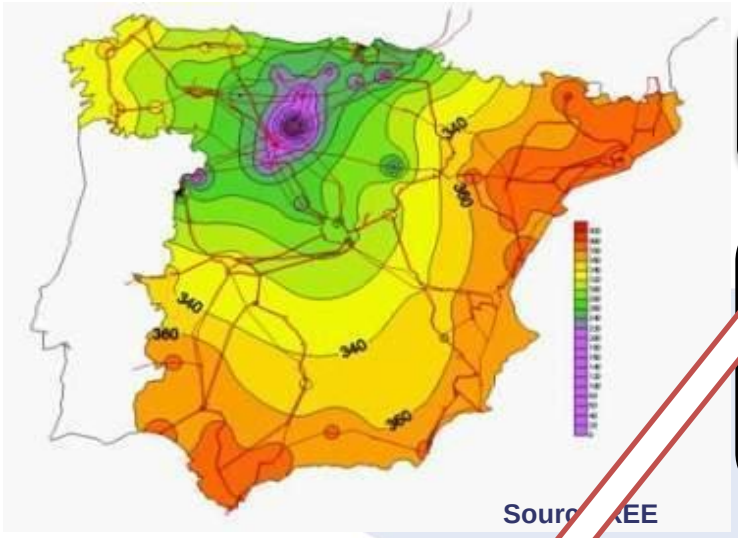






Source: Langstädtler | FGH – Certification

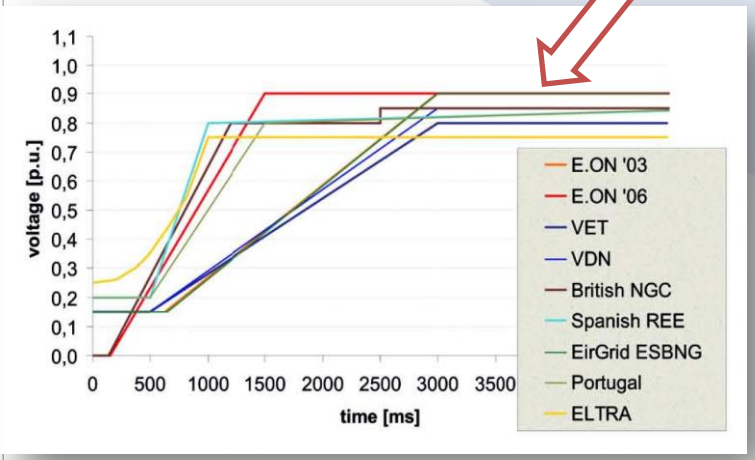
ONLY 5% OF THE WIND POWER INSTALLED IN SPAIN IS NOT ADAPTED TO THE LVRT GRID CODE

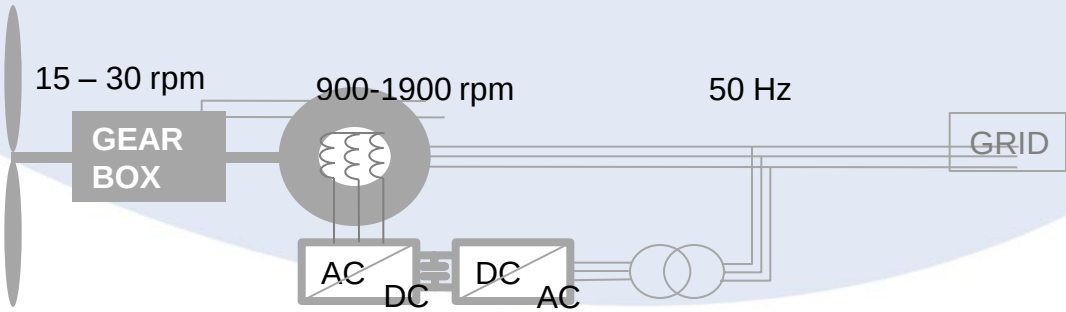


Source: REE

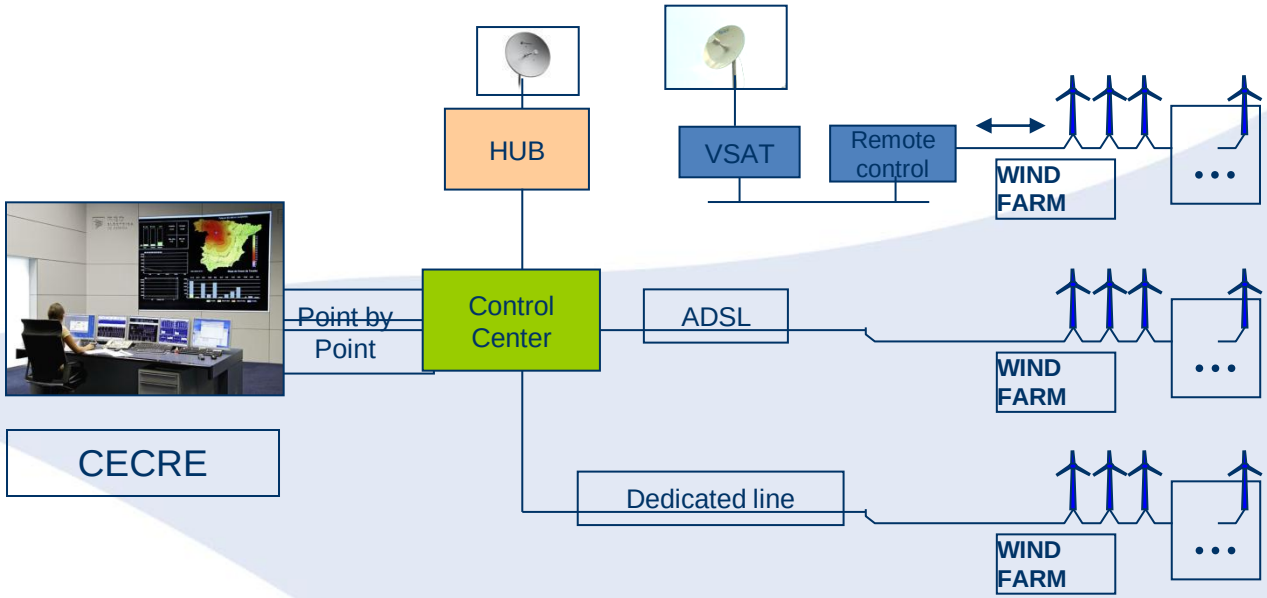
- All the TSOs are concerned by sudden voltage drops and the subsequent risks of instability.

- Wind farms cannot trip off the grid in case of sudden voltage dips (Grid Code O.P. 12.3)
- WTG and Wind Farms have integrated power electronics to fulfil those requirements.
- Certification and test procurement were jointly developed by AEE and the TSO.





ALL WIND FARMS OVER 10 MW OF CAPACITY ARE CONTROLLED BY THE TSO

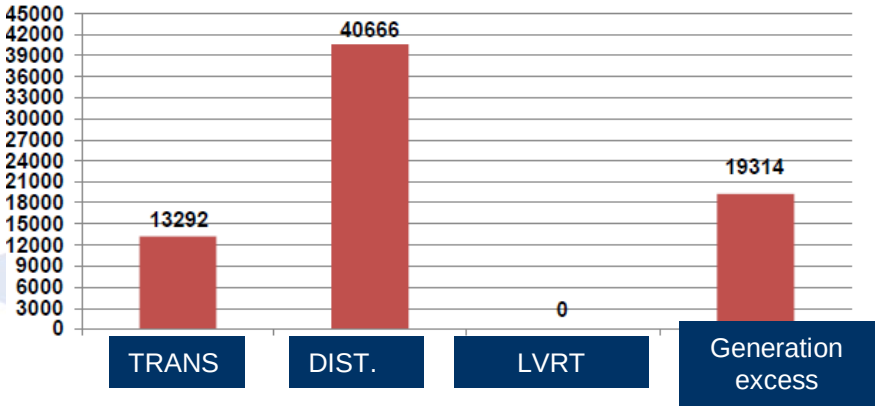


REASONS FOR CURTAILMENTS

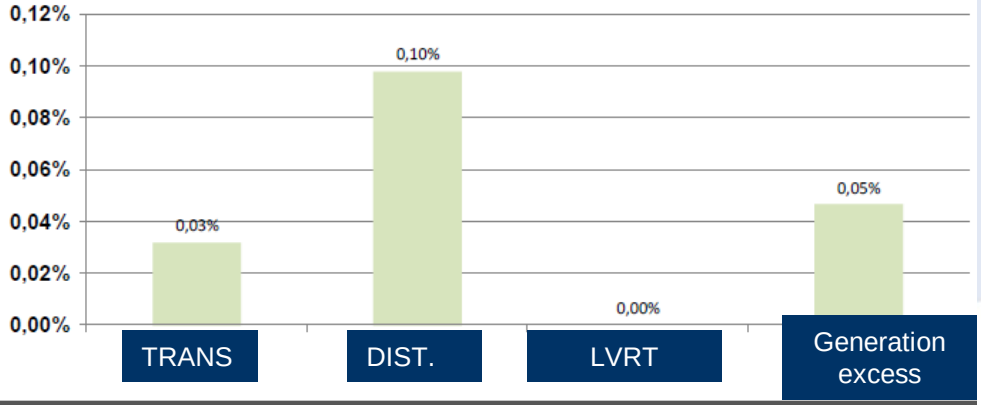
- Overload risks in transmission and distribution grids.
- Risks of lost of power by transient instability (LVRT).
- Limited short circuit capacity of the installed wind farms which could restrict the operation of neighbourhood protections.
- Excess of generation which cannot be consumed by the demand (limited exchange capacity with France).

LOW WIND CONDITIONS AND DEMAND DECREASE REDUCE WIND FARM CURTAILMENTS

MWh curtailed in 2011



MWh curtailed/MWh generated in 2011



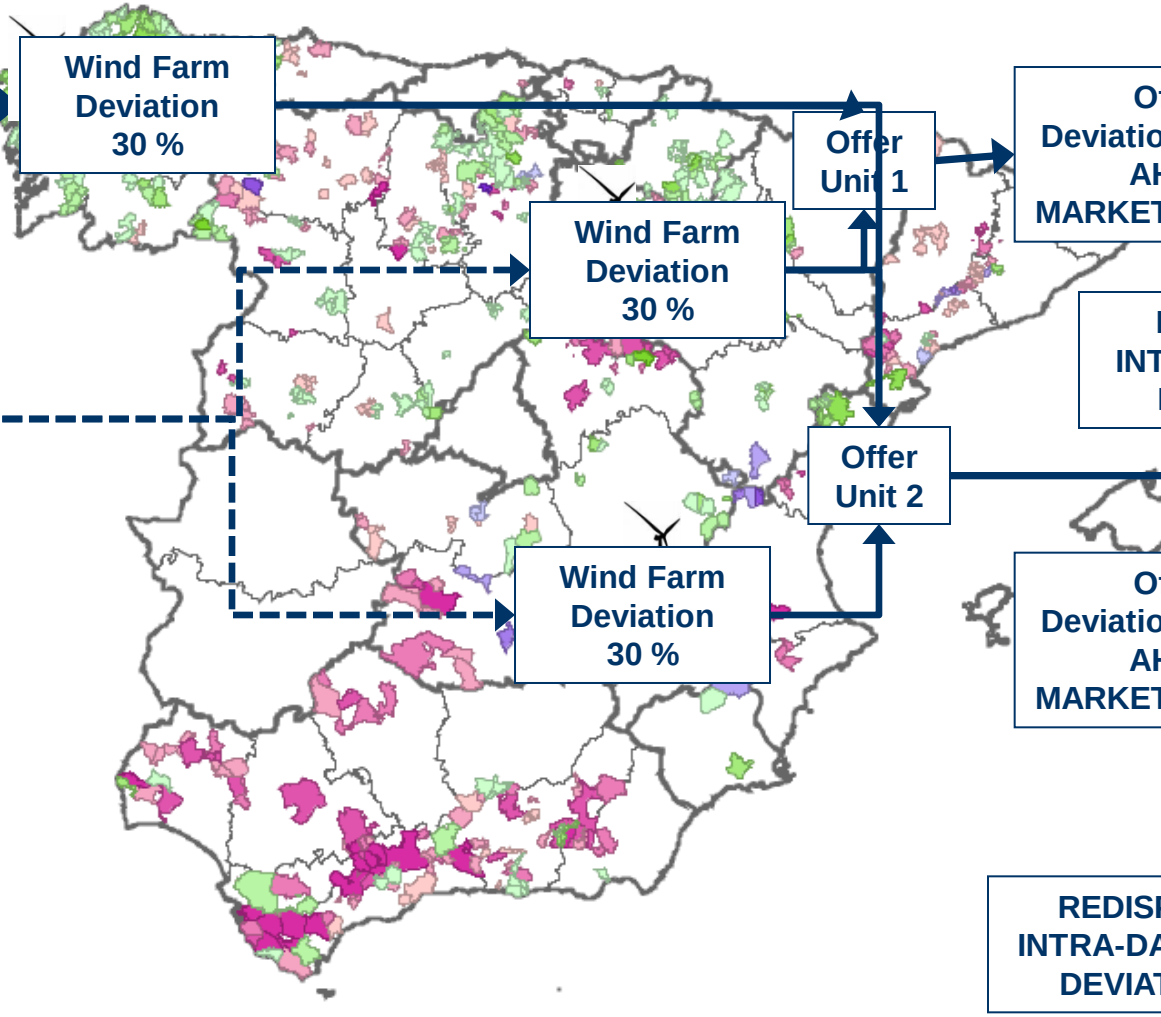
In 2011, only ~ 74,000 MWh were curtailed, 0.18% of all wind power generation in that year

WIND FARMS FORECAST THEIR PRODUCTION FOR THE DAY MARKET TO OPTMIZE THE BALANCING POWER OF CONVENTIONAL POWER PLANTS

GLOBAL METEOROLOGICAL DATA

FORECASTERS

WIND FARM PRODUCTION FORECASTS



Offer Unit 1

Offer Unit 2

Offer 1 Deviation 20% DAY AHEAD MARKET<10.00 A.M

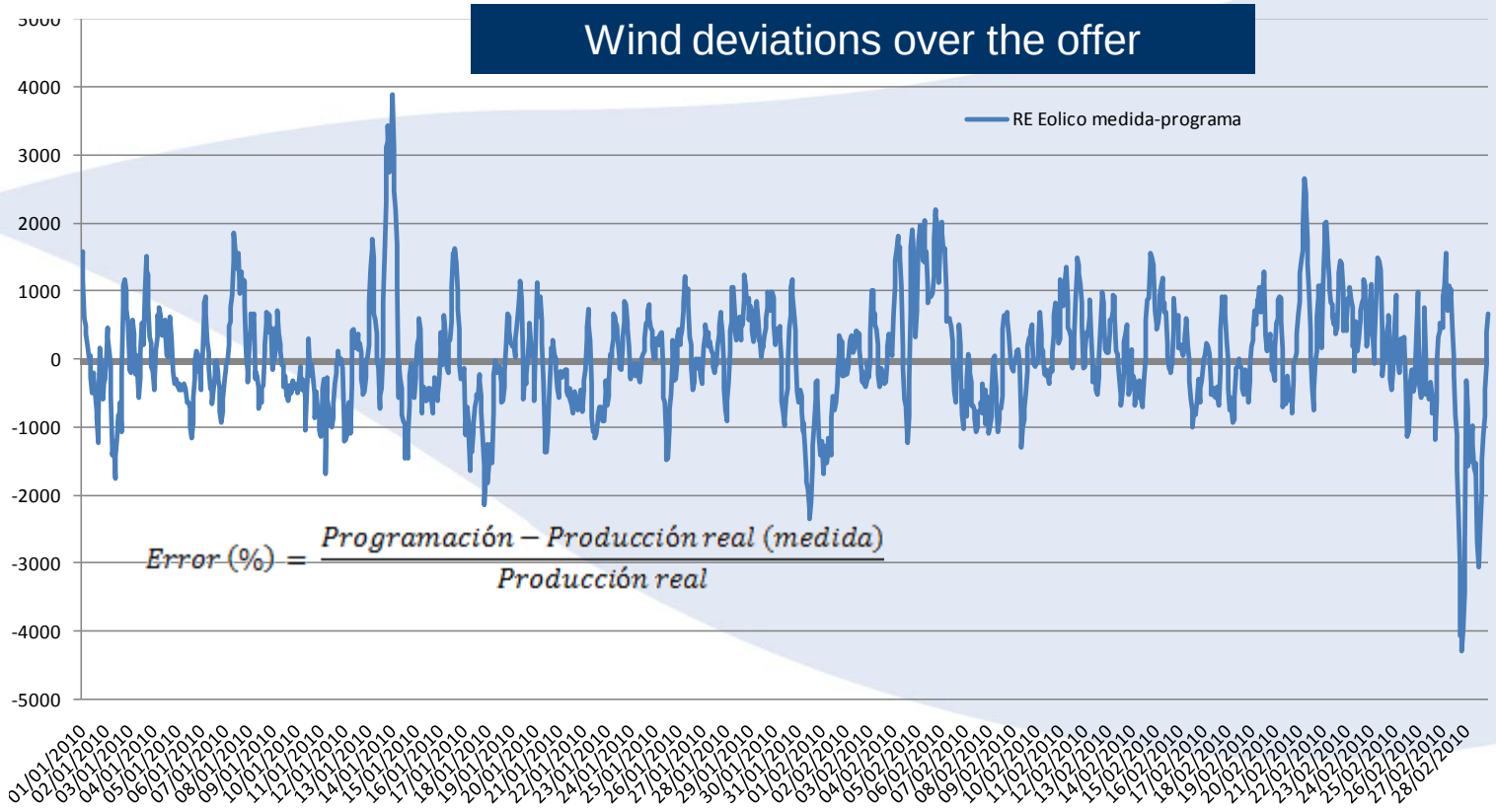
REDISPATCHING INTRA-DAY MARKETS DEVIATION: 15%

Offer 2 Deviation 17% DAY AHEAD MARKET<10.00 A.M

REDISPATCHING INTRA-DAY MARKETS DEVIATION: 13%

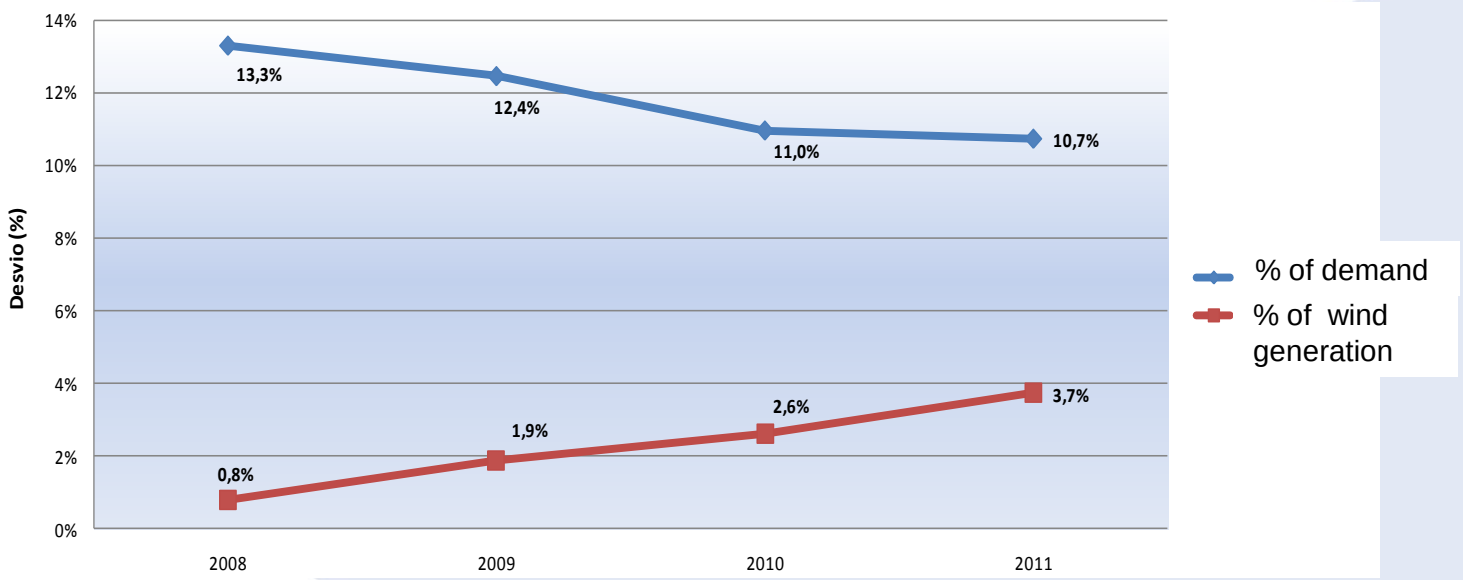
AVERAGE DEVIATION OF WIND FARMS OFFERS IS BETWEEN -13% AND +11%

Wind power could participate in all sessions of intra day markets and it is also affected by technical restrictions



Fuente: ESIOS

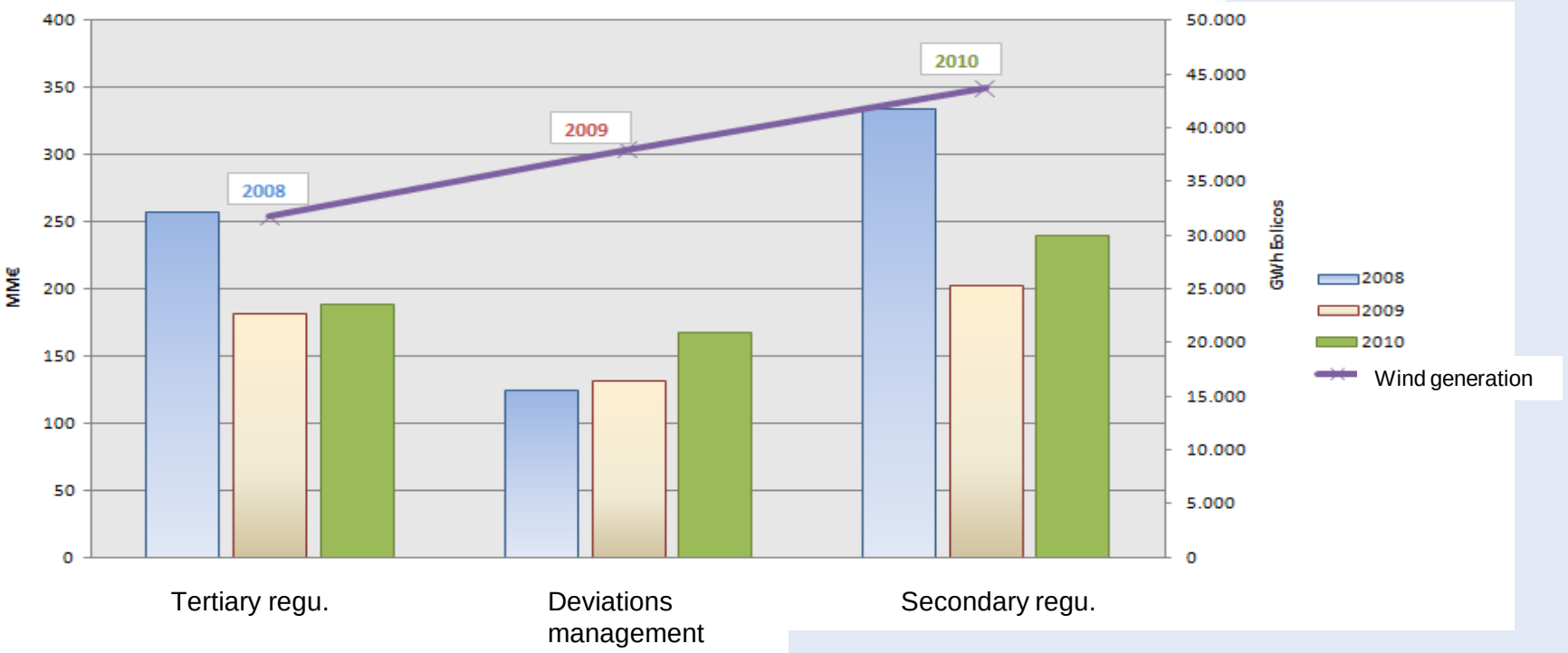
DEVIATIONS OF THE LOAD ARE STILL MUCH MORE IMPORTANT THAN WIND POWER DIFFERENCES



In absolute terms, the deviation of the demand is much more important than the wind generation one, which, moreover, tends to decrease.

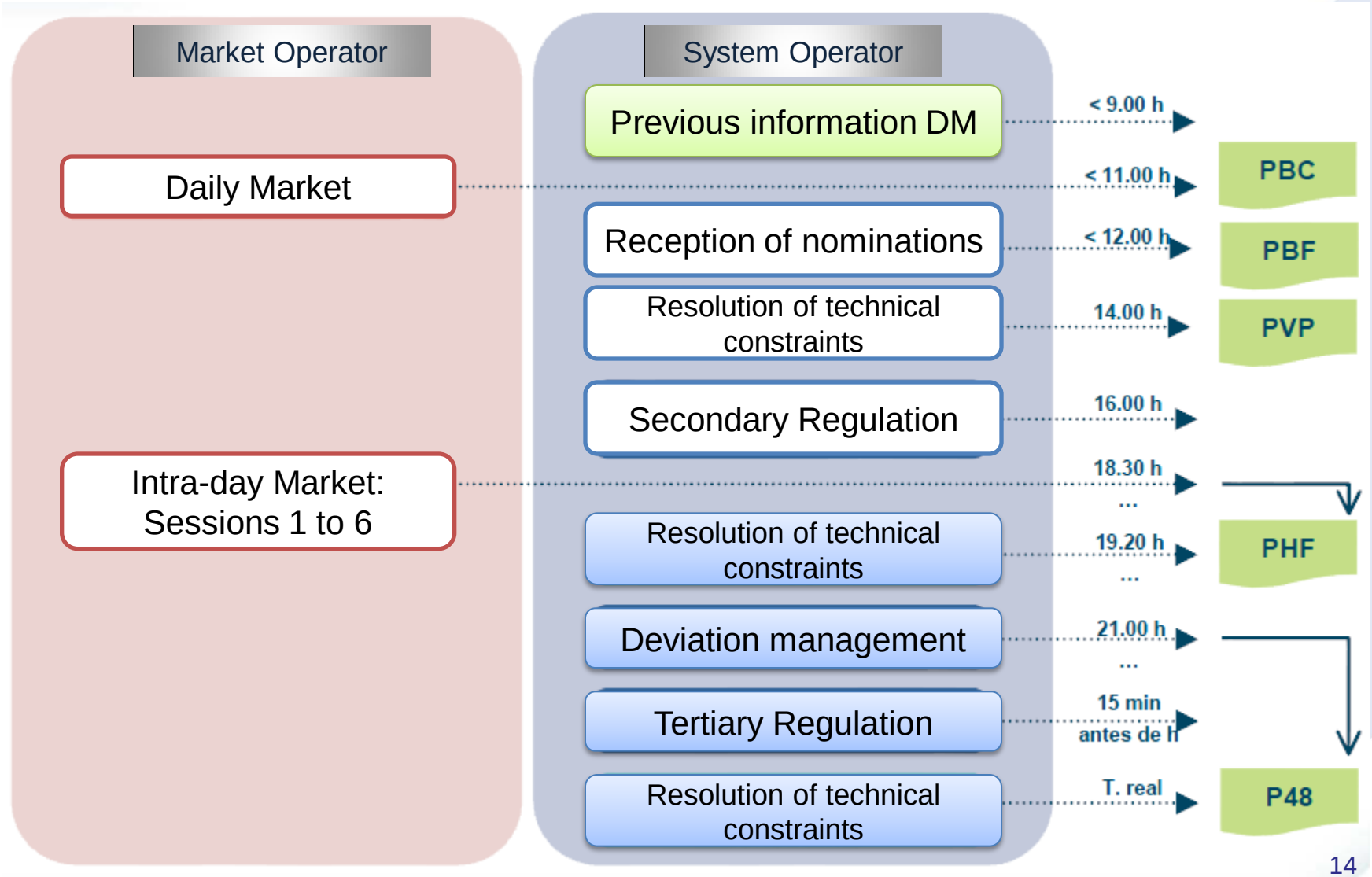
THE GROWING PRESENCE OF WIND ENERGY HAS NOT HAD ANY ECONOMIC IMPACT ON THE REGULATION SERVICES

The increase of deviation management has been caused by deviations between forecasts and actual load

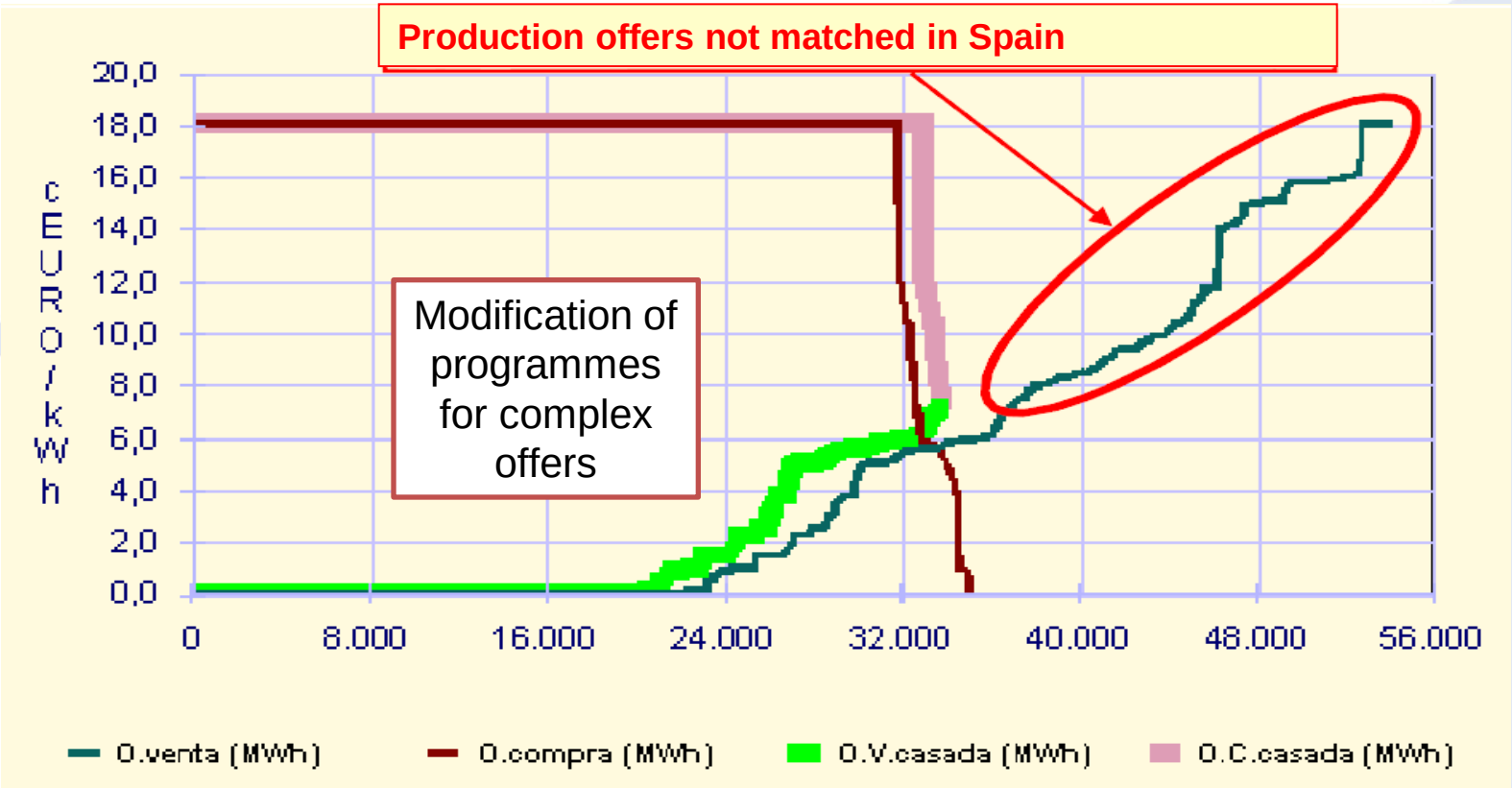


While production has increased by 37.5%, secondary and tertiary regulation costs have decreased by 28% and 27% respectively.

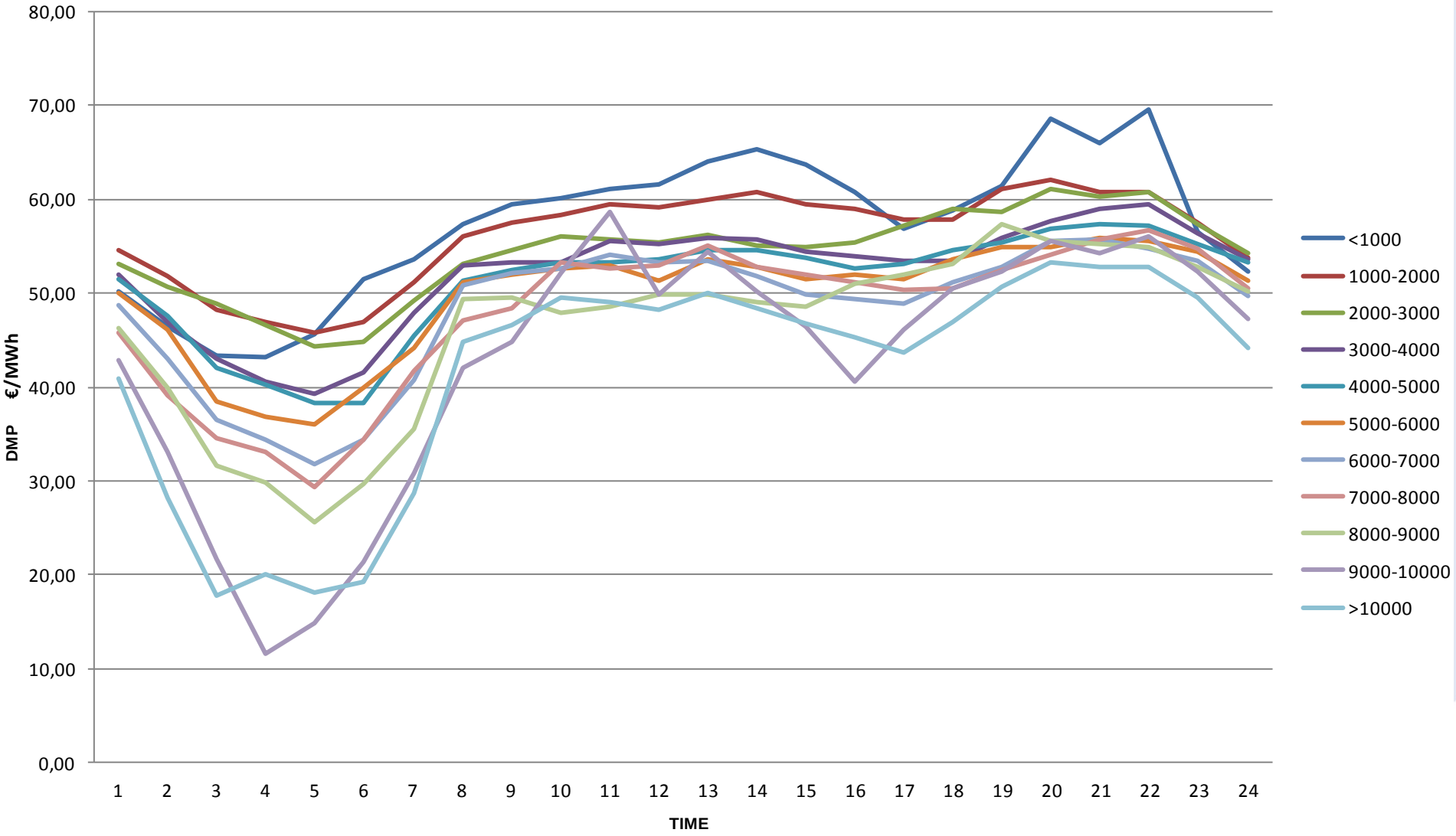
ANCILLARY SERVICES PROGRAMMES MANAGED BY REE



DAILY ELECTRIC MARKET



HOW DID WIND POWER INFLUENCE DAILY MARKET PRICE IN 2011



WIND POWER SIGNIFICANTLY REDUCES THE COST OF ENERGY

TIME	1	2	3	4	5	6	7	8	9	10	11	12
SAVING €/1000 wind MWh	1,3	2,1	2,8	3,2	3,2	3,0	2,5	1,8	1,7	1,4	1,5	1,7
Energy managed in the DM 2011 (MWh). Buy + Exp	7.536.037	6.774.642	6.249.955	5.911.387	5.792.499	5.784.751	6.010.334	6.792.808	7.435.281	7.969.607	8.453.006	8.633.462
Average hourly ofwind MWh produced in 2011	5.154	5.056	4.935	4.784	4.665	4.581	4.521	4.462	4.330	4.142	4.066	4.131
Reduction (€) for the electric system due to wind integration in 2011	50.491.420	71.927.814	86.354.575	90.503.927	86.471.058	79.506.469	67.937.132	54.562.028	54.733.514	46.213.205	51.555.085	60.637.379

TIME	13	14	15	16	17	18	19	20	21	22	23	24
SAVING €/1000 wind MWh	1,3	1,6	1,6	1,7	1,6	1,3	1,1	1,1	1,1	1,2	0,9	0,7
Energy managed in the DM 2011 (MWh). Buy + Exp	8.925.468	8.941.464	8.764.776	8.652.714	8.507.531	8.517.246	8.566.015	8.631.838	8.706.556	8.774.646	8.563.610	7.949.693
Average hourly ofwind MWh produced in 2011	4.267	4.434	4.612	4.782	4.940	5.078	5.208	5.297	5.316	5.310	5.299	5.253
Reduction (€) for the electric system due to wind integration in 2011	49.513.020	63.429.278	64.679.584	70.345.427	67.247.299	56.223.525	49.073.791	50.293.812	50.916.924	55.913.629	40.841.099	29.232.469

Thanks to the wind power production of **2011**, the system saved **1.5** b€ due to the reduction hourly price.

CONCLUSIONS

- Collaboration among utilities, the TSO and the wind sector is essential to increase and facilitate the integration of wind electricity into the grid.

- Grid codes for wind installations are more exacting than those for conventional power plants and their ancillary components. The wind sector has always shown great professionalism and technical skills to react to those requirements.

- Cost reduction and simplification of power electronics have allowed the finding of solutions to ensure the response of wind farms in case of sudden voltage dips as well as in steady permanent conditions.

- Active involvement in the electricity market, through the participation in different markets and extensive use of weather forecasting, maximizes the integration of wind power at the lowest possible cost.

THANK YOU VERY MUCH FOR YOUR ATTENTION

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