



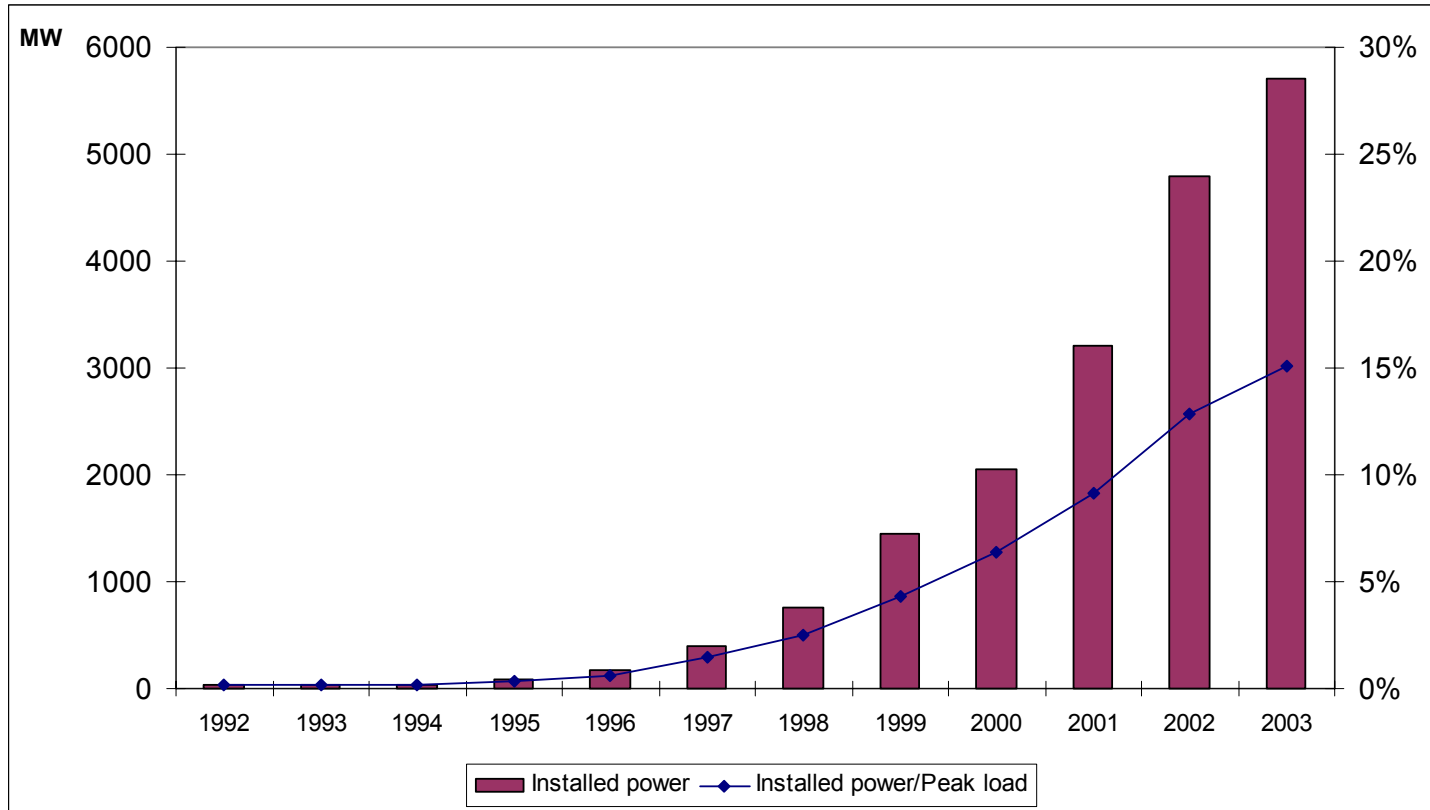
RED ELÉCTRICA
DE ESPAÑA

**EXPERIENCE WITH RAPID GROWTH OF
WIND GENERATION IN SPAIN**

24th of May of 2004



Wind generation installed (SPPS)

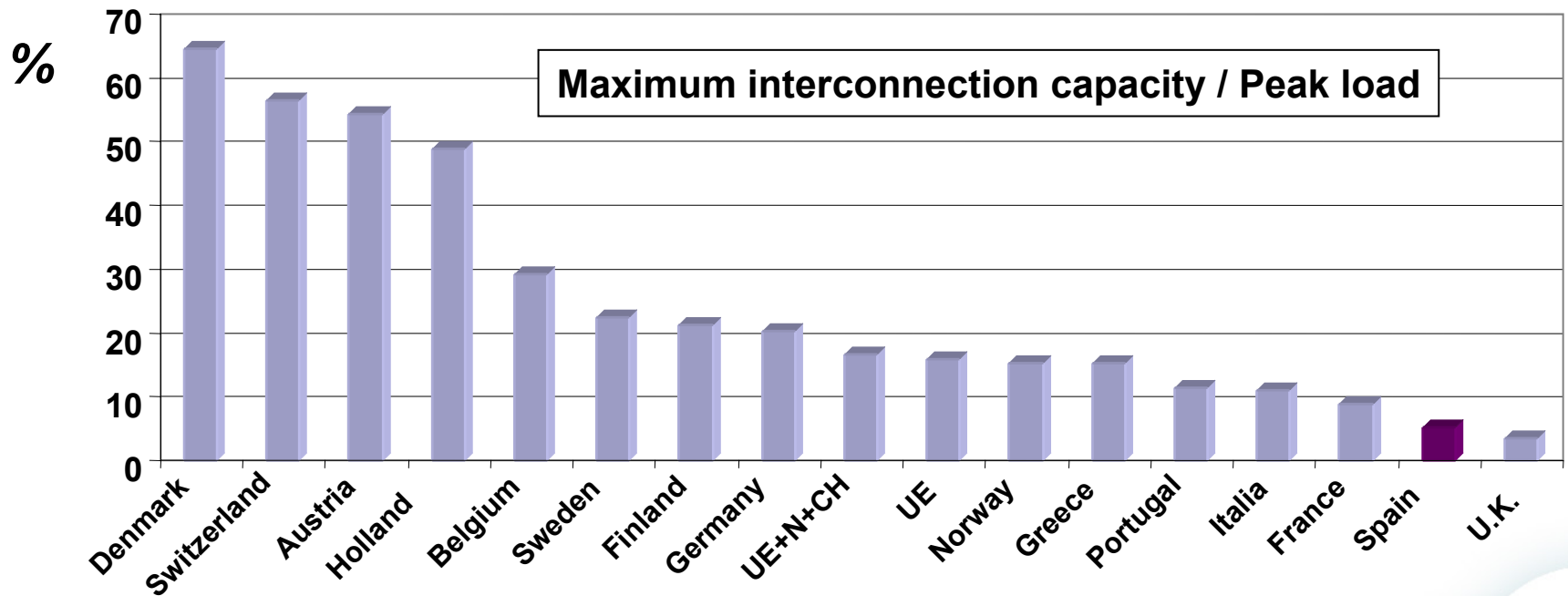


SPPS: Spanish Peninsular Power System



Relative importance of wind power

Year 2002	Installed wind power (MW)	Wind production (GWh)	Annual demand (TWh)	Peak load (MW)	Installed wind power / Peak load	Wind production / Total production	Wind production / Annual demand
Germany	12.001	16.500	498,6	75.800	15,8%	3,27%	3,31%
Spain	4.830	9.039	210,3	33.771	14,3%	4,26%	4,30%





Impact of wind farms on the electric power system

□ Local:

- Modification of power flows and voltages
- Influence over protection schemes and contribution to fault current
- Power quality:
 - Harmonics
 - Flicker
- Need for new installations and reinforcements – not meshed substations

□ Global:

- Transient stability
- Voltage control and reactive power
- Frequency regulation
- Influence in the generation program



Fault ride-through capability of wind farms

Disconnection of wind generation due to correctly cleared short-circuits in 2004

- 17th & 18th of January. Several single-phase two-phase and three-phase faults, cleared with definitive trips and trips with re-closing. Lost up to 465 MW of wind power.
- 26th of February. Two-phase fault in a 400 kV busbar. Lost aprox. 600 MW of wind power.
- 1st of April. Two three-phase faults in 400 kV network. 500 MW of wind power disconnected.
- 18th of April. Three-phase fault in 400 kV line close to substation. Lost aprox. 400 MW.





System security. Transient stability

- During correctly cleared short-circuits occurred in the transmission network, big amounts of wind generation are disconnected from the system, due to too sensitive protection systems
- Ministerial order of 5th September 1985 – “Three instantaneous minimum voltage protection systems must be installed between phases, adjusted at $0,85 \cdot U_m$, to detect performance in island”
- Self-protection of wind generators – Some technologies are not able to stay coupled when voltage goes under 0,9 pu due to their internal electronic components.

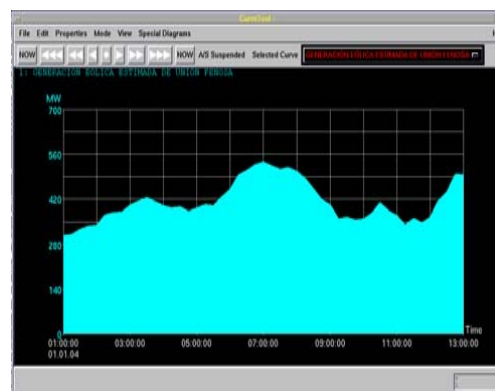
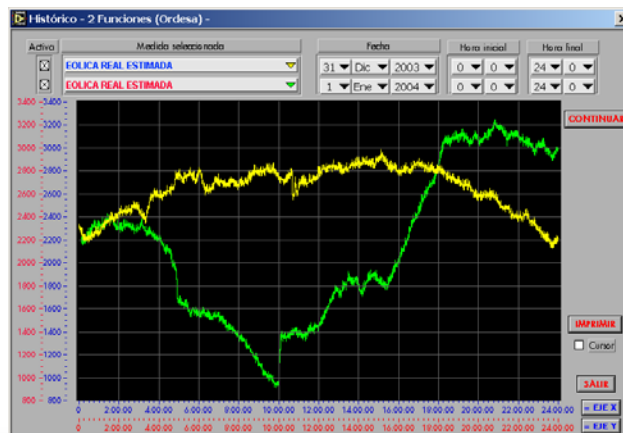
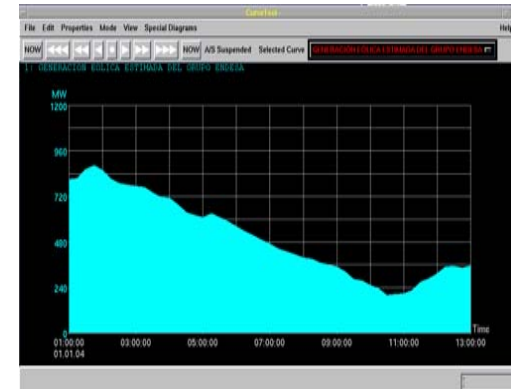
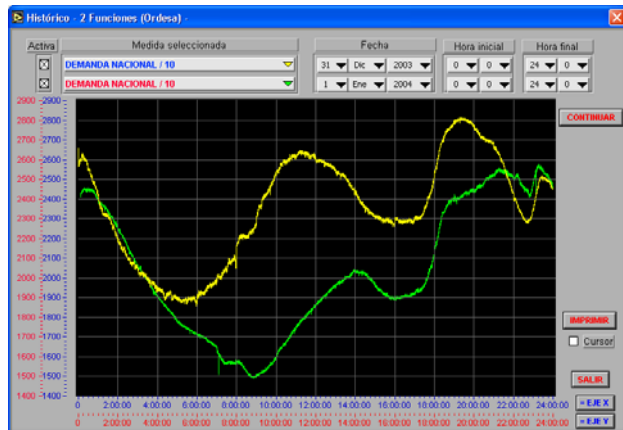
Demand	Delay of the protection	Wind production admissible
Peak load	500 ms	10.000 MW
Off-peak load	500 ms	3.000 MW
	1 sec.	5.000 MW

Installed power
13.000 MW



Production control

- Special demand situations – Deep off-peak scenarios in which conditions are more extreme than in the studies used to determine maximum wind production admissible (1st of January of 2004)





Influence of wind generation in system operation. Operation program

- ❑ **Generation program**
 - Very affected by the precision of wind production forecast
- ❑ **Technical restrictions**
 - In occasions it is not possible to maintain the system variables within acceptable values applying technical restrictions only to ordinary generation
- ❑ **Unbalance**
 - More energy managed

**Bad precision in wind production forecast
forces a bigger use of operation markets**



Influence of wind generation in system operation. Ancillary services

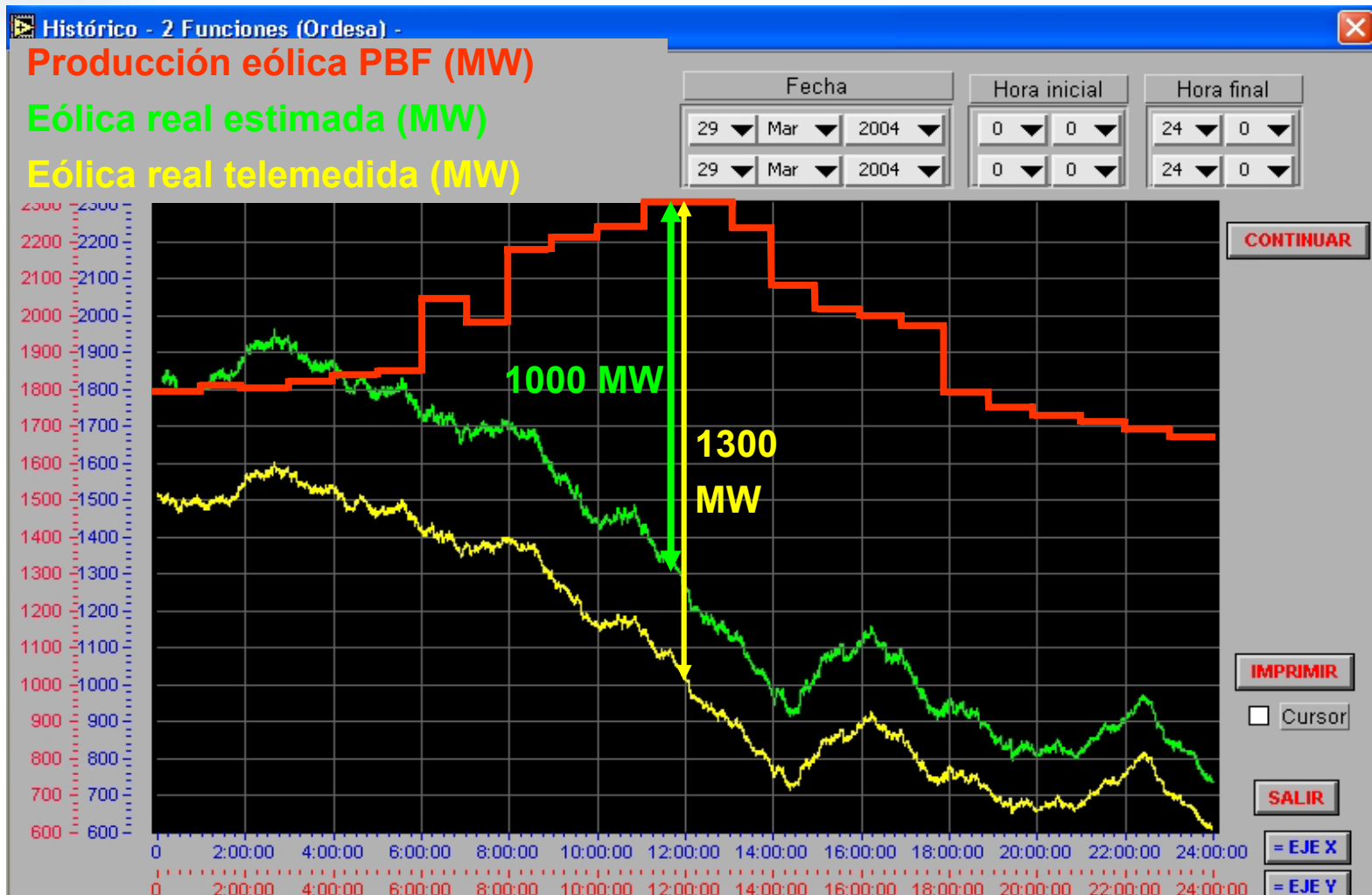
- ❑ **Primary regulation**
- ❑ **Secondary regulation**
- ❑ **Tertiary regulation**
- ❑ **Voltage control**

Variability in wind generation forces a bigger use of ancillary services

Wind generation replaces ordinary generation and reduces the resources available for regulation and voltage control



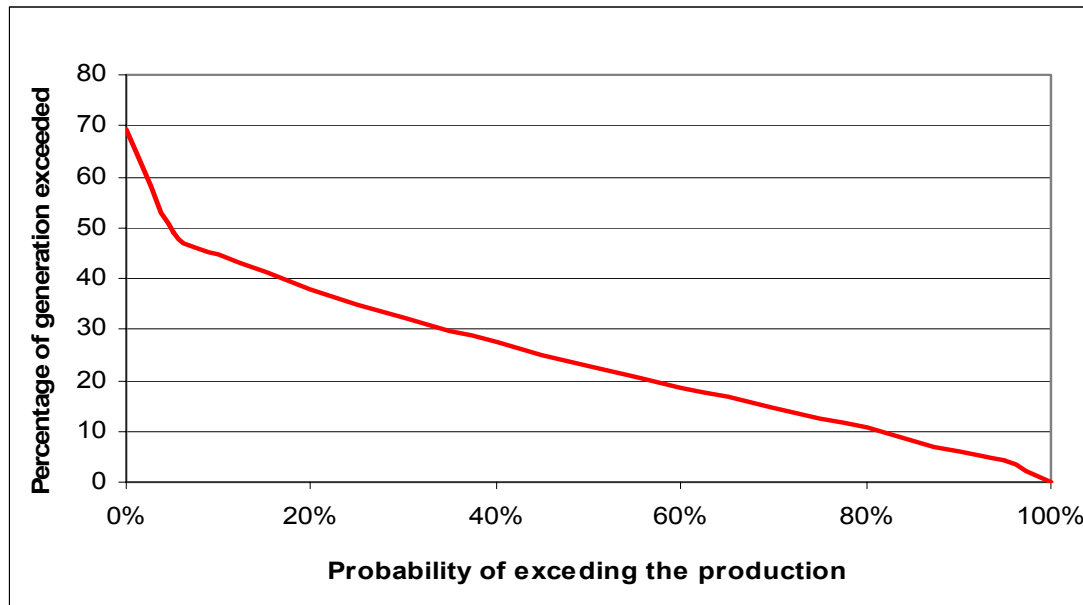
Excessive use of secondary regulation





Influence of wind generation in system security

- ❑ Not meshed substations
- ❑ System restoration
 - Wind generation does not have black start capability
 - Difficulties to know its state during restoration
- ❑ Production vs. Installed power





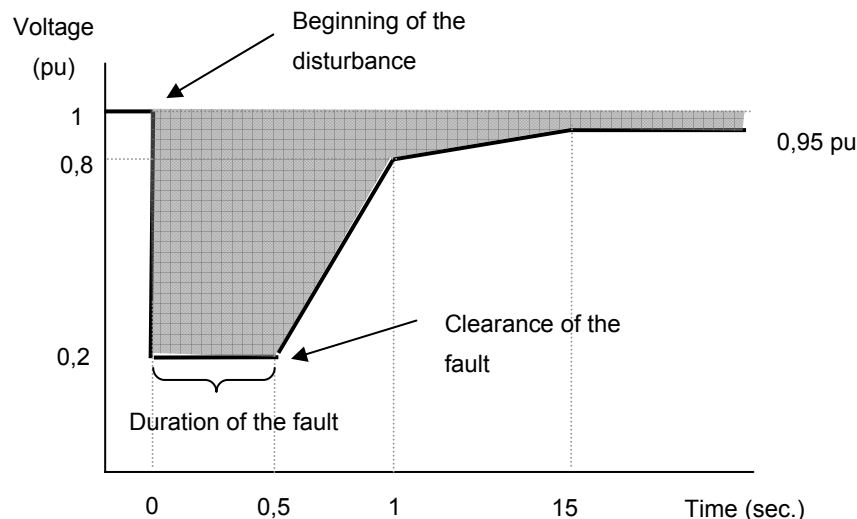
Power quality

- **The affection of wind generation to power quality is limited by the connection criteria**
 - **Evacuated power $\leq 50\%$ of the evacuation capacity in the connection bus:**
 - **Capacity of the lines**
 - **Capacity of the transformers**
 - **Evacuated power $\leq 5\%$ of the short-circuit power in the connection bus**
- **Ministerial Order in draft, with emission limits for all major disturbances:**
 - **Harmonics**
 - **Flicker**
 - **Unbalance**



Conclusions: Red Electrica's proposal (I)

- In order to integrate a big amount of wind generation in the Spanish electric system, maintaining the security and quality conditions, it is needed that these installations meet some requirements:
- Capability to not disconnect during short-circuits (not consuming active or reactive power during the disturbance). Do not disconnect in the gray area of the figure.





Conclusions: Red Electrica's proposal (II)

- **Participation in solving technical restrictions, specially in critical stability situations.**
- **Integration in dispatching offices that can accept Red Eléctrica's orders to meet the requirement mentioned above.**
- **Participation in voltage regulation.**
- **Forecast of the production.**
- **Evacuation in existing substations.**
- **Adequacy to these requirements of the existing wind farms.**