

RED
ELÉCTRICA
DE ESPAÑA

Integration of solar power and storage in Spain

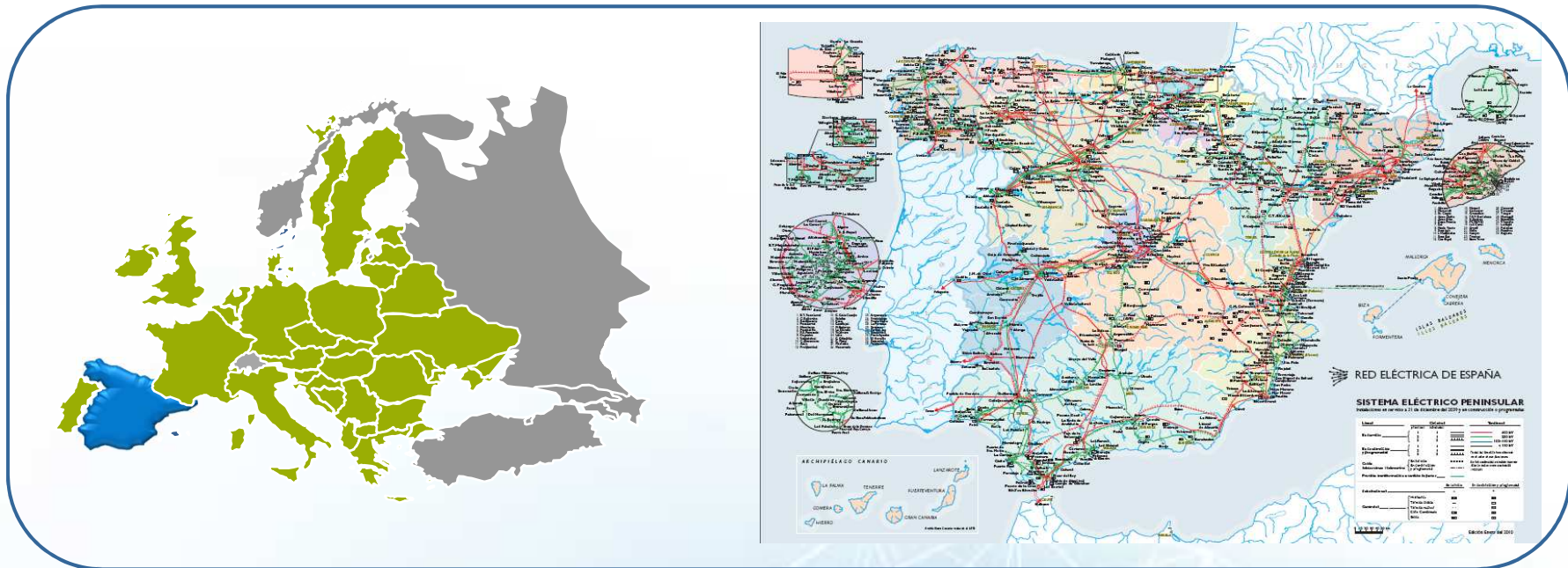
Miguel de la Torre

September 5th 2017

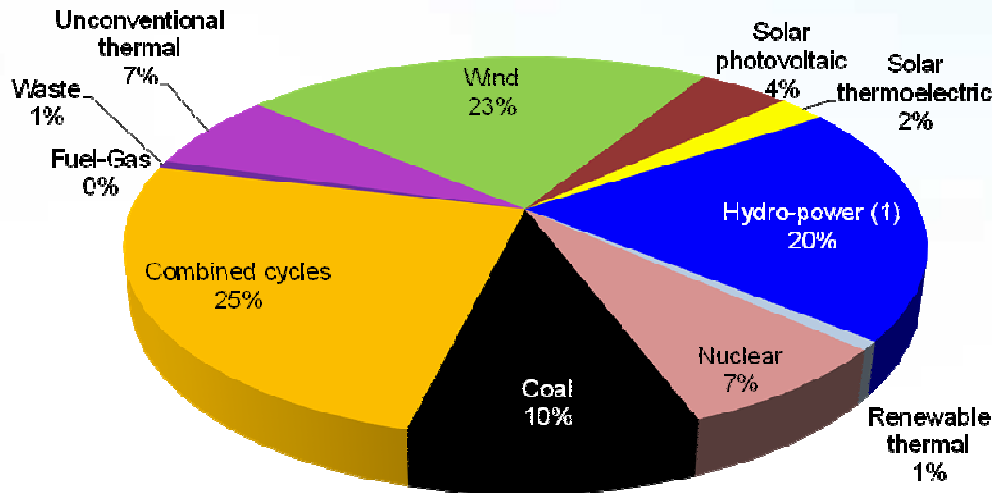
The Spanish electricity system

Red Eléctrica de España (REE) is the only Spanish transmission system operator (TSO) owning 99,5% of the transmission grid.

- Peninsular system connected to Continental Europe + 10 island systems.
- Record peak demand: 45 450 MW in December 2007.
- Network: 39 719 km of 400 and 220 kV lines, 612 substations.



Installed capacity in 2017



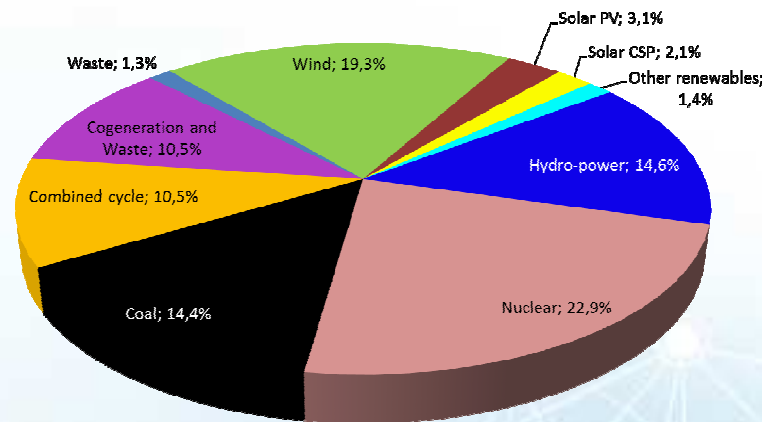
Technology	MW	%
Wind	22,891	22.9
Solar photovoltaic	4,430	4.4
Solar thermoelectric	2,300	2.3
Hydro-power (1)	20,353	20.3
Other renewables	744	0.7
Nuclear	7,573	7.6
Coal	9,536	9.5
Combined cycles	24,948	24.9
Waste	677	0.7
Unconventional thermal	6,631	6.6
Total	100,083	100.0

(1) Includes pumping power

- There are 5613 MW of pumping units installed.

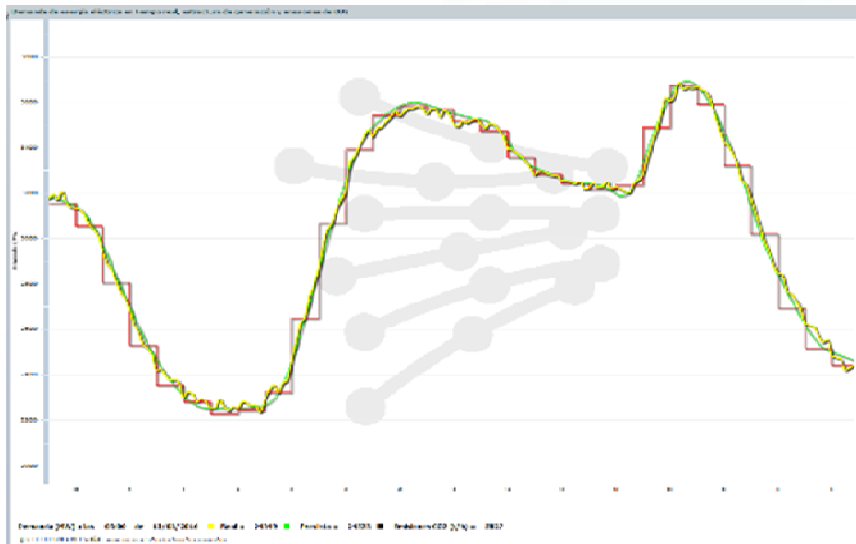
Structure of the accumulated net generation in 2016

Σ Energy without CO₂ emissions ≈ 63,7%



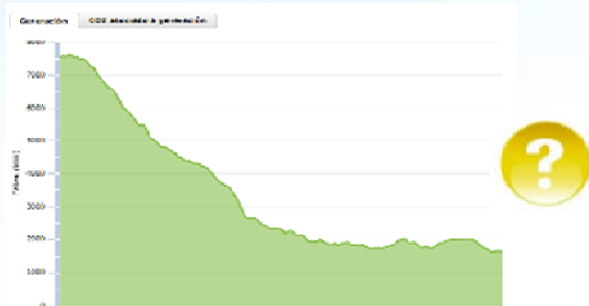
Σ Renewable Energy ≈ 40,8%

Generation profiles and demand

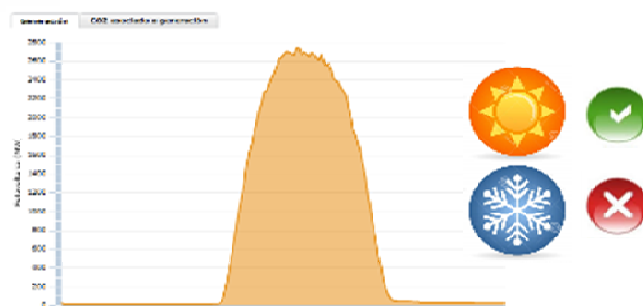


- Differences compensated by non-nuclear thermal, hydro and pump-storage power plants and international exchange programs depending on wholesale market prices.

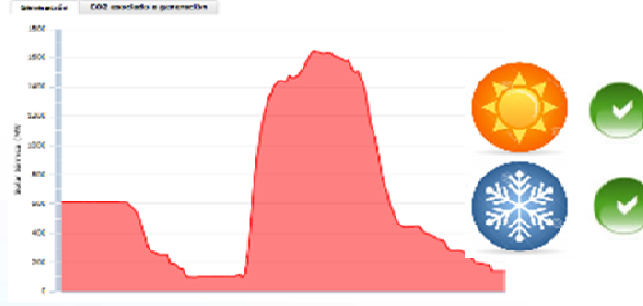
Eólica



Fotovoltaica



Solar Térmica



Regulatory and operational considerations for solar power

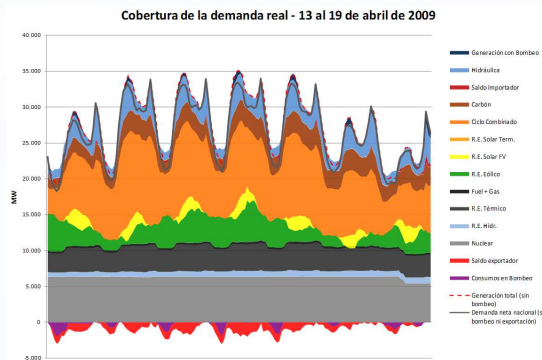
Current regulation approved in 2014

- Small regulatory differences between conventional power plants and Renewable Energy Sources (RES).
- Solar generation participates in the wholesale markets and pays for its deviations.
- Plants with installed capacity >1 MW send real-time telemetry to REE and this data is used to calculate real-time solar production and feed REE's forecasting tools. Plants >5MW shall attend real-time limitations from REE within 15 minutes.
- Real-time information and forecasting tools are essential to maintain a proper balancing of the system at low balancing costs. Uncertainties in generation forecasting lead to deviations from the solar schedules and to a larger need for balancing reserves.
- Solar plants may participate in balancing services in competition with any other power plant. However, effective participation is currently negligible, unlike wind.
- In large systems, the variability of single and dispersed plants is not an issue. The largest solar variability in Spain is ramping at dawn and dusk on sunny days.

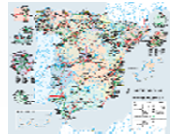


The role of storage in the Spanish electricity system

- Shifts generation from hours with lower marginal prices to hours with higher marginal prices. It allows to store energy in hours with low demand and high RES.
- Provides balancing services, voltage control and congestion management.
- Provides fast cold reserves if reservoirs are sufficiently filled counteracting possible extreme variability events or large imbalances due to any other reason.
- Provides inertia to the system also when storing energy (only for pump-storage).
- Allows balance responsible parties to mitigate deviations.
- Role is more relevant when storage attends the needs of the whole system and not the specific needs of a single power plant or group of plants.



Instruments for integration of variable renewable energy



Reinforcements international interconnections



Storage facilities



Control instruments (CECRE)



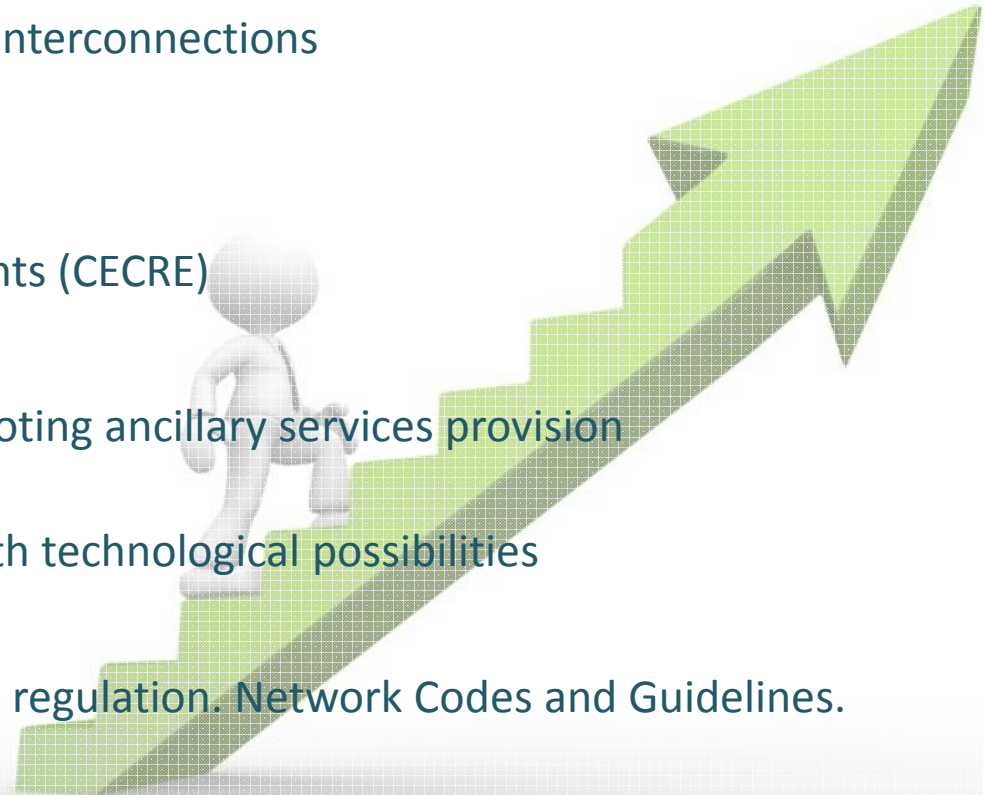
Legislation promoting ancillary services provision



Coherent legislation with technological possibilities



Introduction of Europe-wide regulation. Network Codes and Guidelines.





cuidamos tu energía

www.ree.es

Thanks for your attention