CDTI-NEDO-JWPA delegation visit to CECRE (REE)

Grid Integration of Wind Energy in Spain

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5th July 2018

¿What is Reoltec?

Plataforma Tecnológica del Sector Eólico Español Integra y coordina las acciones de I+D+i entre la industria, sector investigador y las administraciones

- Compartir conocimiento para reforzar la competitividad de la tecnológica de la industria eólica
- Vertebrar las actividades de I+D+i. CCAA. Universidad-Empresa. Plataformas tecnológicas
- Identificar necesidades de la industria eólica para definir prioridades I+D+i
- Seguimiento de líneas de ayuda. Impulsar la presentación de proyectos y la formación de consorcios
- Difusión de avances y comercialización de proyectos innovadores
- Seguimiento de patentes y del estado del arte de la industria y la tecnología

Políticas Públicas I+D+i

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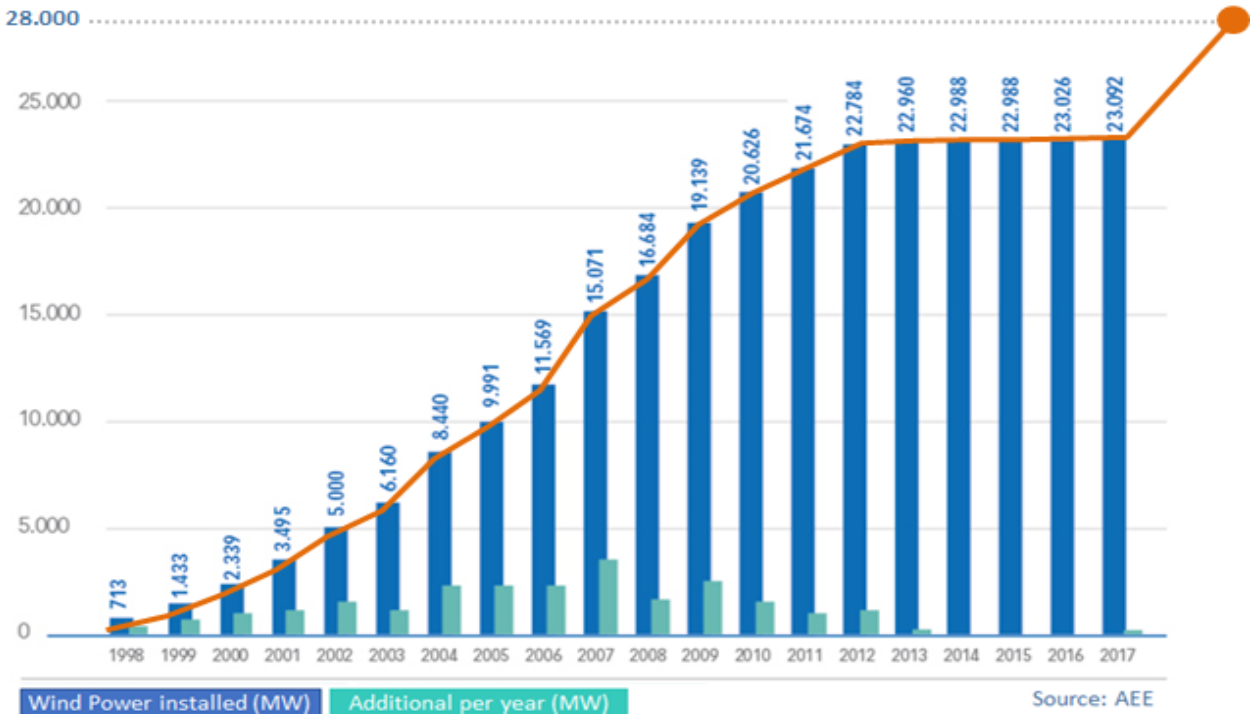
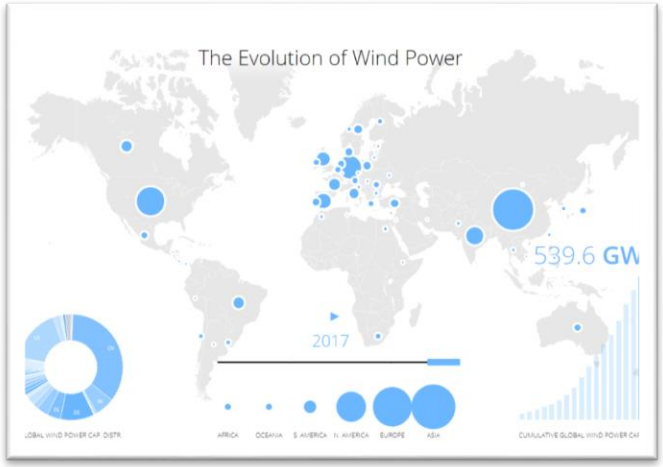
Overview of Wind Power in Spain

Evolution of Wind Power capacity in Spain



+ 5.000 MW before March 2020

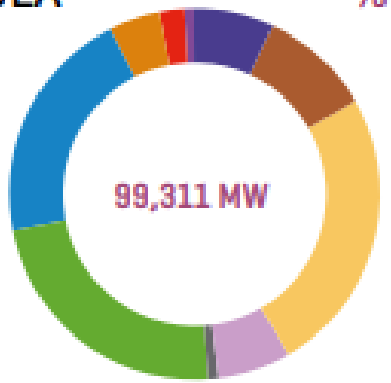


Spain´s installed power capacity and demand coverage (2017)

INSTALLED POWER CAPACITY ON THE PENINSULA
AS AT 31 DECEMBER 2017 (GW)

Nuclear	7.2	Wind	23.0
Coal	9.6	Hydro (1)	20.5
Combined cycle	25.1	Solar photovoltaic	4.5
Cogeneration	6.4	Solar thermoelectric	2.3
Waste	0.7	Other renewables	0.7

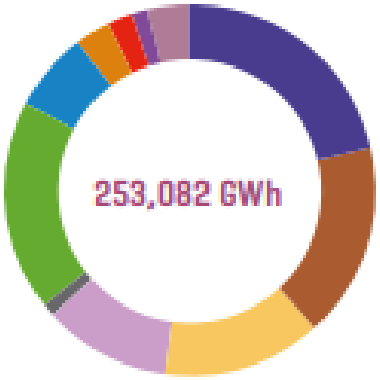
(1) Includes pure pumped storage (3,329 MW).



PENINSULAR ELECTRICITY
DEMAND COVERAGE (2017) (%)

Nuclear	21.5	Wind	18.2
Coal	17.0	Hydro (1)	7.0
Combined cycle	13.9	Solar photovoltaic	3.1
Cogeneration	11.0	Solar thermoelectric	2.1
Waste	1.2	Other renewables	1.4
		Importer balance regarding international exchanges	3.6

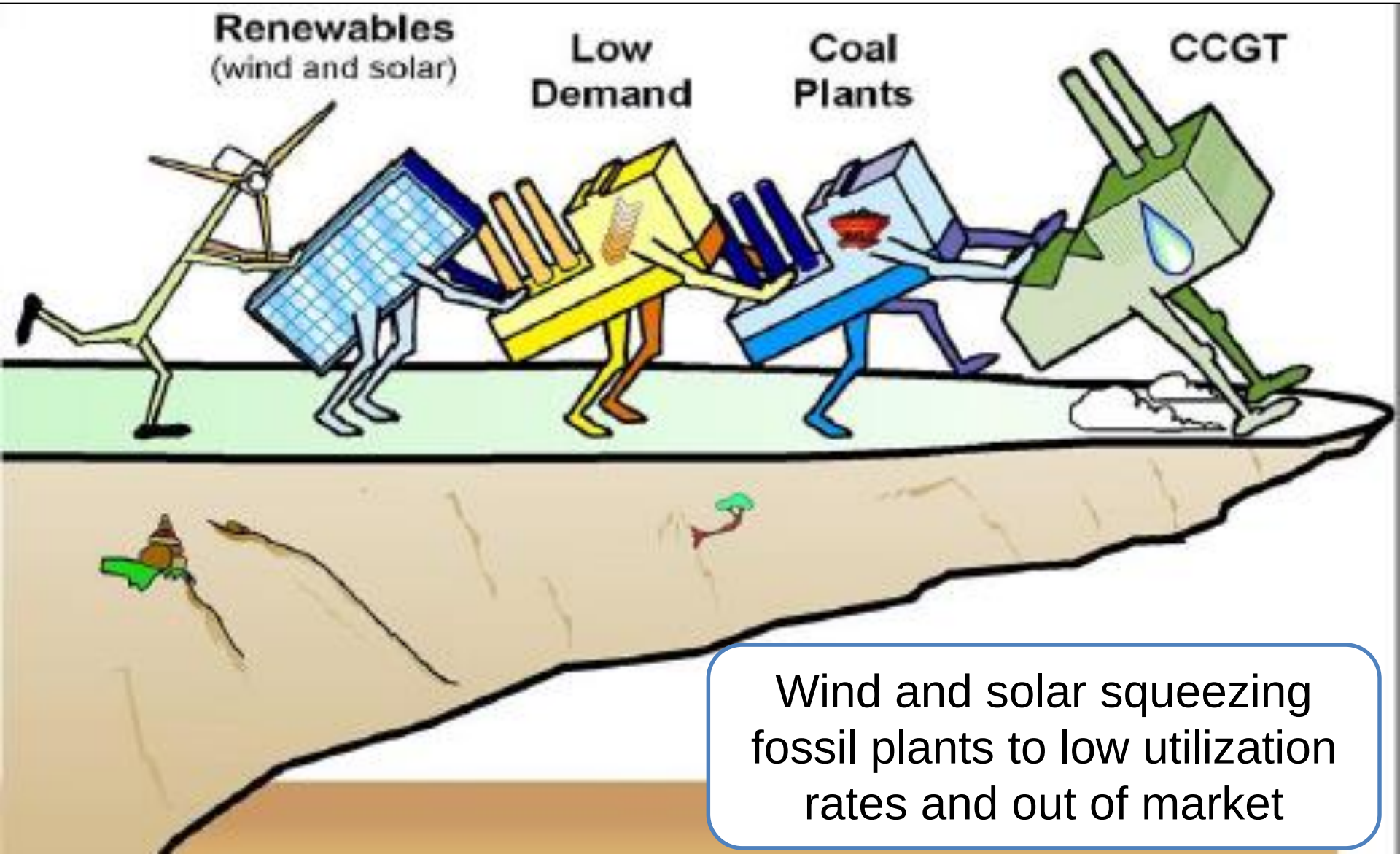
(1) Pumped storage not included.



WIND

Second source of electricity generation

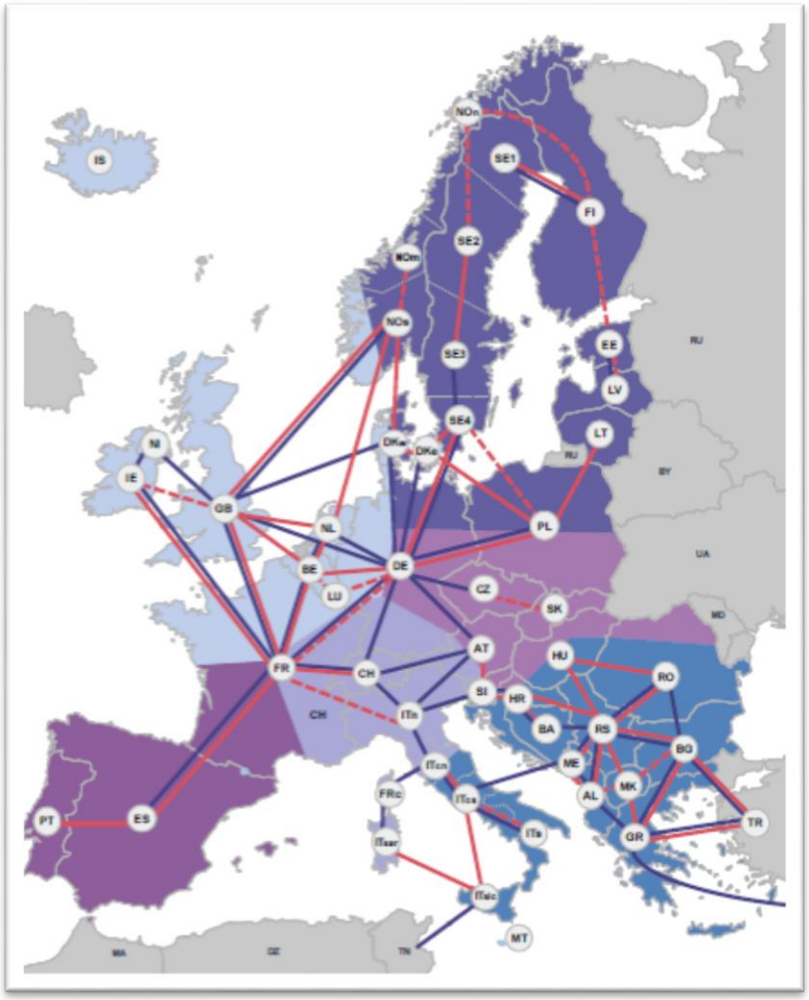
2030 Energy Transition Scenarios



Wind and solar squeezing fossil plants to low utilization rates and out of market

Interconnection Capacity and Energy Exchange (2017)

- Spain has limited Commercial Exchange Capacities with the rest of Europe
- Spain's interconnection ratio < 5%
- EU recommendation = 10% (2020) and 15% (2030)



Source: **ENTSOE & REE**

Grid Integration Challenges

Variable Renewable Energy Characteristics and effects

Variability: Available power output fluctuates with availability of the resource.

Uncertainty: Resource availability can change in the short-term.

Non-synchronous: VRE plants connect to the grid via power electronics.

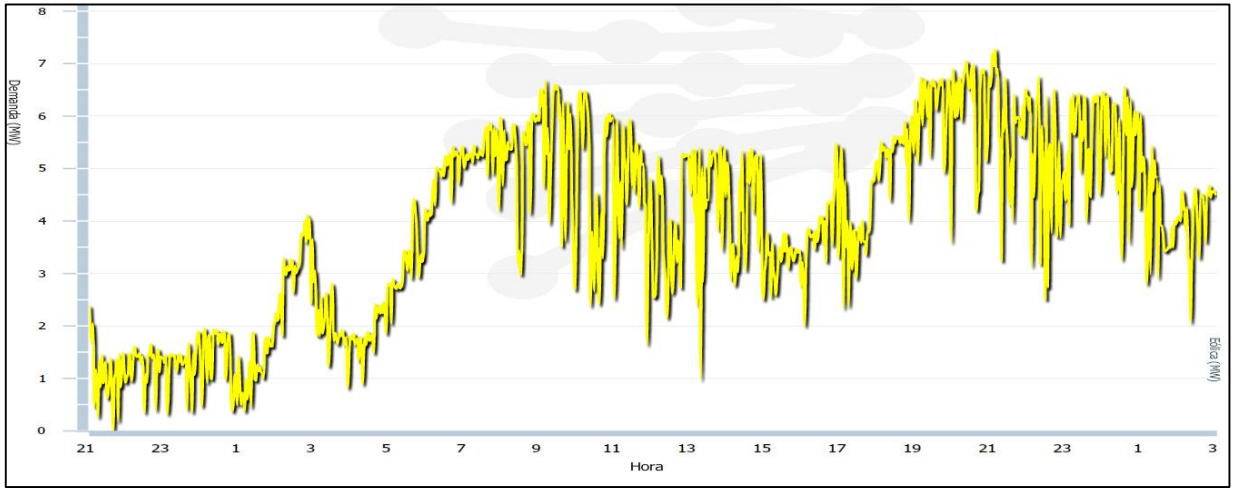
Modularity: Scale of individual VRE units is smaller than conventional plants.

Location-constraint: Resource varies by location; cannot be transported.

Profile effects

Balancing effect

Grid effects



Challenges for grid integration of Renewables

1.- RES Integration introduces new ways of operation

Traditional concepts:

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

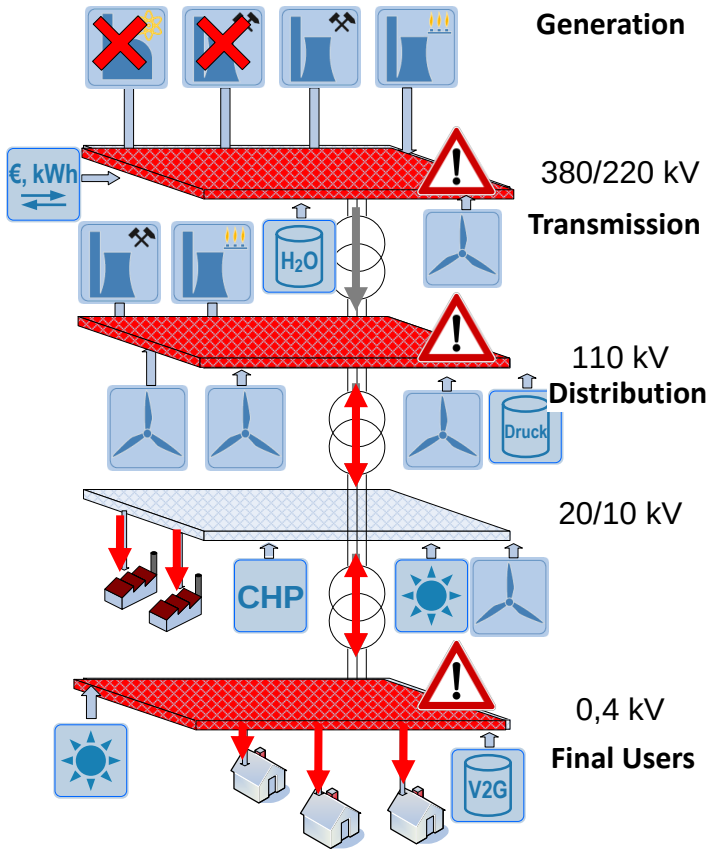
Future scenarios:

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

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

➔ REs must get involved in balancing and ancillary services.

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



Source: FHG/AEE

Challenges for grid integration of Renewables

2.- Improve flexibility in the technical operation of the system

- **Wind Power already contributes to balancing the system.**

- Optimize the use of ***flexible generation*** to provide efficient backup services and demand response:

Electric Vehicle

Storage

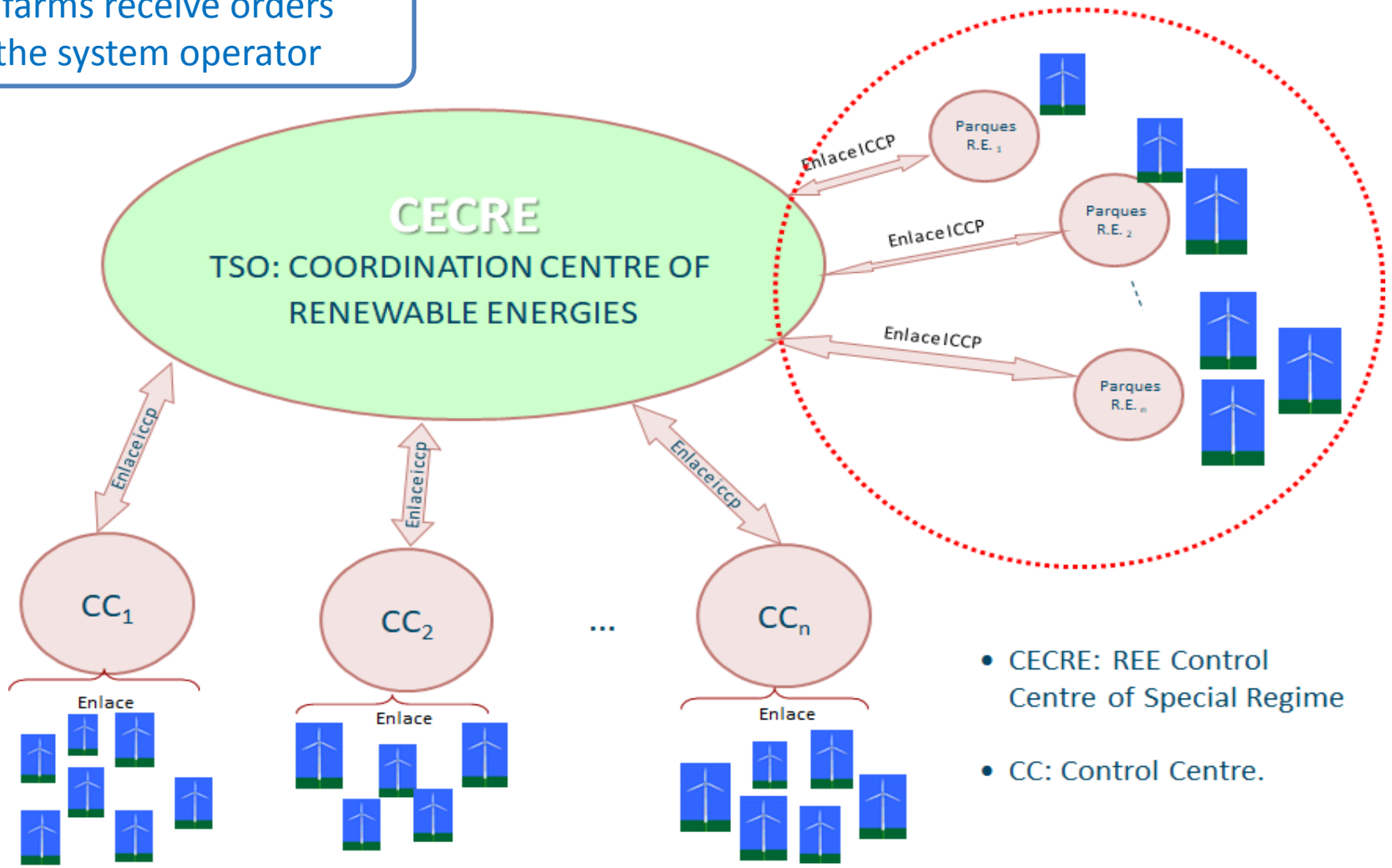
Hybrid renewable solutions (i.e. wind + solar)

- ***Digitalize renewables*** to improve connection to control rooms: Automatic and remote operation of power plants.

Challenges for grid integration of Renewables

2.- Improve flexibility in the technical operation of the system

Wind farms receive orders from the system operator

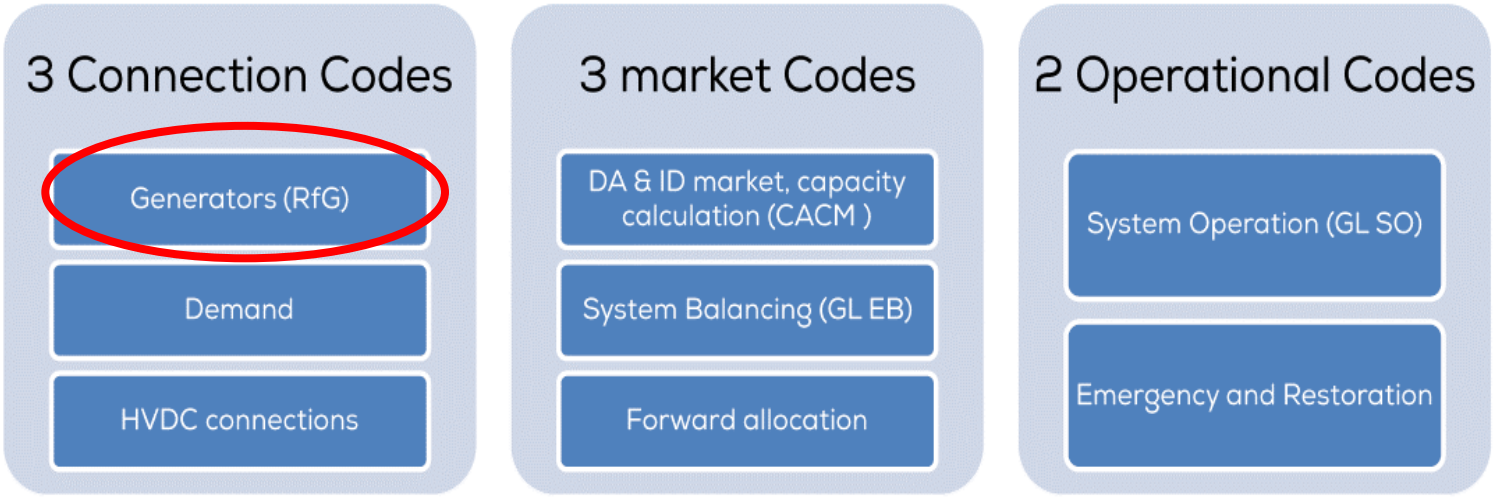


- CECRE: REE Control Centre of Special Regime
- CC: Control Centre.

Challenges for grid integration of Renewables

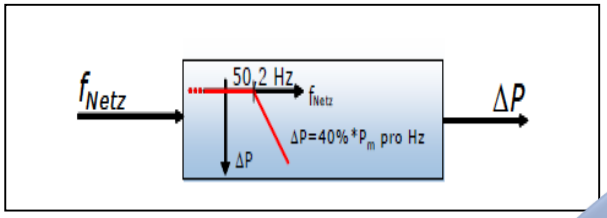
3.- Implementation of new European Grid codes

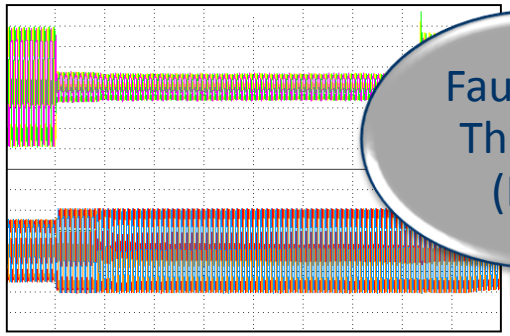
- REE is currently implementing the new ***European Grid codes*** developed by ENTSOE to the Spanish electrical system.
- These new grid codes imply ***higher requirements for Wind Turbines and Wind Farms***.

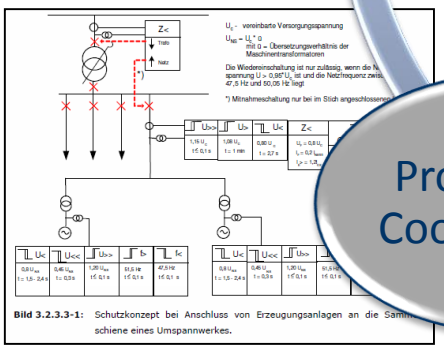


Challenges for grid integration of Renewables

3.- Implementation of new European Grid codes







Frequency Regulation

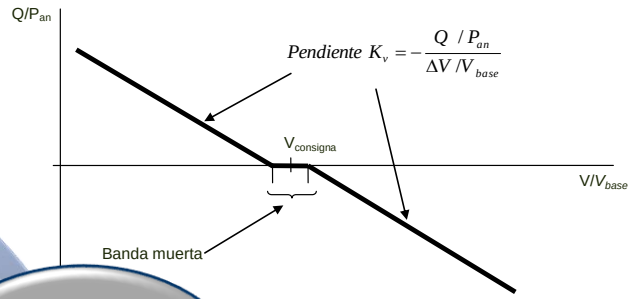
Fault Ride Through (FRT)

Fast Fault Current Injection

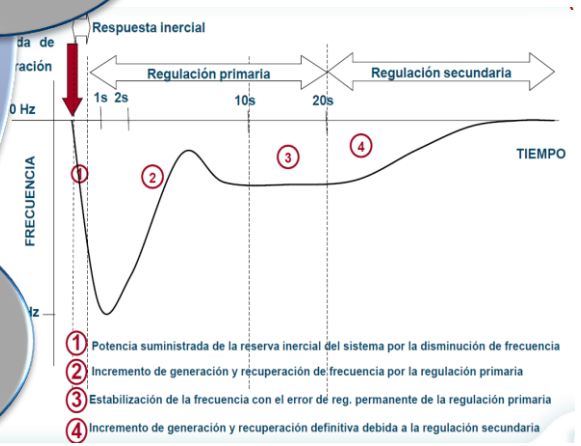
Grid Codes Requirements

Protections Coordination

Inertia Emulation



iva unitaria en función del desvío unitario de la tensión.



Source: Langstädtler | FGH – Certification

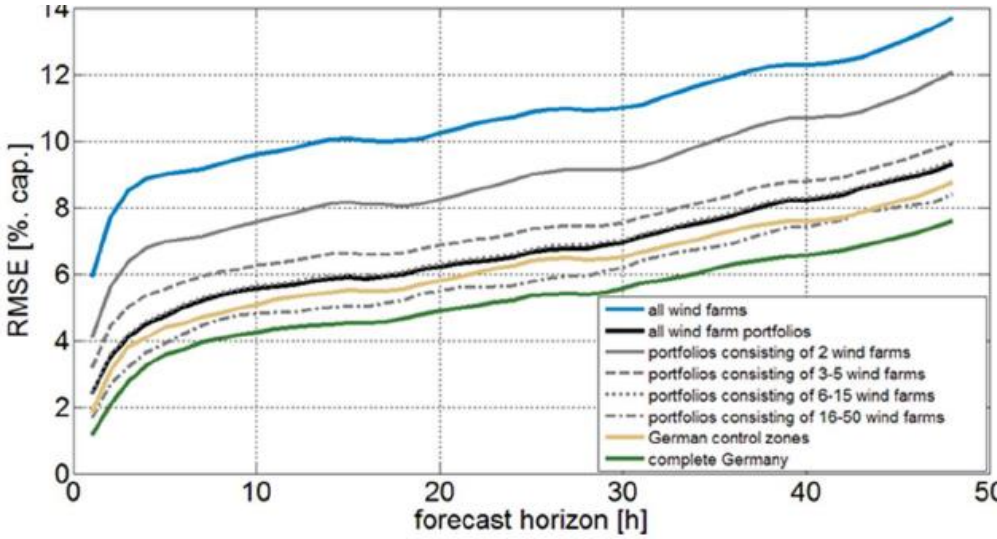
Challenges for grid integration of Renewables

4.- Economic operation of the electrical system

- Develop market mechanisms to increase renewables participation (day ahead offer, balancing markets, etc).
  - Wind power increases market liquidity.
  - Day-ahead offers are based on weather forecasting.
  - Deviations can be compensated in the intra-day markets.

- Improve **forecasting mechanisms** of renewable resources:
  - Avoid deviations in production programmes of wind farms
  - Strengthen the participation in ancillary services.

Shorter time horizons + **Accuracy**

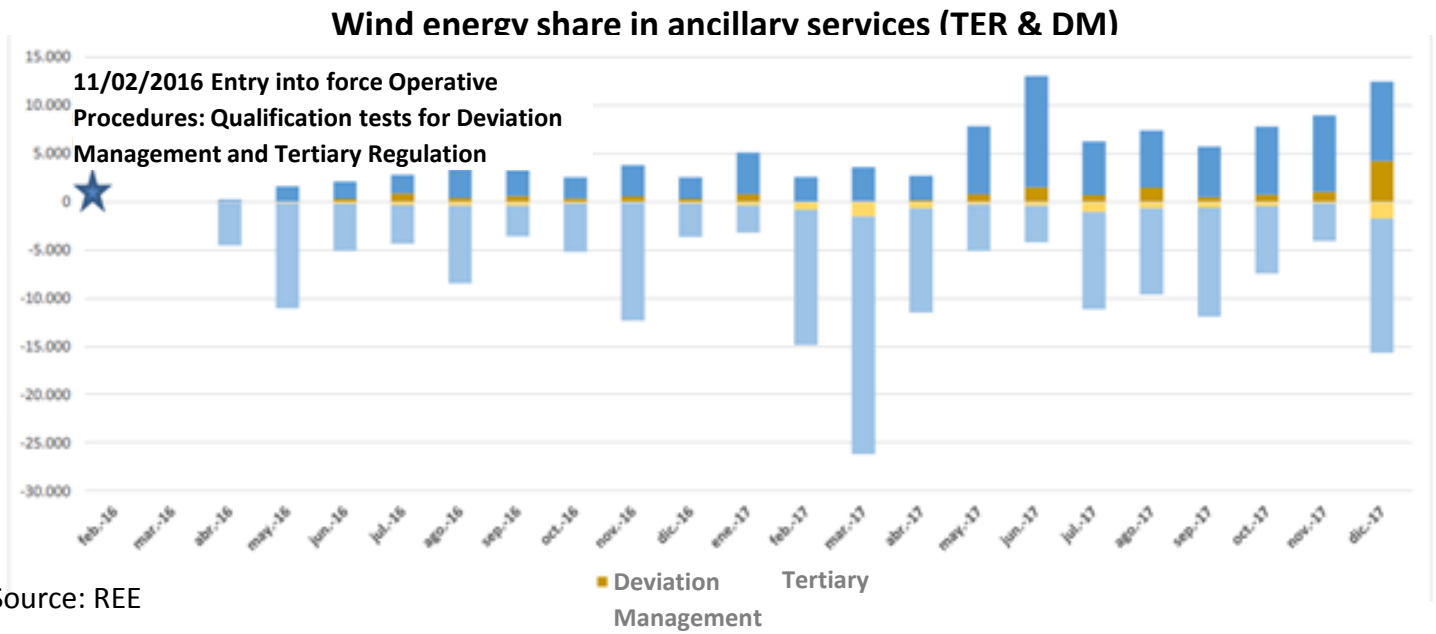


Participation of wind power in ancillary services

Technology	Deviation Management & Tertiary Regulation (MW)	Secondary Regulation (MW)	Deviation Management & Tertiary Regulation (% over total installed power)	Secondary Regulation (% over total installed power)
Hydraulic	14.985	14.956	87%	87%
Wind	10.442	230	46%	1%
Solar Thermal	30	0	1,3%	0%
Biomass	20	0	2,7%	0%
Solar PV	0	0	0%	0%

Wind MWs approved to participate in ancillary services

Spain is the first country in Europe to have, since 2016, wind power participating in the TSO´s ancillary services, specially in tertiary regulation and deviations´ management.

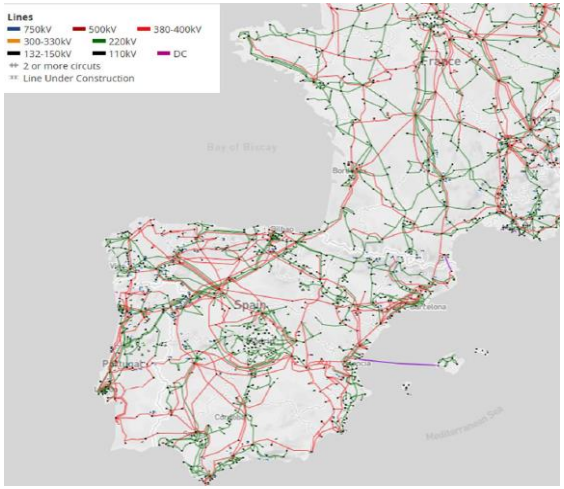


Source: REE

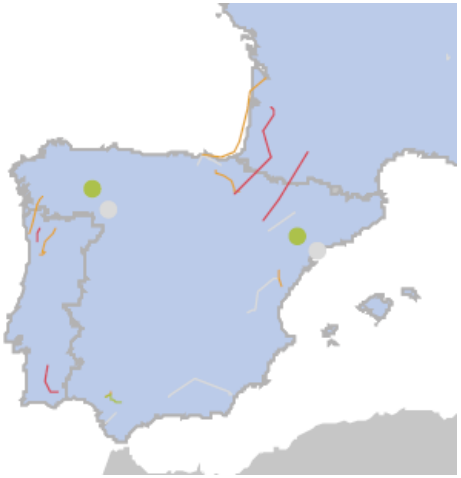
Challenges for grid integration of Renewables

5.- Development and reinforcement of grid infraestructures.

- **Grid planning and internal investment** needed to match the grid with new energy flow patterns (Generation vs. Demand)
- Establish the ***required access capacity*** according to geographical areas of good renewable resources (wind and solar)
- Need to s**trengthen cross-border interconnections** with France to achieve an interconnection ratio above 10% and improve integration to European electricity markets.



Spain Electrical Network (ENTSOE)



Planned projects to increase cross-border interconnection

Demand vs. Wind generation

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: Curtailments


¡Thanks for your attention!
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