**RED ELÉCTRICA DE ESPAÑA**
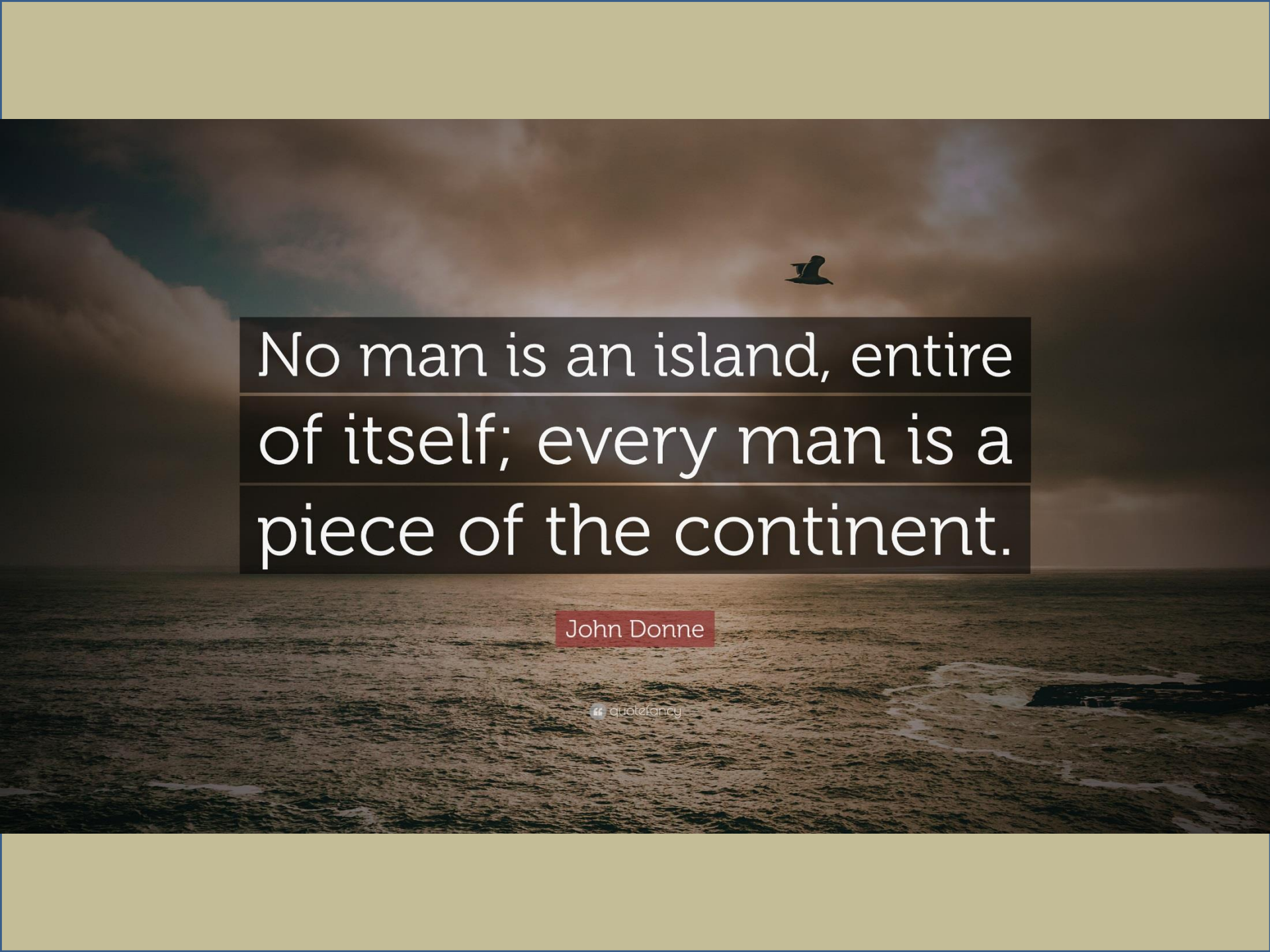
# Evolution of Spanish Wind and Solar Plant Forecasting and Market Operation

Mayte García Casado

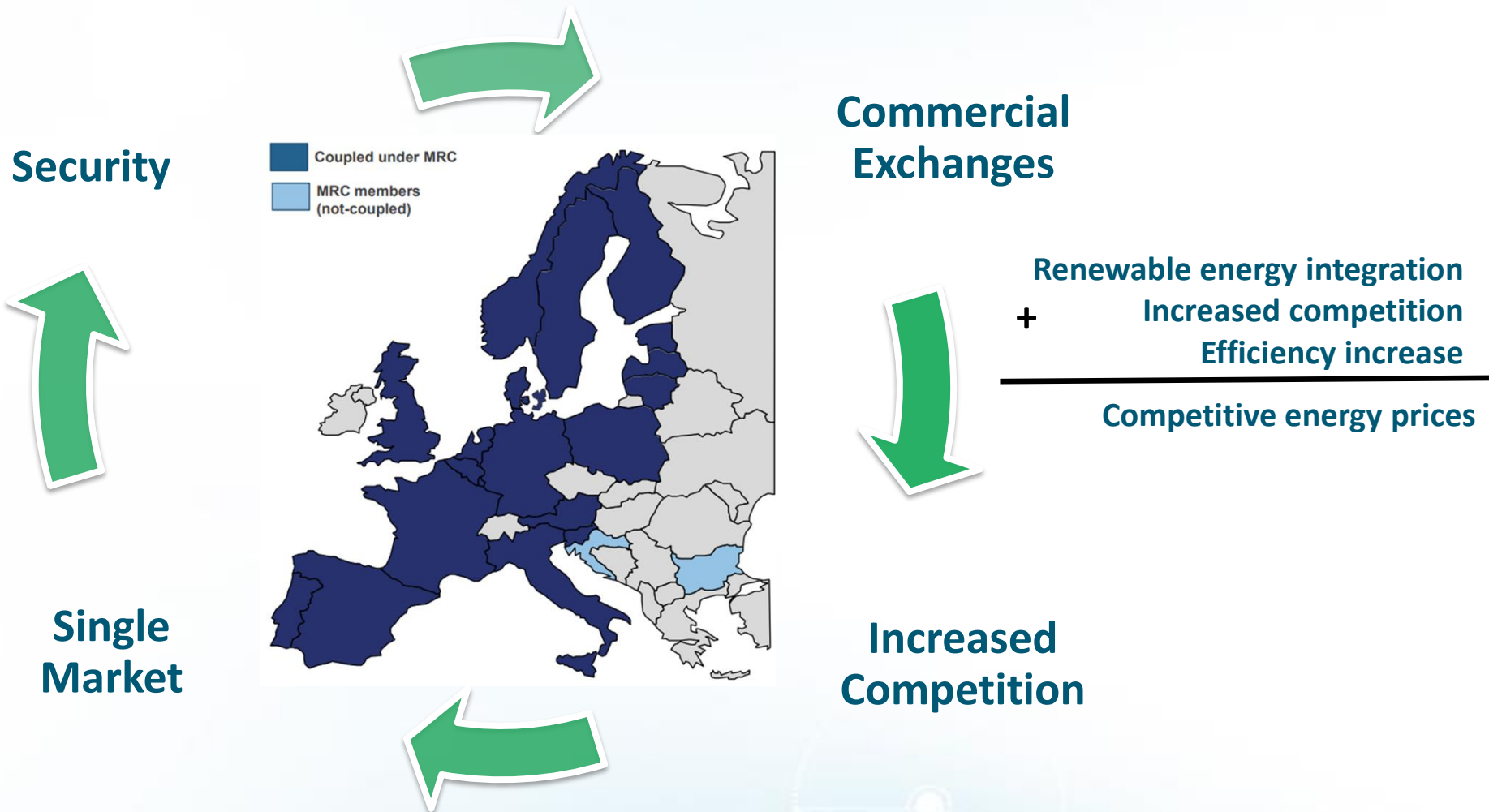June 2018

No man is an island, entire of itself; every man is a piece of the continent.

John Donne

# European Single Market



**Security**

**Commercial Exchanges**
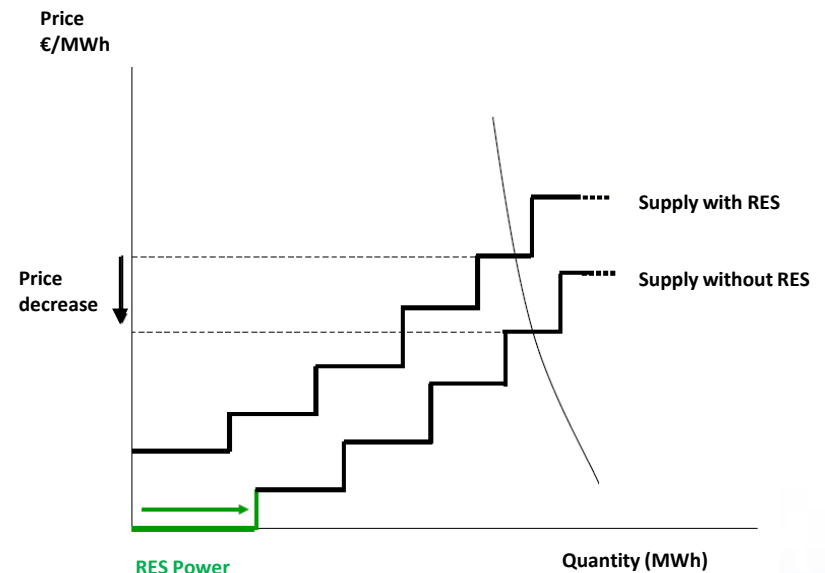
**Single Market**

**Increased Competition**

Renewable energy integration
Increased competition
Efficiency increase

+

Competitive energy prices

Coupled under MRC

MRC members (not-coupled)

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DE ESPAÑA

# The Daily Market

**Price €/MWh**

Peak load plants (fuel oil) and obsolete power palnts; regulation-capable hydro plants

Coal plants and less competitive combined cycles , hydro power plants, etc

Coal plants and most competitive combined cycles

Nuclear power plants, wind farms, flow-hydro

**Quantity (MWh)**

- The offers are ordered and aggregated by price.
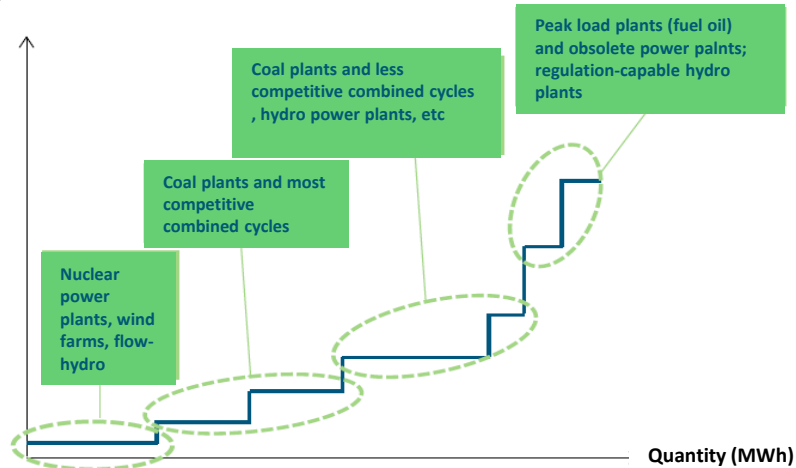
- The RES participation reduces the price

**Price €/MWh**

Supply with RES

Supply without RES

Price decrease
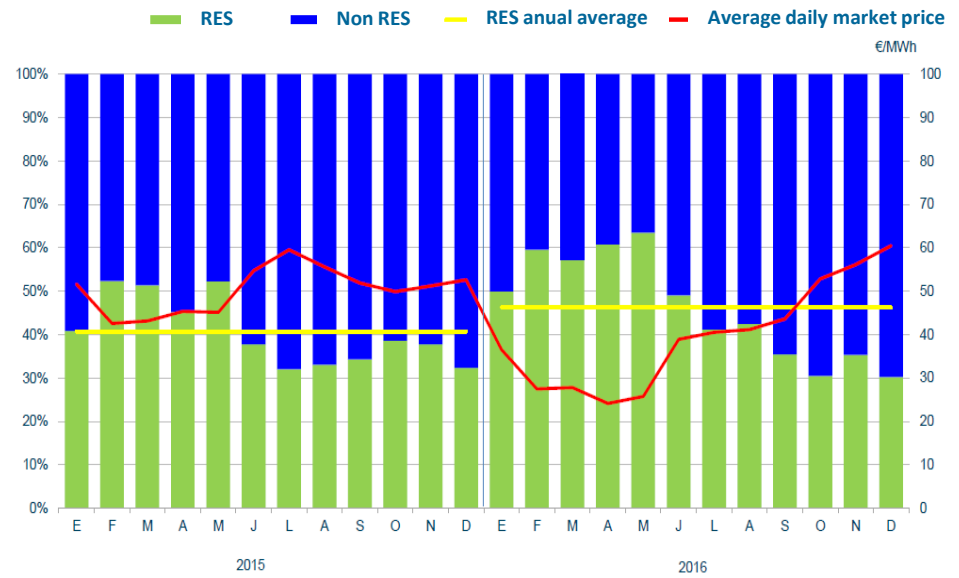
**RES Power**

**Quantity (MWh)**

# The Daily Market
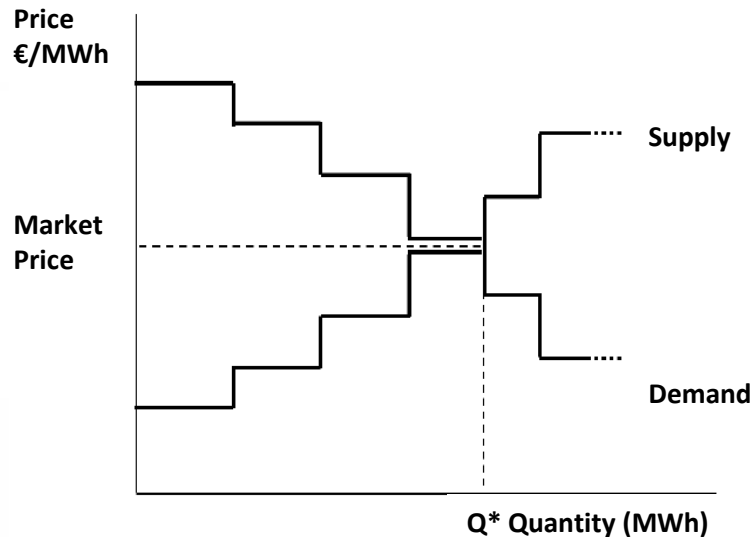


- The crossing of the demand and generation curves defines the price

- Greater RES participation, lower price

# Multi-Regional Coupling (MRC)

## Portugal-Spain (IPE) & France-Spain (IFE)

### Market Coupling
### (Multi Regional Coupling - MRC)

- A single Price coupling algorithm (Euphemia) is used to calculate electricity prices across Europe taking into account the capacity.

- Benefits:
  - Efficiency
  - Reduction of the price
  - Greater integration of renewable energies

- Benefit conditioned on the level of available capacity
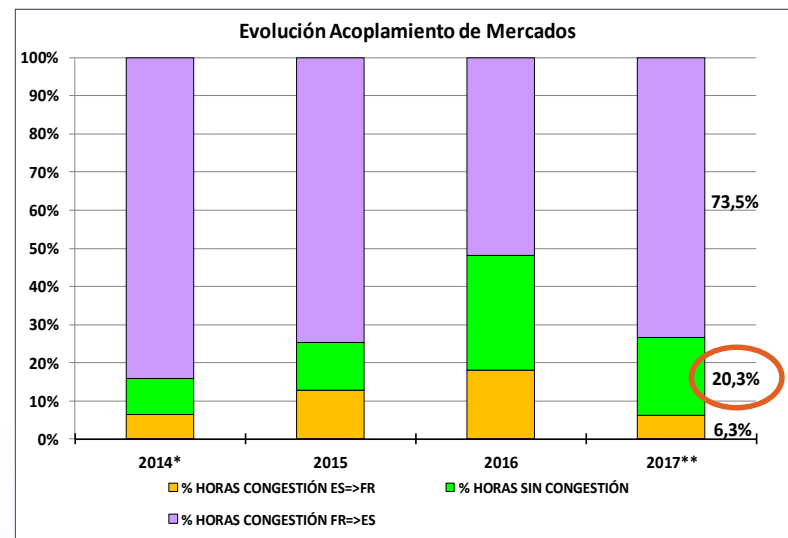
# Daily market IPE
## SPAIN - PORTUGAL

| Year | Hours without cong. | Cong. SP=>PT | Cong. PT=>SP | Mean Market Price Spain (€/MWh) | Mean Market Price Potugal (€/MWh) |
|------|------|------|------|------|------|
| Sep- 17 | 98,3% | 1,0% | 0,7% | 49,15 | 49,16 |
| Oct-17 | 96,4% | 3,2% | 0,4% | 56,77 | 56,97 |

# Daily market IFE
## SPAIN- FRANCE

| Year | Hours without cong. | Cong. SP=>FR | Cong. FR=>SP | Mean Market Price Spain (€/MWh) | Mean Market Price France (€/MWh) |
|------|------|------|------|------|------|
| Sep- 17 | 5,4% | 0,0% | 94,6% | 49,15 | 36,95 |
| Oct-17 | 36,1% | 4,0% | 59,9% | 56,77 | 49,68 |



Evolución Acoplamiento de Mercados
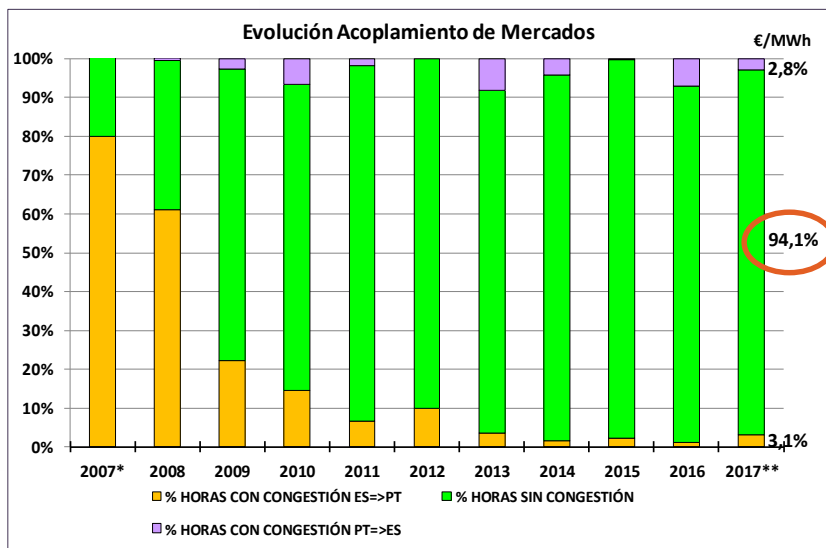
94,1% hours without congestion in 2017



Evolución Acoplamiento de Mercados

20,3% hours without congestion in 2017

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# Spain, an electrical island
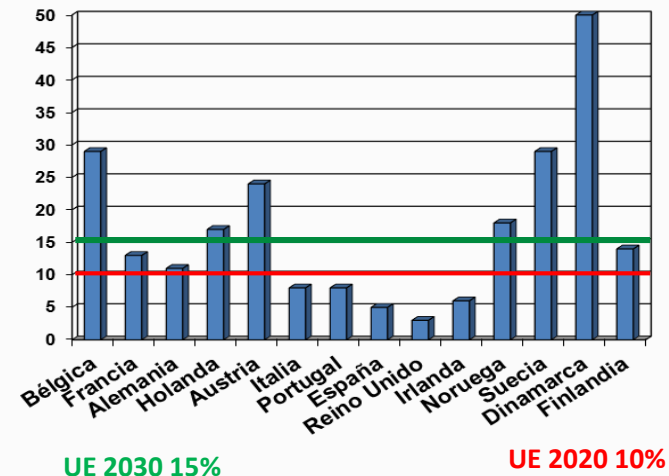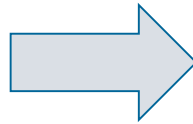
- Limited interconnection capacity with France, security link with the European Interconnected system. In practice almost an "electrical island".

- EU Target of 10% interconnection by 2020. Nowadays, 5.8%. New project (2025) 7.5%

# System Services Markets



**MAIN FUNCTION**
**Guarantee the continuity and the security of the supply and the coordination between both, the production and the transmission systems**

- **Constraints Solving Process**
  - Technical constraints

- **Ancillary services**
  - Additional Upwards Reserve
  - Frequency - power regulation and balancing mechanisms
    - Secondary regulation
    - Tertiary regulation
  - Voltage control

- **Cross-Border Balancing Services**
- **Deviation Management**

# Participation of RES in Ancillary services

## Generators Obligations

- Metering equipment for settlement, billing and monitoring

- Controllability: All generation > 5 MW are dispatchable according to their bids.

- Minimum bid size: 10 MW (aggregation of installations of the same technology allowed)

- **Priority dispatch at same bid price for RES**

- To succeed in the prequalification tests approved for each service: during 72 hours REE may ask unit to reduce output to its technical minimum or increase output to its maximum available power within 30 minutes or within 15 minutes depending on service.

- Real wind generation participation:

  - 50% $P_{inst}$ in Tertiary reserves and Replacement Reserves

  - 35% $P_{inst}$ in Secondary reserves.
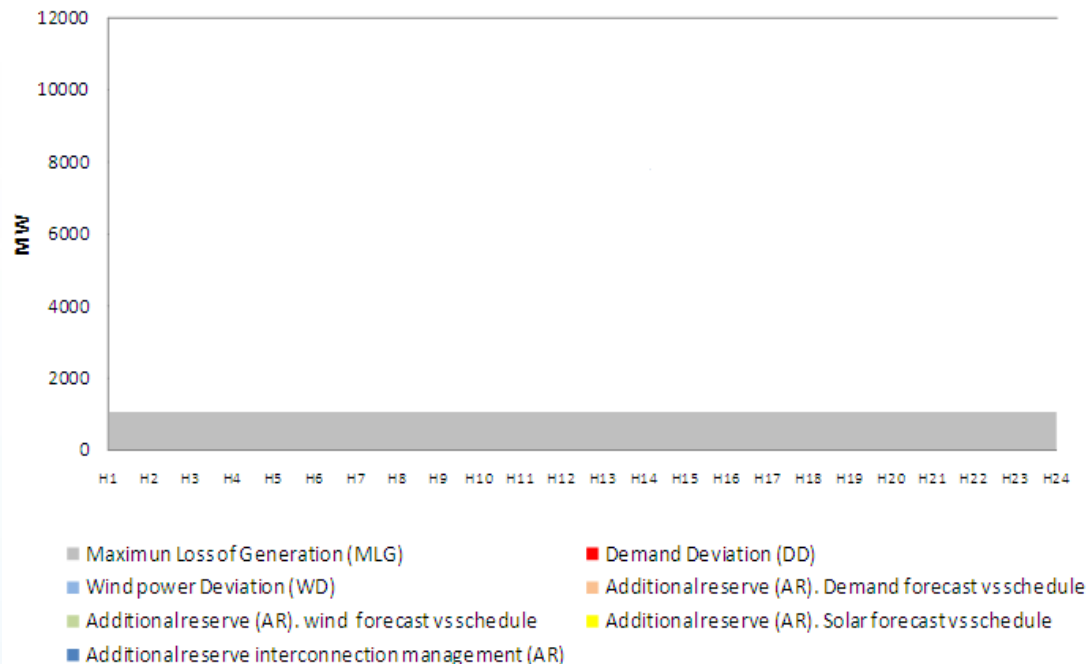
# Monitor and control RES
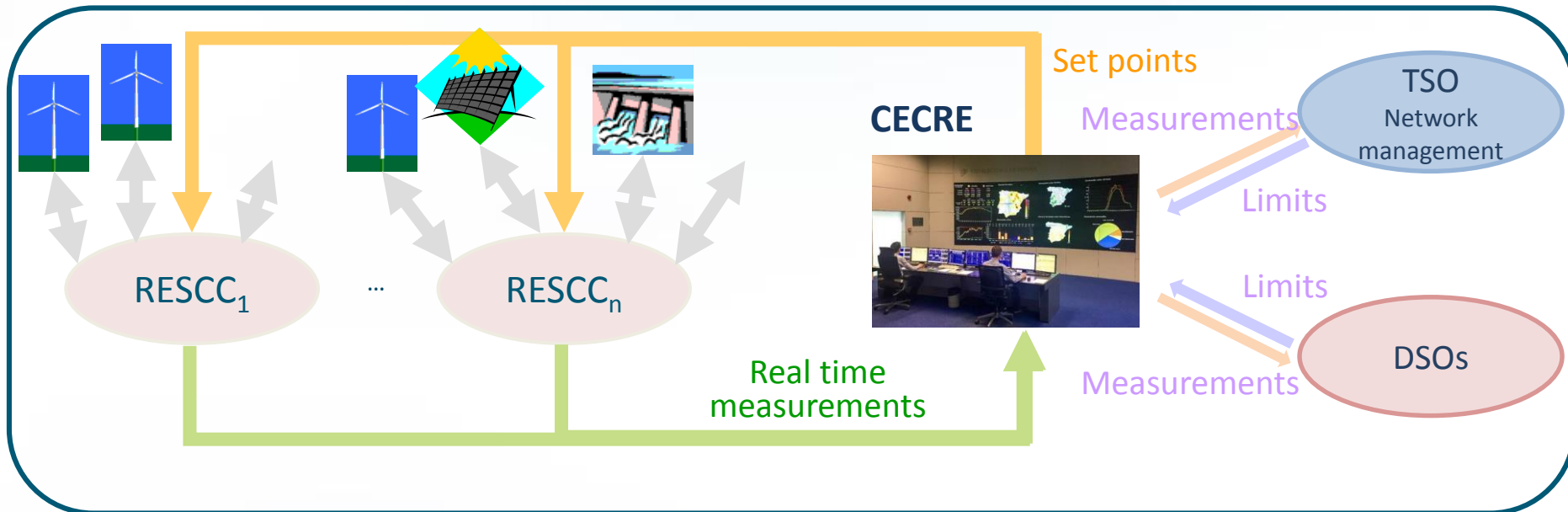
- ✓ **CECRE** communicates to more than 35 Control Centers which aggregate more than 3 000 generation units.
- ✓ CECRE checks with the application GEMAS if with the real-time wind scenario the System is safe due to voltage dips, congestions or off-peak balance feasibility.
- ✓ If curtailments are needed, renewable generation set-points are calculated and sent.
- ✓ Fast and efficient process allows waiting until the last minute to issue the needed curtailments.

# Calculation of reserves

- This method adds a certain amount of reserve for every uncertainty.

$$\text{Req. Reserve} = \text{MLG} + \text{DD} + \text{WD} + \text{AR}$$

- **DD (Demand Deviation).** This is related to possible demand forecast errors (2%) or a certain possible generation loss (Nuclear Power Plant, 1.100 MW).

- **WD (Wind power Deviation).** This variable takes into account uncontrolled wind variations and forecast errors.

- **AR (Additional Reserve).** This variable takes into account the possible deviations due to the variation between forecast and market schedules and the management of international interconnections.

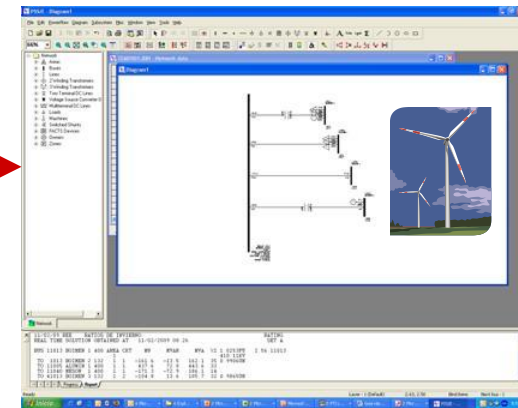# Constraints Solving Process

- Forecast by transmission node can be exactly modeled for future scenarios in PSS/E in order to run power flow simulations.
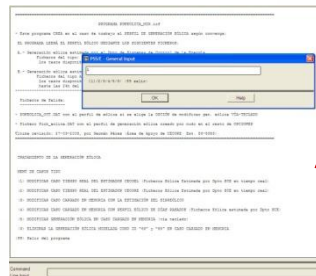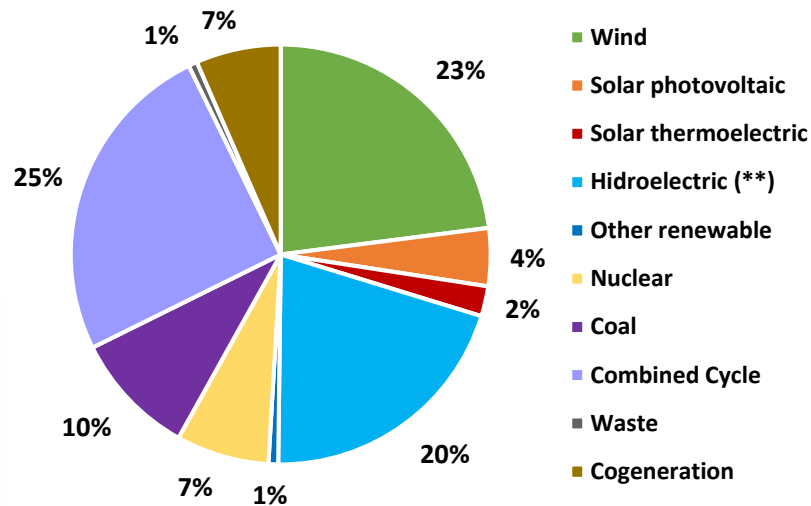


Future scenario

Future scenario with modeled wind and solar forecast

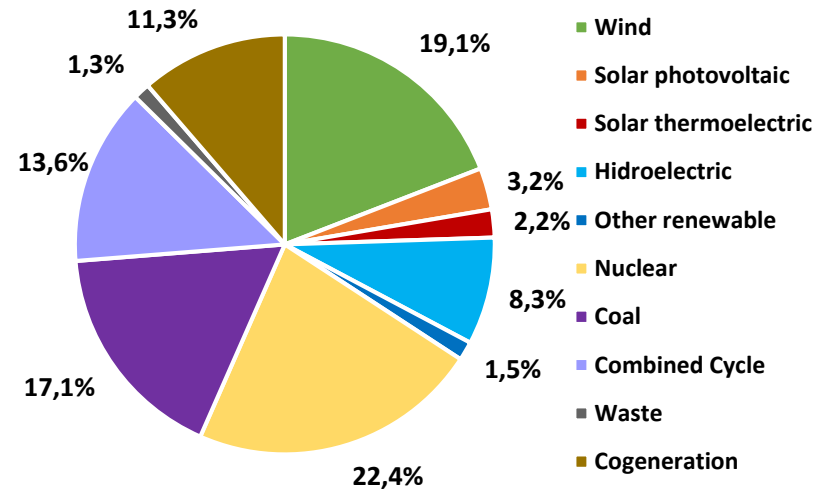# Electricity system in the Peninsular Spanish System



**Installed capacity 2018 (99 GW)**

- 23% Wind
- 4% Solar photovoltaic
- 2% Solar thermoelectric
- 20% Hidroelectric (**)
- 1% Other renewable
- 7% Nuclear
- 10% Coal
- 25% Combined Cycle
- 1% Waste
- 7% Cogeneration

Legend:
- ■ Wind
- ■ Solar photovoltaic
- ■ Solar thermoelectric
- ■ Hidroelectric (**)
- ■ Other renewable
- ■ Nuclear
- ■ Coal
- ■ Combined Cycle
- ■ Waste
- ■ Cogeneration

∑ **Installed RES = 47 %**

∑ **Installed capacity free $CO_2$ emissions = 54 %**

**Net Generation Mix 2017**

- 19,1% Wind
- 3,2% Solar photovoltaic
- 2,2% Solar thermoelectric
- 8,3% Hidroelectric
- 1,5% Other renewable
- 22,4% Nuclear
- 17,1% Coal
- 13,6% Combined Cycle
- 1,3% Waste
- 11,3% Cogeneration

Legend:
- ■ Wind
- ■ Solar photovoltaic
- ■ Solar thermoelectric
- ■ Hidroelectric
- ■ Other renewable
- ■ Nuclear
- ■ Coal
- ■ Combined Cycle
- ■ Waste
- ■ Cogeneration

∑ **RES Energy = 33,3 %**

∑ **Energy free $CO_2$ emissions = 55,7 %**

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# Forecasting system: combination strategy

- The module combines each hour several vendors forecasts and the REE on-site model forecast.

- Combination criteria→ more weight to the prediction with less error.

- The reference to calculate errors in real time→ Telemeasurements.
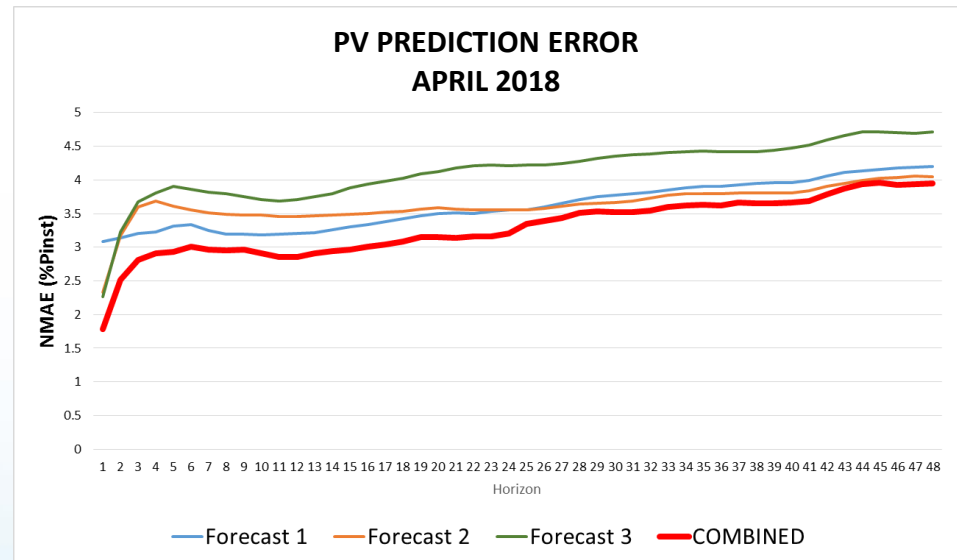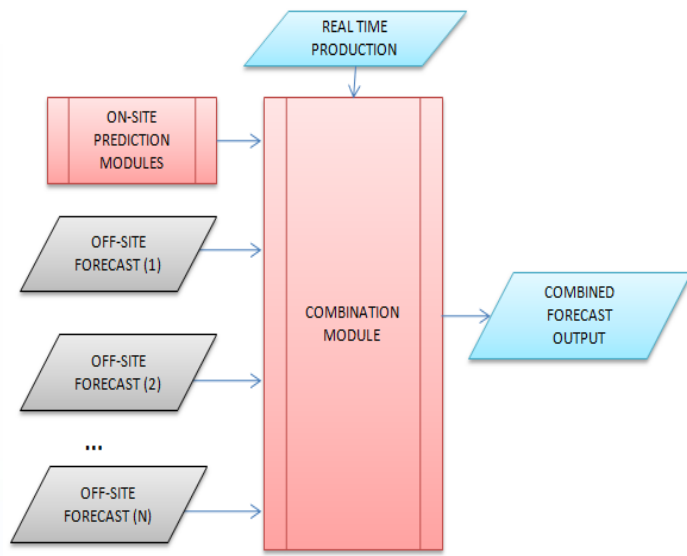
# On Site predictions models (SIPREOLICO and SIPRESOLAR)

- Prediction methods based on neural networks.

- Wind forecasts are calculated for individual wind farms.

- 240 horizons. Hourly refresh.

- Probabilistic power forecast.

- NWP model used: European Center (refresh twice a day)

  - ➢ Wind variables: wind speed and direction forecast at 100 m.
  - ➢ Solar variables: Global radiation and cloudiness .
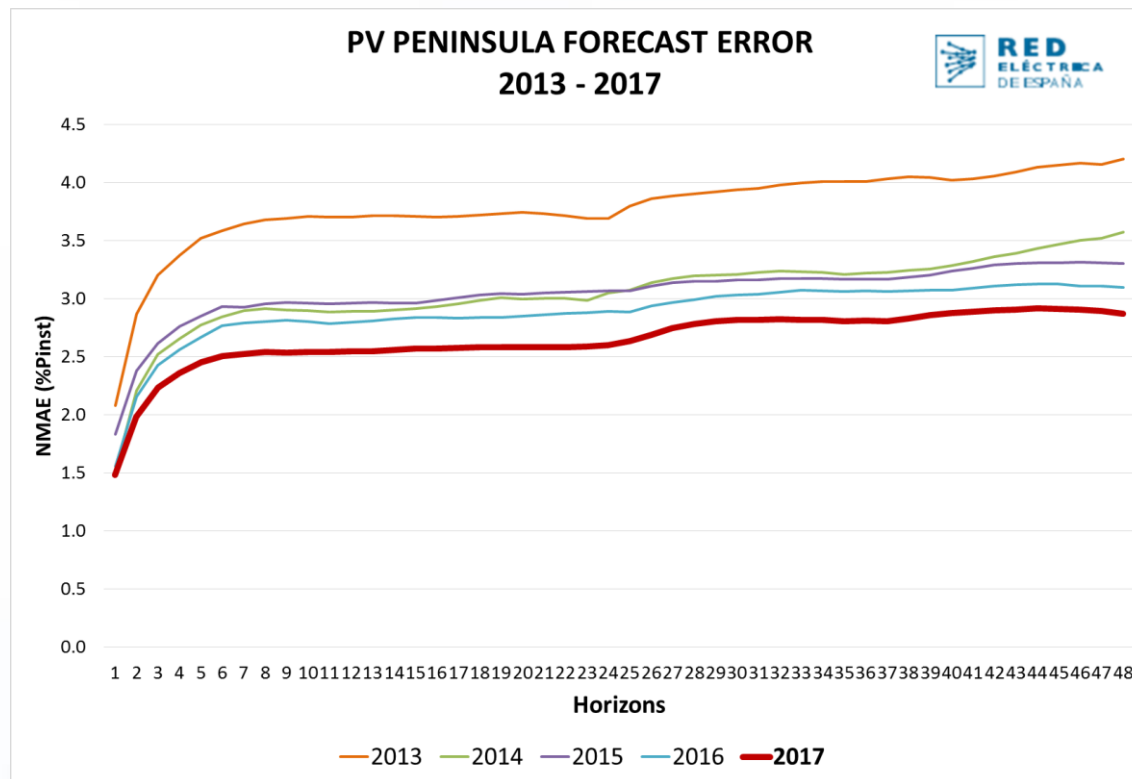
# WIND power forecast errors

SIPREOLICO improved significantly the first years but the last years the errors have stalled..

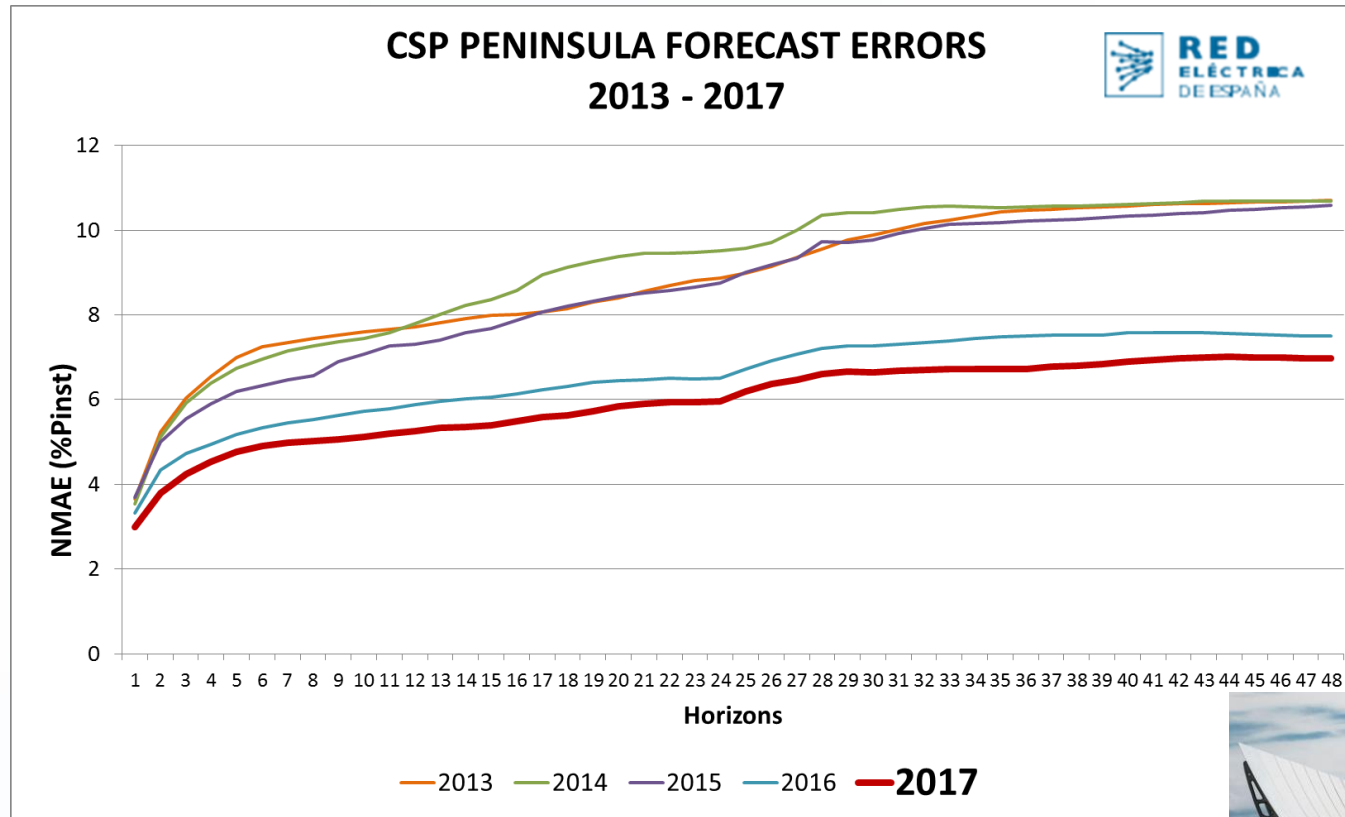Further improvements seem to be limited by weather prediction models.
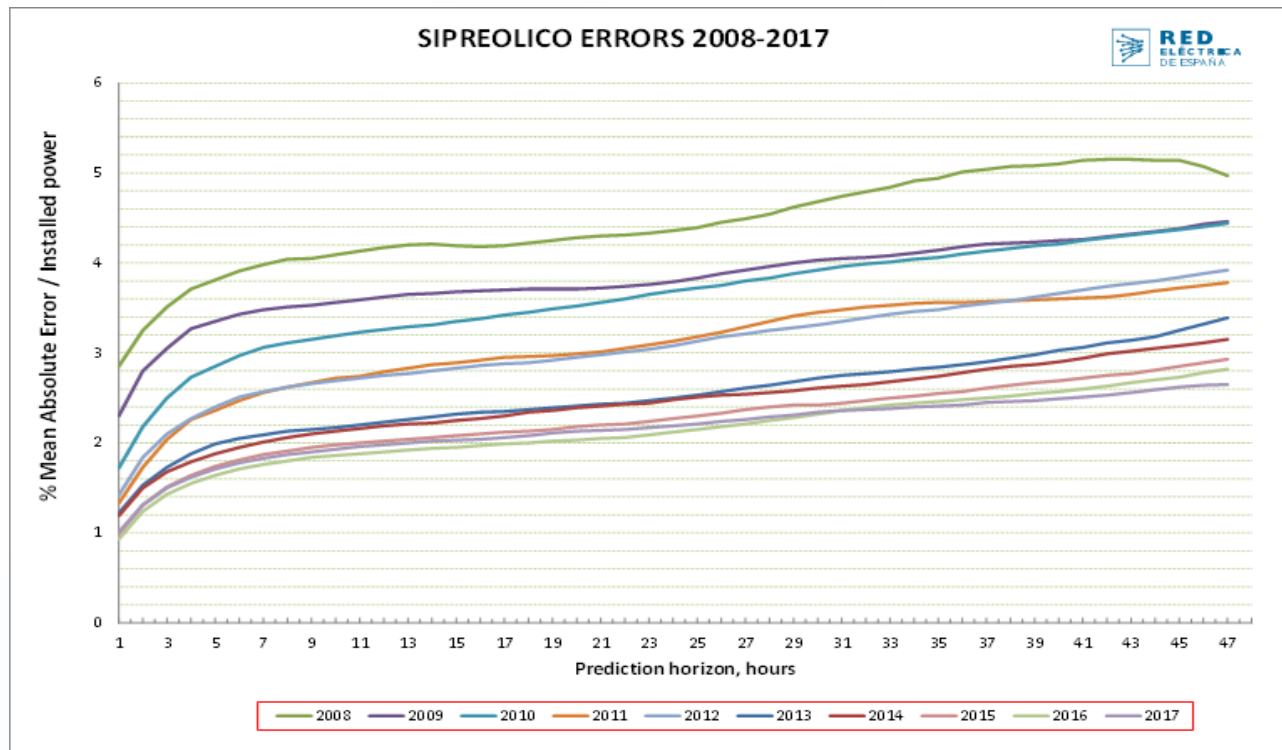
# PV power forecast errors. Peninsula

The PV Peninsula error forecast has improved the last 2 years thanks to the providers improvement and the right combination module behavior.
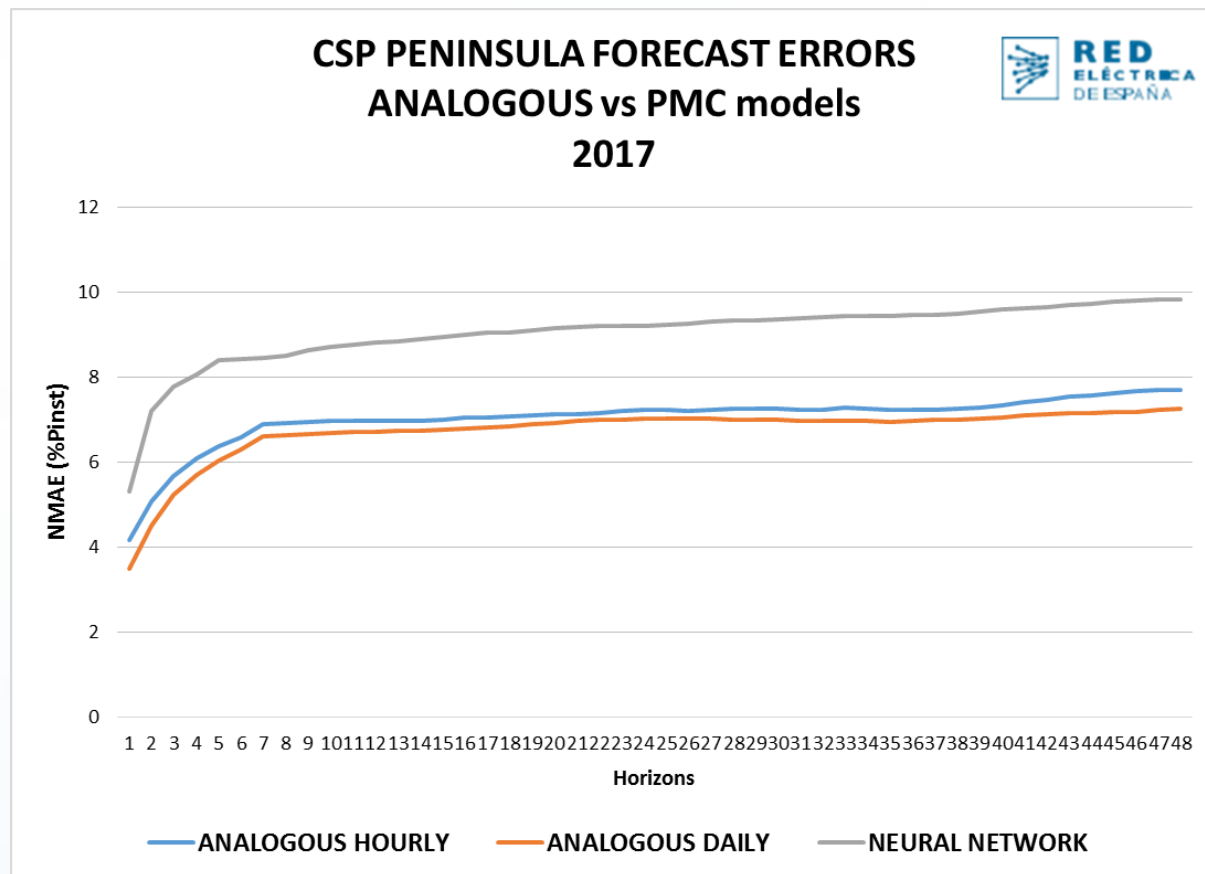
# CSP power forecast errors

The CSP production prediction has improved too...

# R&D Projects (I)
# New production forecast model. Results

The new model based on analogous methodology improves the results with the neural network.

# R&D Projects (II)
# New meteo: Nowcasting model

- Project about nowcasting prediction based on satellite imagery analysis (in collaboration with AEMET)

    - Goal: to predict local cloudiness in small systems and improve the short term forecast





PV Forecast / Production TENERIFE 18/4/2015

67% error
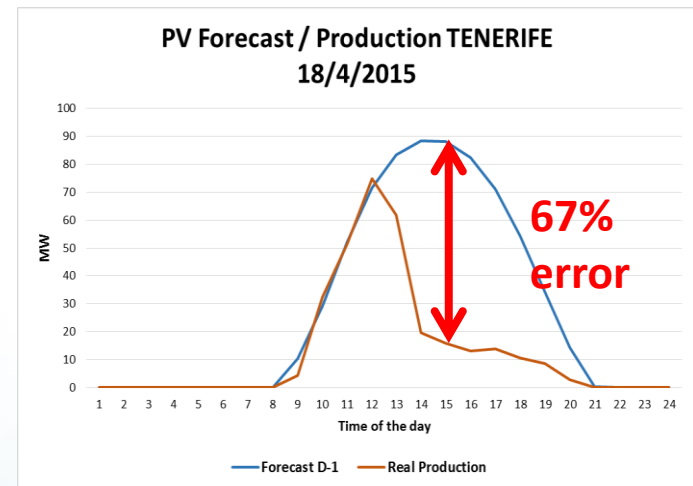
# R&D Projects (II)
# New meteo: Nowcasting model. Results

Best results using satellite images during the first 2 hours, the NWP has lower error the last ones → Transition function developed to join Nowcasting model and NWP.

| nRMSE | GHI.SAF | GHI.HAR |
|---|---|---|
| 1 hora | 19,00% | 24,47% |
| 2 horas | 22,86% | 24,61% |
| 3 horas | 26,00% | 25,22% |
| 4 horas | 28,70% | 25,10% |
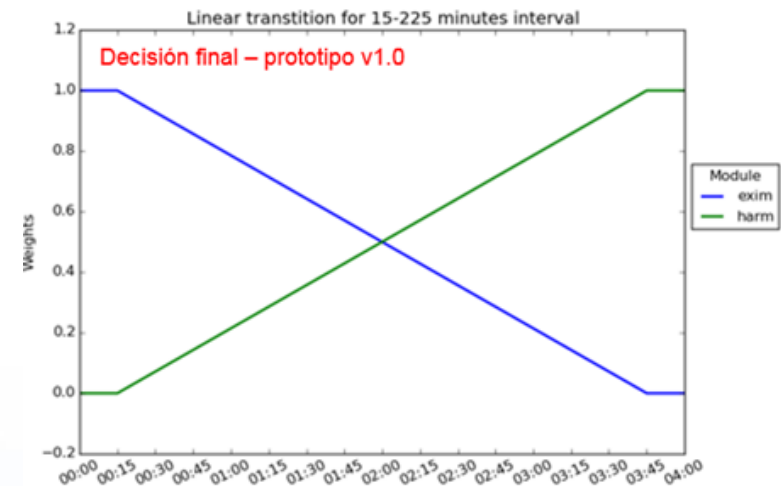


*Linear transition for 15-225 min interval*

➢ **Next step: deliver the files with the new meteo and introduce them in the production model. → December 2018**

# R&D Projects (III)
# New meteo methodology: LISA

The dust storms from Sahara desert is the main cause of higher errors in CSP prediction
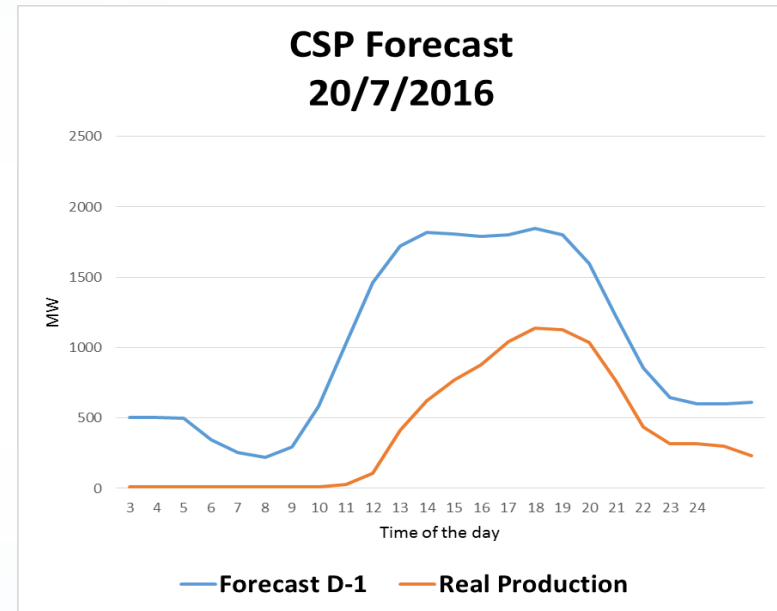




R&D in collaboration with AEMET has developed a new methodology (LISA) that takes into account the aerosols prediction in the direct and global radiation prediction
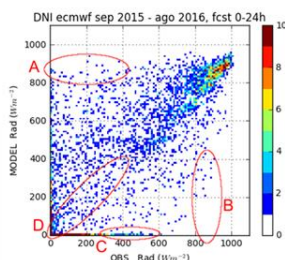
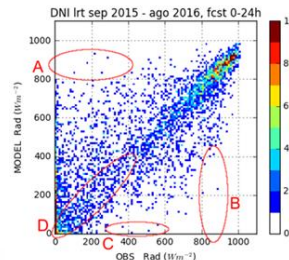# R&D Projects (III)
# New meteo methodology: LISA

- Results: The LISA DNI prediction improves ECMWF prediction the days with aerosols. The production model doesn't give better results with this meteo.

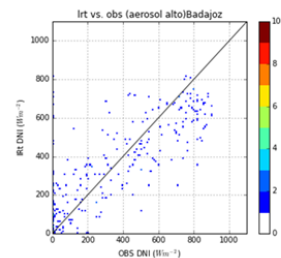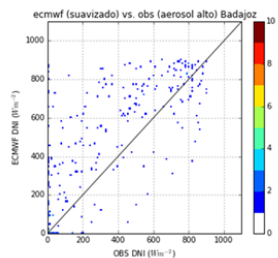- Current work: Detailed analysis of the behavior of the analogous model with this new meteo



ECMWF                    LISA

All days

Only days with aerosols

*Data set: Sept'15 – Aug'16*

# Renewables rol in the decarbonization process

> **DECARBONIZATION ENGAGEMENT**

> Until 2035, an investment of 2.2 billions of dollars in the electric sector is required in order to renew the existing infrastructure to fulfill the decarbonization objectives…

**Needed investments in the European power sector in the period 2014-2035**
billions of USD
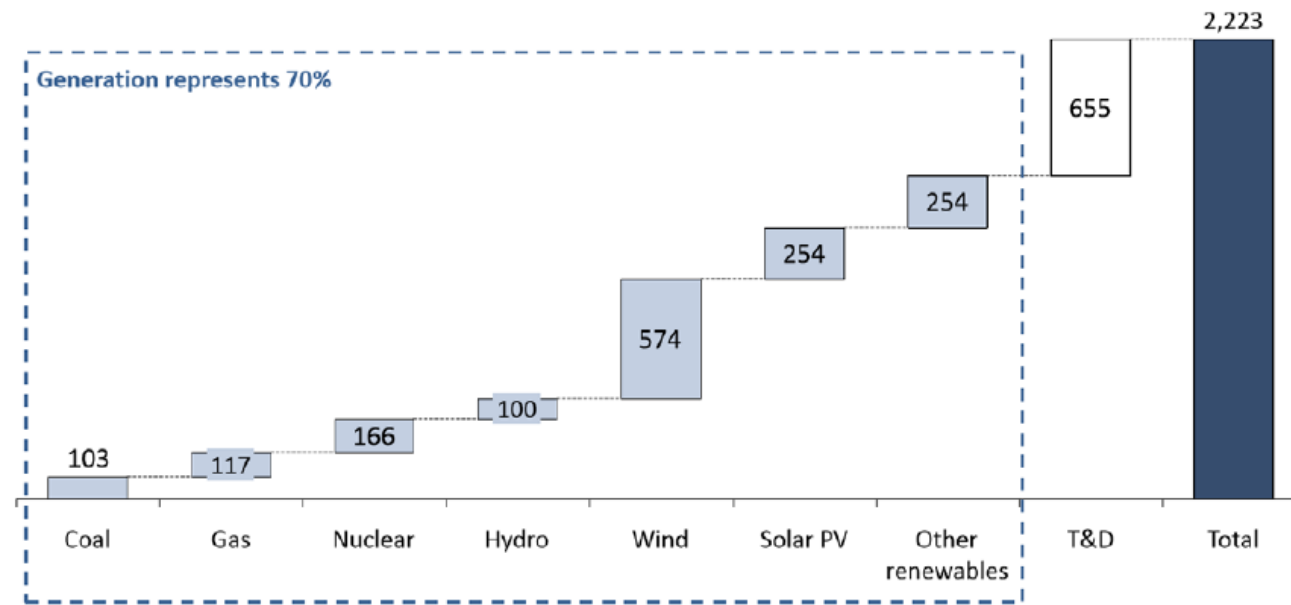
# Renewables rol in the decarbonization process



EU agrees compromise renewables target of 32%

June 14 (Renewables Now) – The European Commission, the EU Parliament and the Council agreed this morning on a package of new rules for renewable energy, including a binding 2030 renewables target of 32%.

The new 2030 renewable energy target for the EU includes a review clause by 2023 for an upward revision. The newly agreed binding level is higher than

European Commission. Author: Sébastien

EUROPE: Following negotiations between the European Commission, the bloc has agreed a "binding" 32% by 2030 renewables target.

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Thank you for your attention

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**maytegar@ree.es**