

R&D  
**NESTER**

# Wind and Solar Forecasting in Portugal Status and Prospects

Rui Pestana - 20<sup>th</sup> June 2018

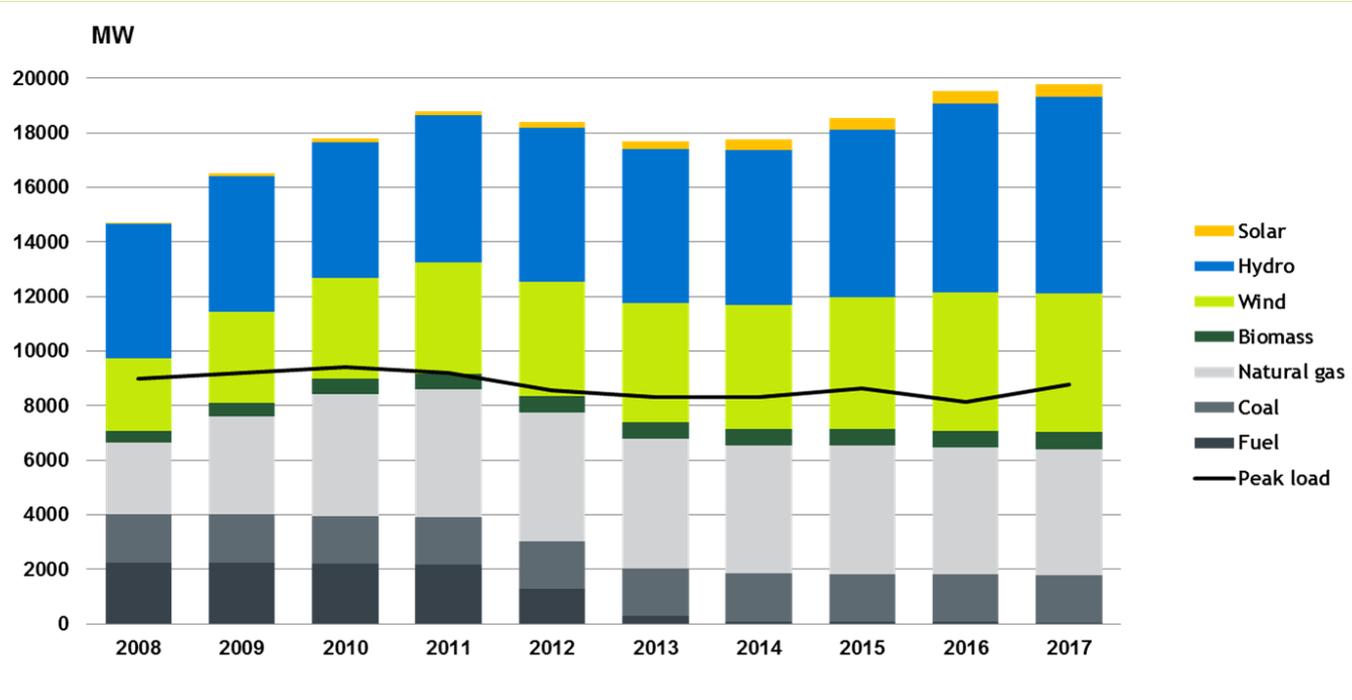
## Wind and Solar Forecasting in Portugal – Status and Prospects

### Topics

- Installed capacity in Portugal
- Energy supply in 2017
- Wind extremes in 2016 and 2017
- Wind power forecast tender
- Wind & Solar with SCADA
- Solar PV forecast
- Conclusions

# Wind and Solar Forecasting in Portugal – Status and Prospects

## Installed capacity in 2017



	MW
<b>TOTAL</b>	<b>19 800</b>
<b>RENEWABLE GENERATION</b>	<b>13 397</b>
Hydro	7 193
Wind	5 090
Biomass	624
Solar	490
<b>NON-RENEWABLE GENERATION</b>	<b>6 403</b>
Coal	1 756
Natural Gas	4 607
Others	40
<b>PEAK LOAD</b>	<b>8 771</b>
Hydro pumps	2 698

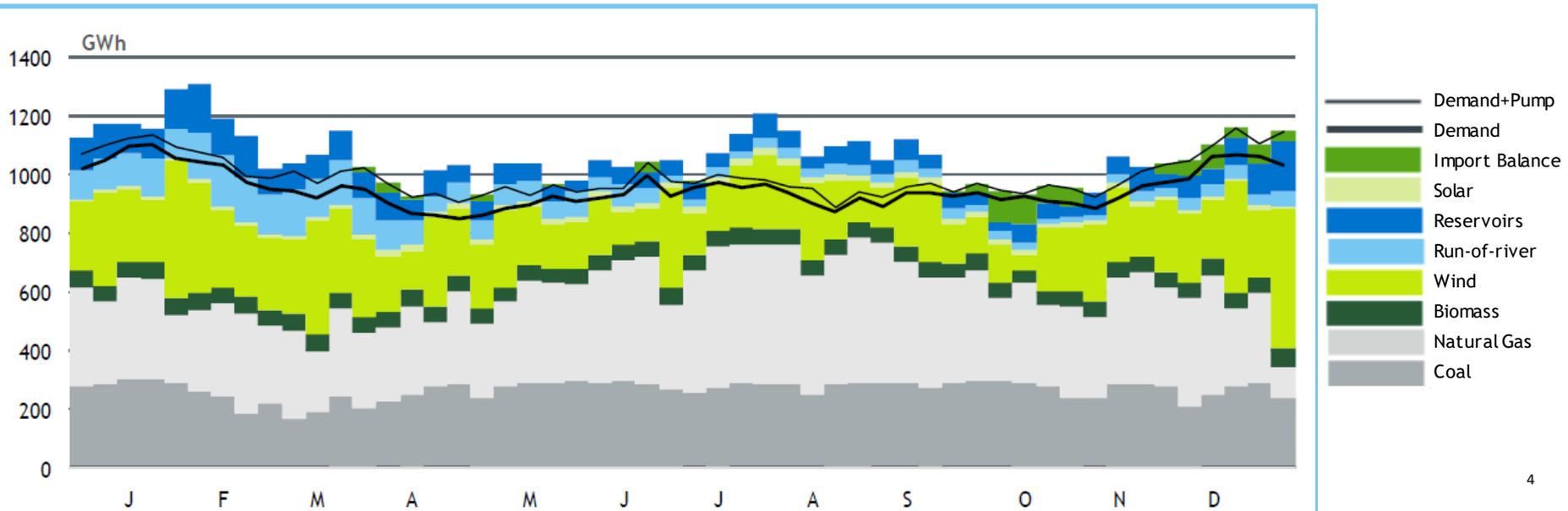
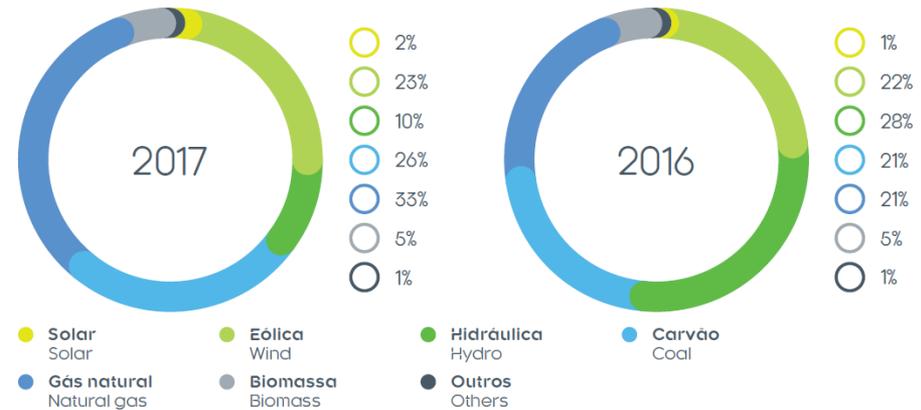
*Peak load is less than half of total install capacity*

*Very good mix of flexible generation (Hydro & NG)*

# Wind and Solar Forecasting in Portugal – Status and Prospects

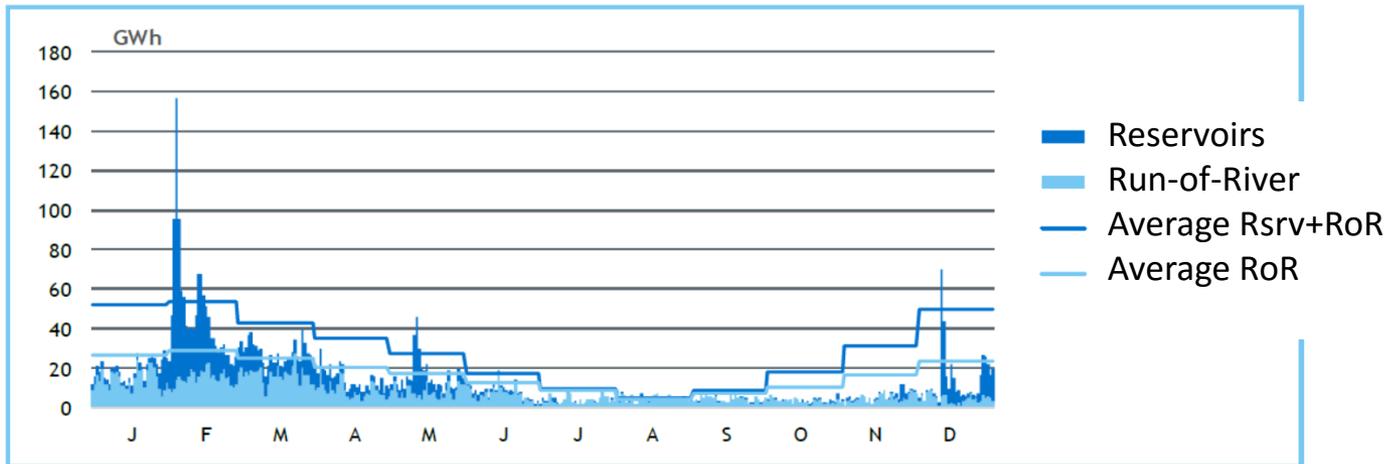
## Energy supply in 2017

- Solar 2%
- Wind 23%
- Hydro 10% (dry year)
- Biomass 5%

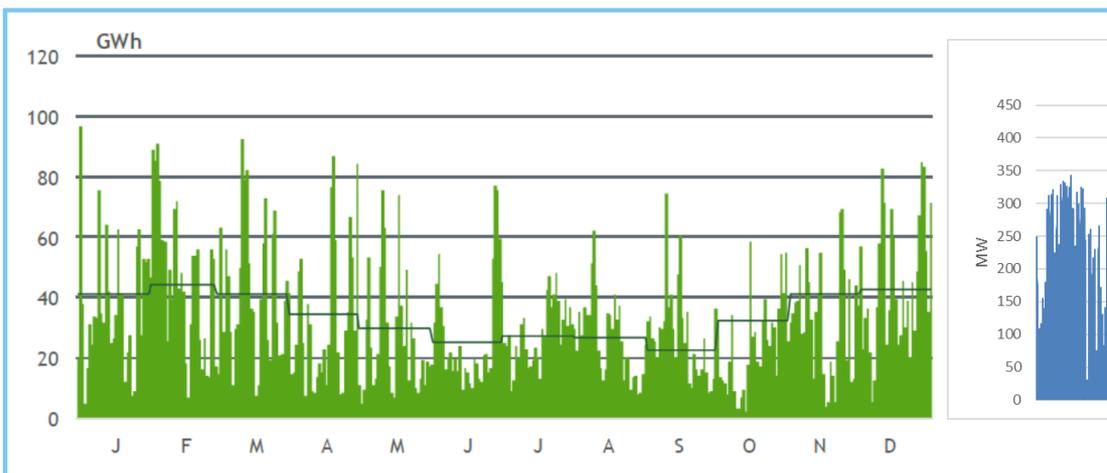


# Wind and Solar Forecasting in Portugal – Status and Prospects

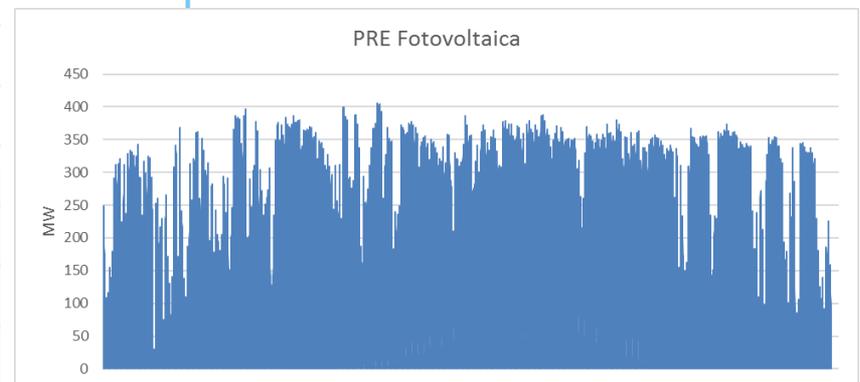
## Hydro – season behavior



## Wind



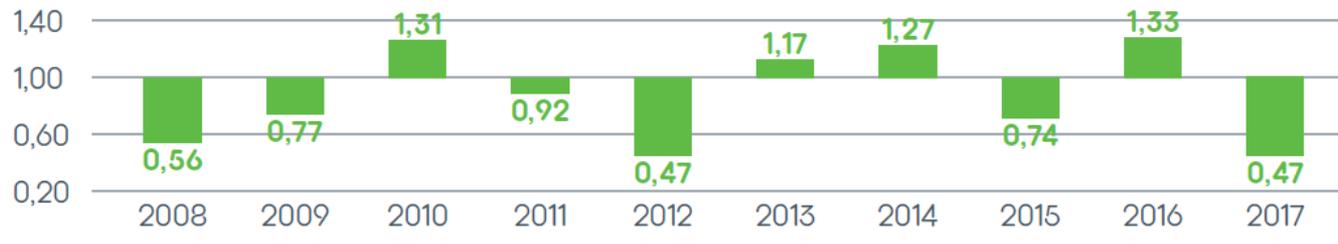
## Solar



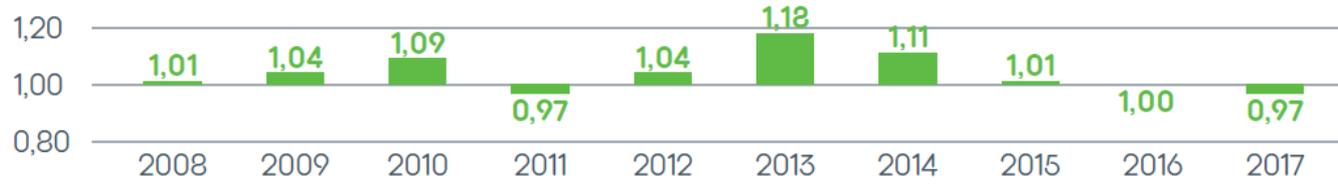
## Wind and Solar Forecasting in Portugal – Status and Prospects

### Renewable Capability factor (yearly)

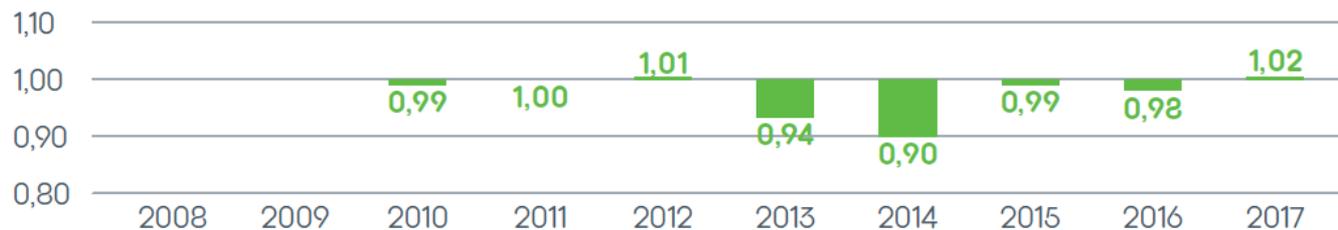
Hidroelétrica Hydro



Eólica Wind

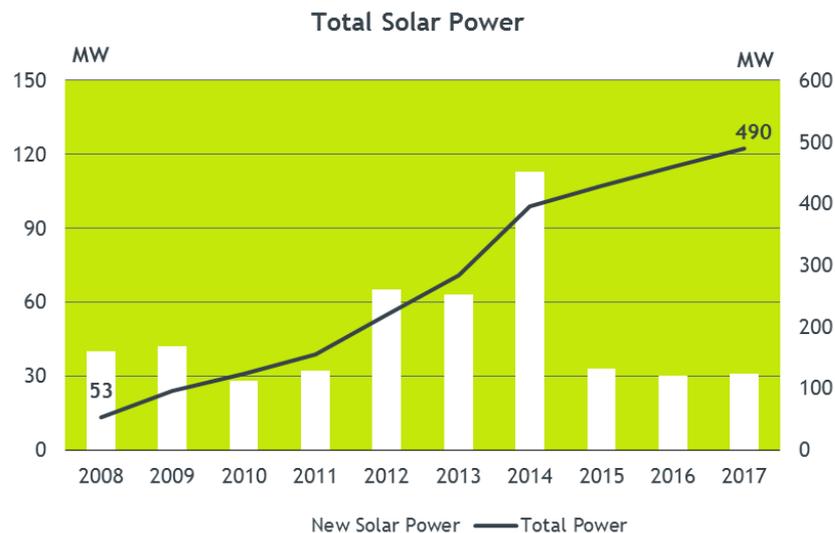
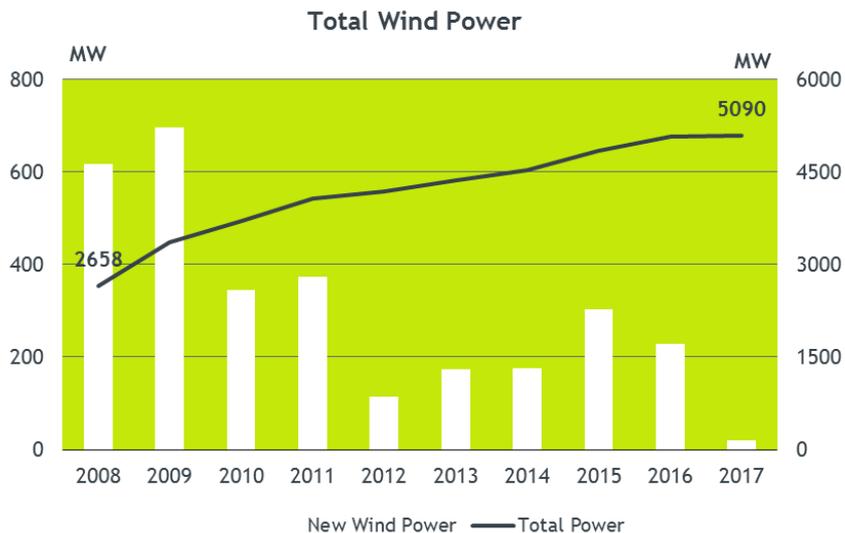


Solar Solar

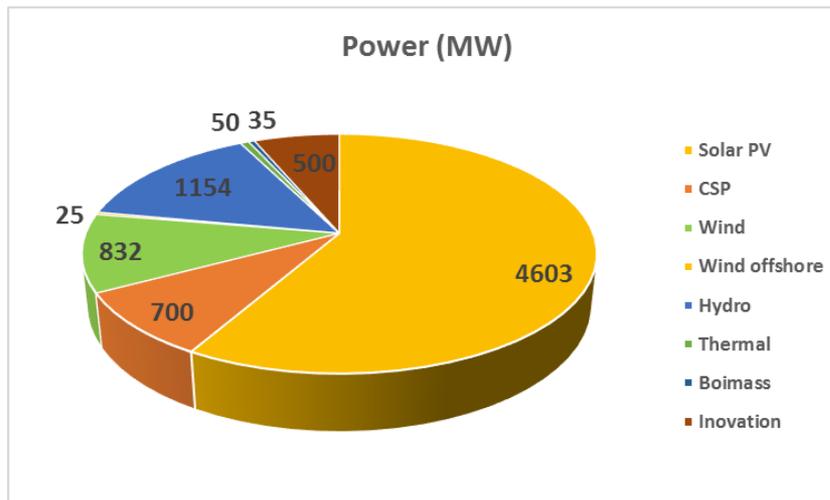


# Wind and Solar Forecasting in Portugal – Status and Prospects

## Wind and Solar power install capacity



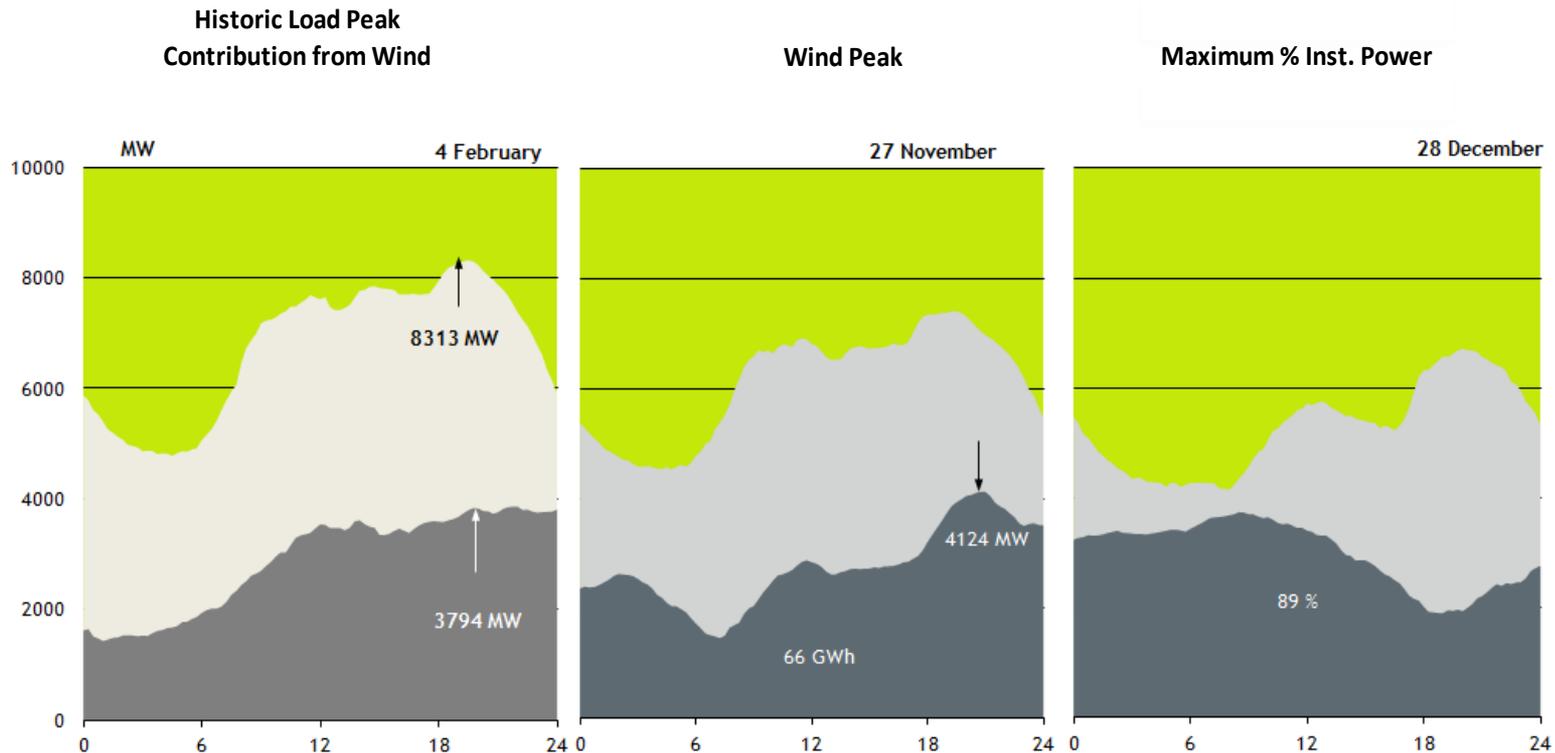
## New requests from Producers (Dec-17)



# Wind and Solar Forecasting in Portugal – Status and Prospects

## Extremes in 2014

- 89% of the load was delivered by wind (instantaneous)

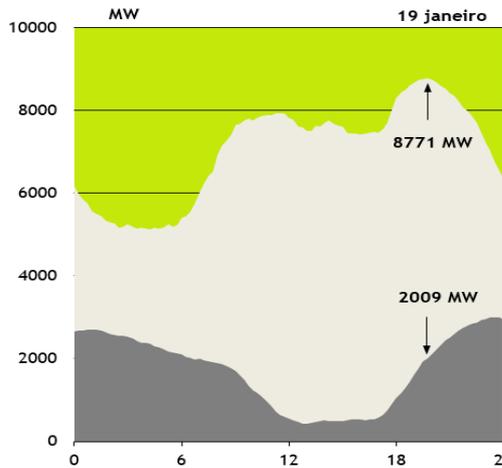


# Wind and Solar Forecasting in Portugal – Status and Prospects

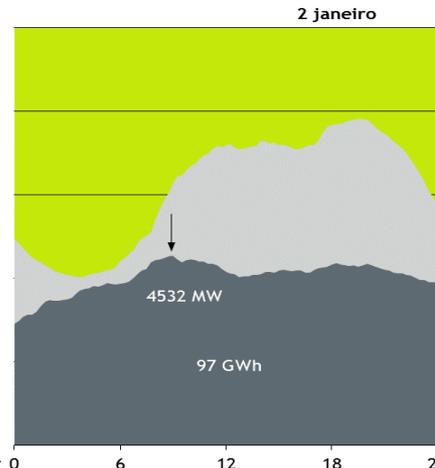
## Extremes in 2017

- 109% of the load was delivered by wind (instantaneous)

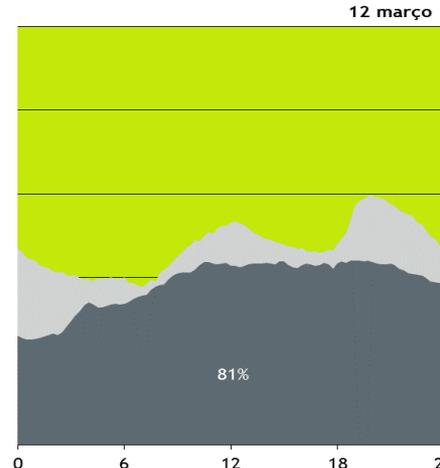
**Historic Load Peak  
Contribution from Wind**



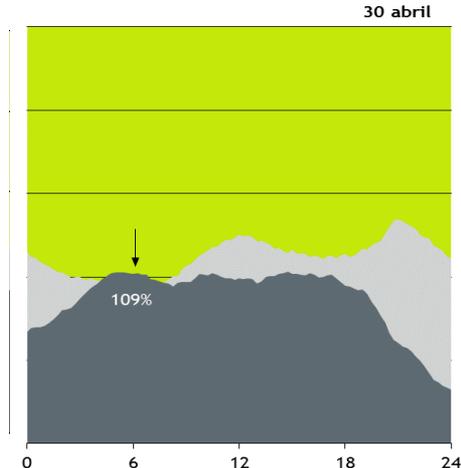
**Wind Peak  
Maximum Energy Daily**



**Maximum % Energy Daily**

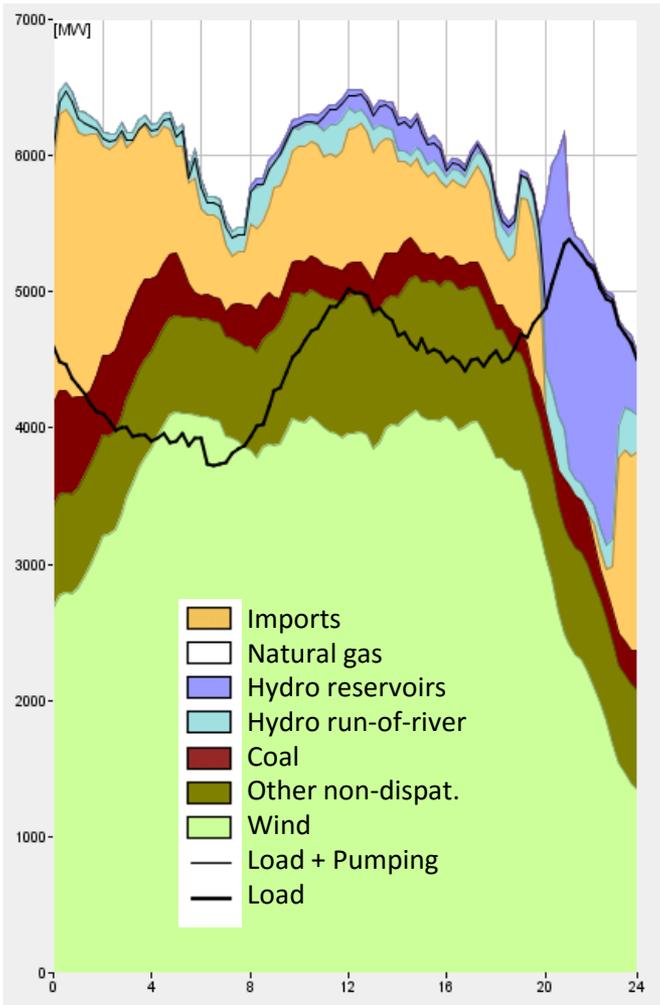


**Maximum % Inst. Power**



# Wind and Solar Forecasting in Portugal – Status and Prospects

## Extremes in 2017 (30<sup>th</sup> April)

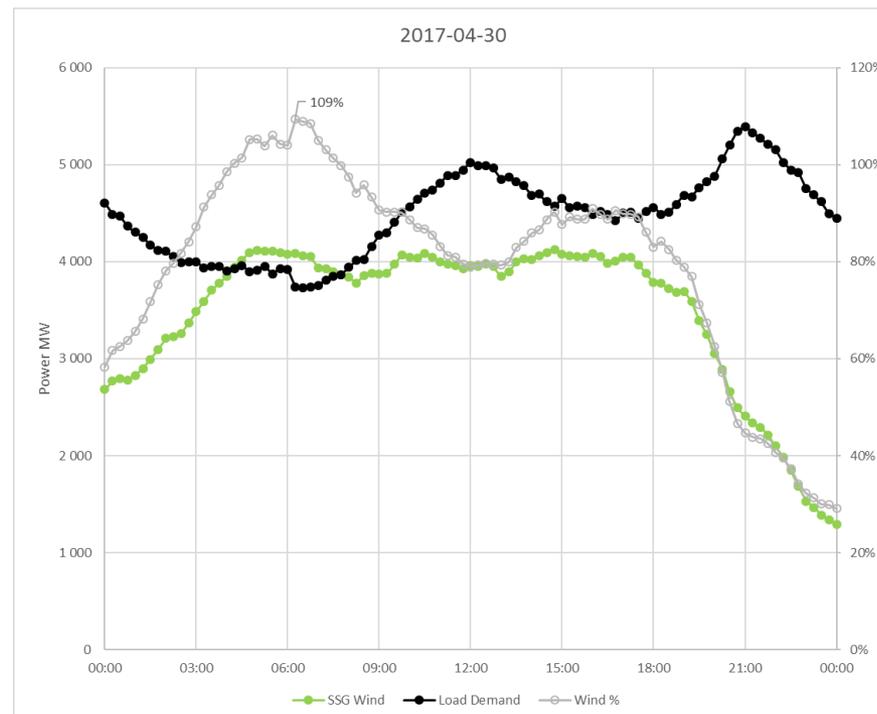


109 % = Wind / Load

72 % = Wind / (Load + Pumping + Exports + Losses)

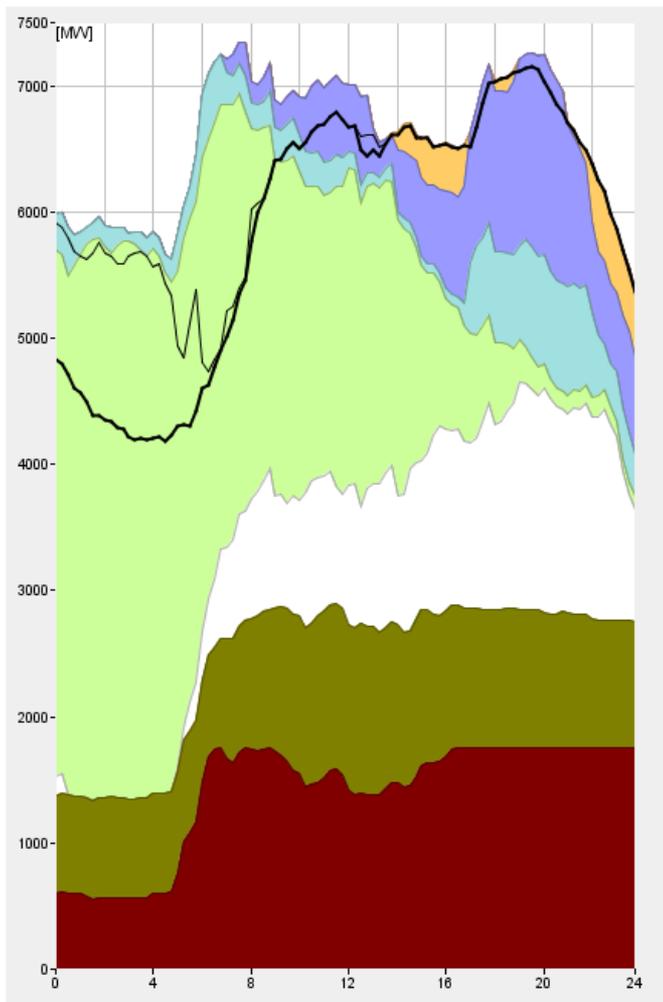
72 % = Wind / (Generation + Imports)

80 % = Wind / Generation



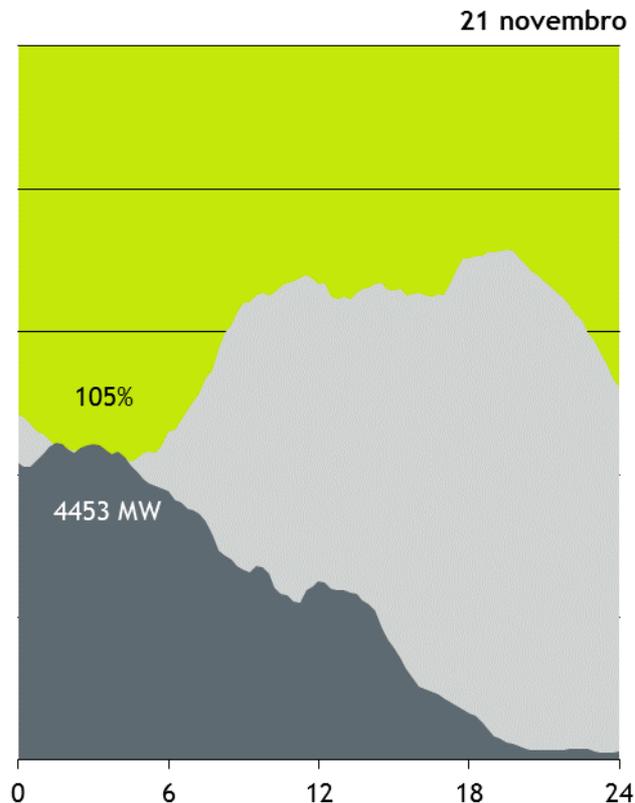
# Wind and Solar Forecasting in Portugal – Status and Prospects

## Extremes in 2016 (21<sup>st</sup> November)



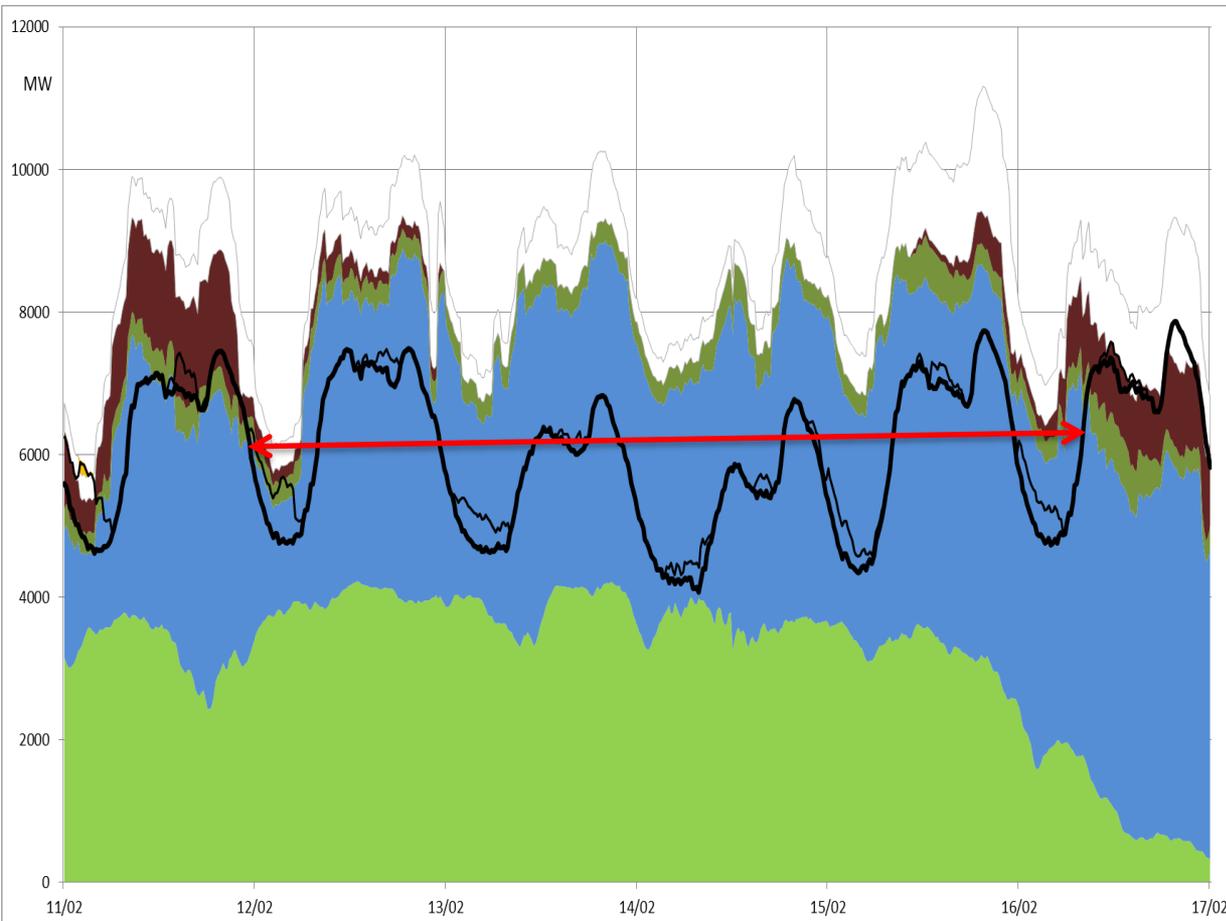
From Maximum to minimum (99 MW) in 22 hours

- Imports
- Natural gas
- Hydro reservoirs
- Hydro run-of-river
- Coal
- Other non-dispat.
- Wind
- Load + Pumping
- Load



## Wind and Solar Forecasting in Portugal – Status and Prospects

**In Feb-2016, RES has supplied all national consumption for 4 consecutive days** (Wind and hydro were the main RES generation sources)



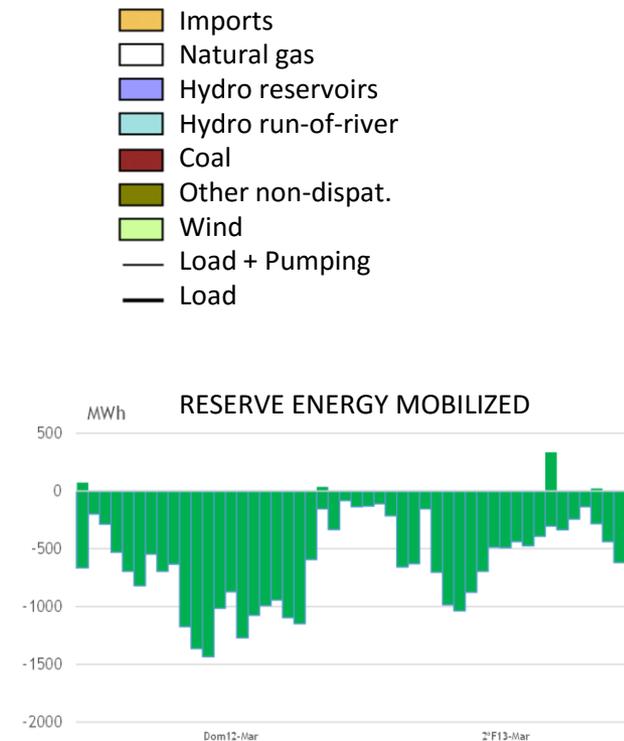
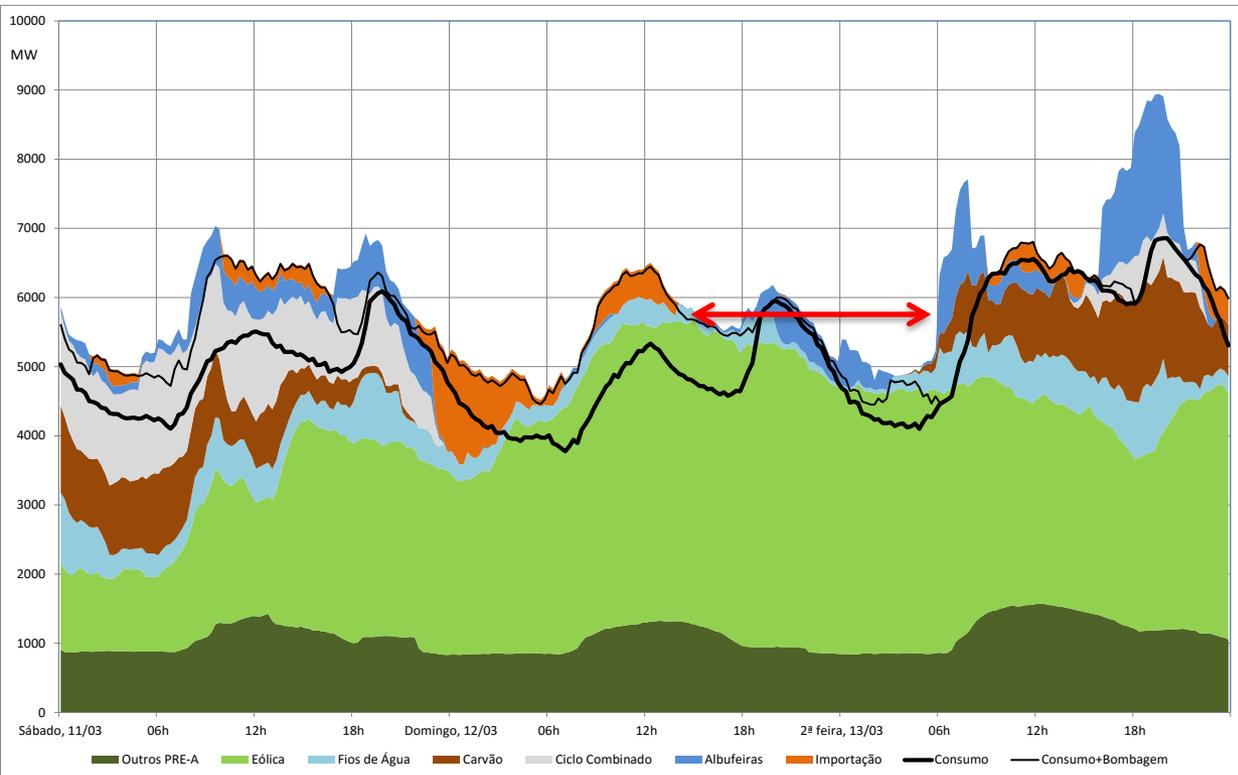
-  Imports
-  Natural gas
-  Hydro reservoirs
-  Hydro run-of-river
-  Coal
-  Other non-dispat.
-  Wind
-  Load + Pumping
-  Load

<b>Minimum demand load</b>	<b>4.078 MW</b>
<b>Maximum demand load</b>	<b>7.737 MW</b>
<b>Average wind share</b>	<b>60%</b>
<b>Average hydro reservoir share</b>	<b>36%</b>
<b>Average hydro run-of-river</b>	<b>33%</b>
<b>Other RES share</b>	<b>5%</b>

# Wind and Solar Forecasting in Portugal – Status and Prospects

**In Feb-2017, Wind was curtail for the 1<sup>st</sup> time (and only time)**

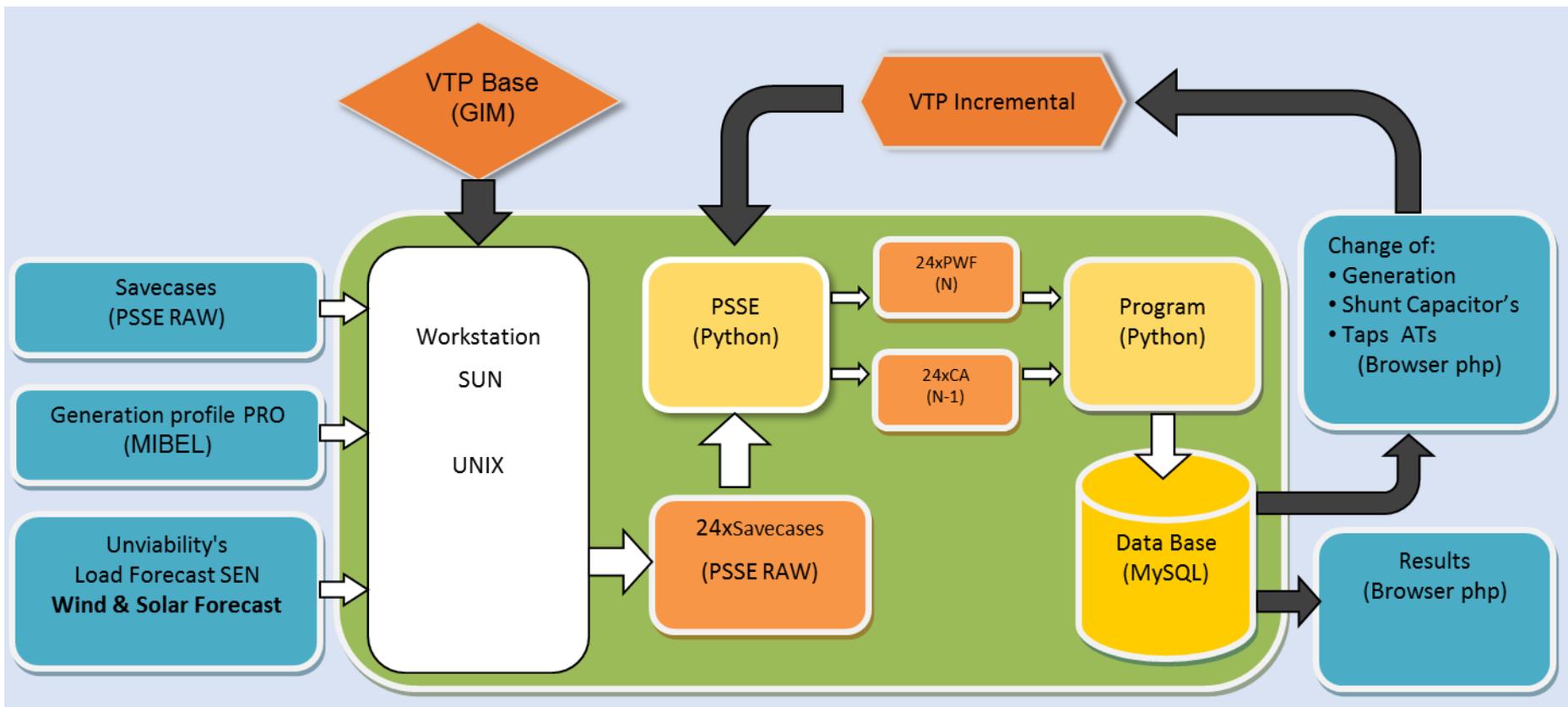
Total order of curtailment of 1388 MWh (/11974 GWh) = 0,0116%



## Wind and Solar Forecasting in Portugal – Status and Prospects

### Security Analysis process

- REN developed internally a tool for the validation of the day ahead market, that takes in consideration the last wind and solar forecast:



## Wind and Solar Forecasting in Portugal – Status and Prospects

### Annual wind power forecast tender by REN (PT TSO)

- Invited 10 provider, 8 have accepted.
- 2 months real trial period.
- 120 wind farms, totalizing 4300 MW.
- Ranking multi-criteria formula:

$$\text{Rank} = V_{\text{Time\_Horizon}} + V_{\text{Reliability}} + 4 \times V_{\text{Performance}} + 2 \times V_{\text{Cost}}$$

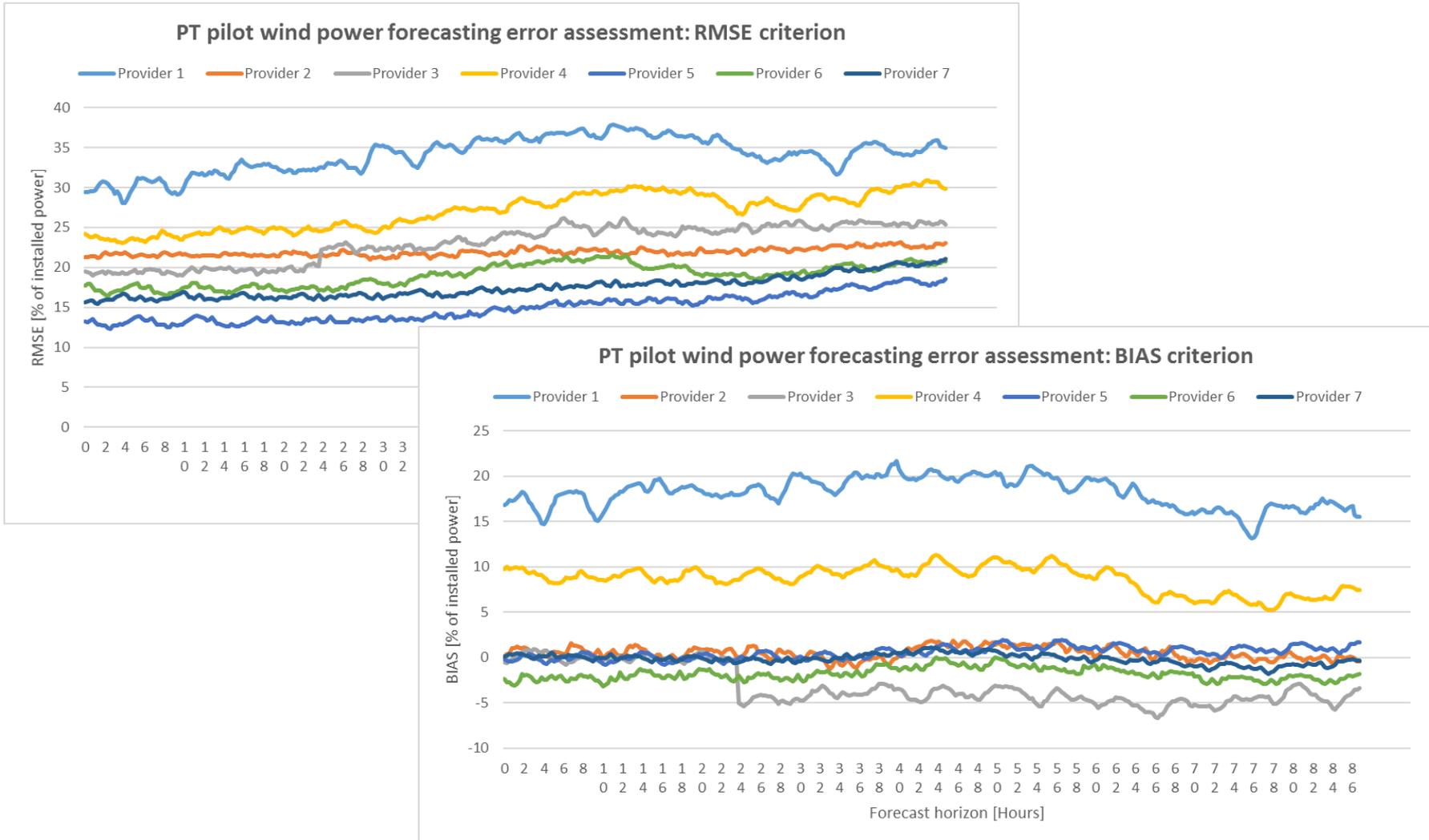
- Performance formula:

$$V_{\text{Performance}} = 25\% \text{ Perf (D)} + 50\% \text{ Perf (D-1)} + 25\% \text{ Perf (D-5)}$$

- Best 2 have a two year contract, next 2 have one year contract.

# Wind and Solar Forecasting in Portugal – Status and Prospects

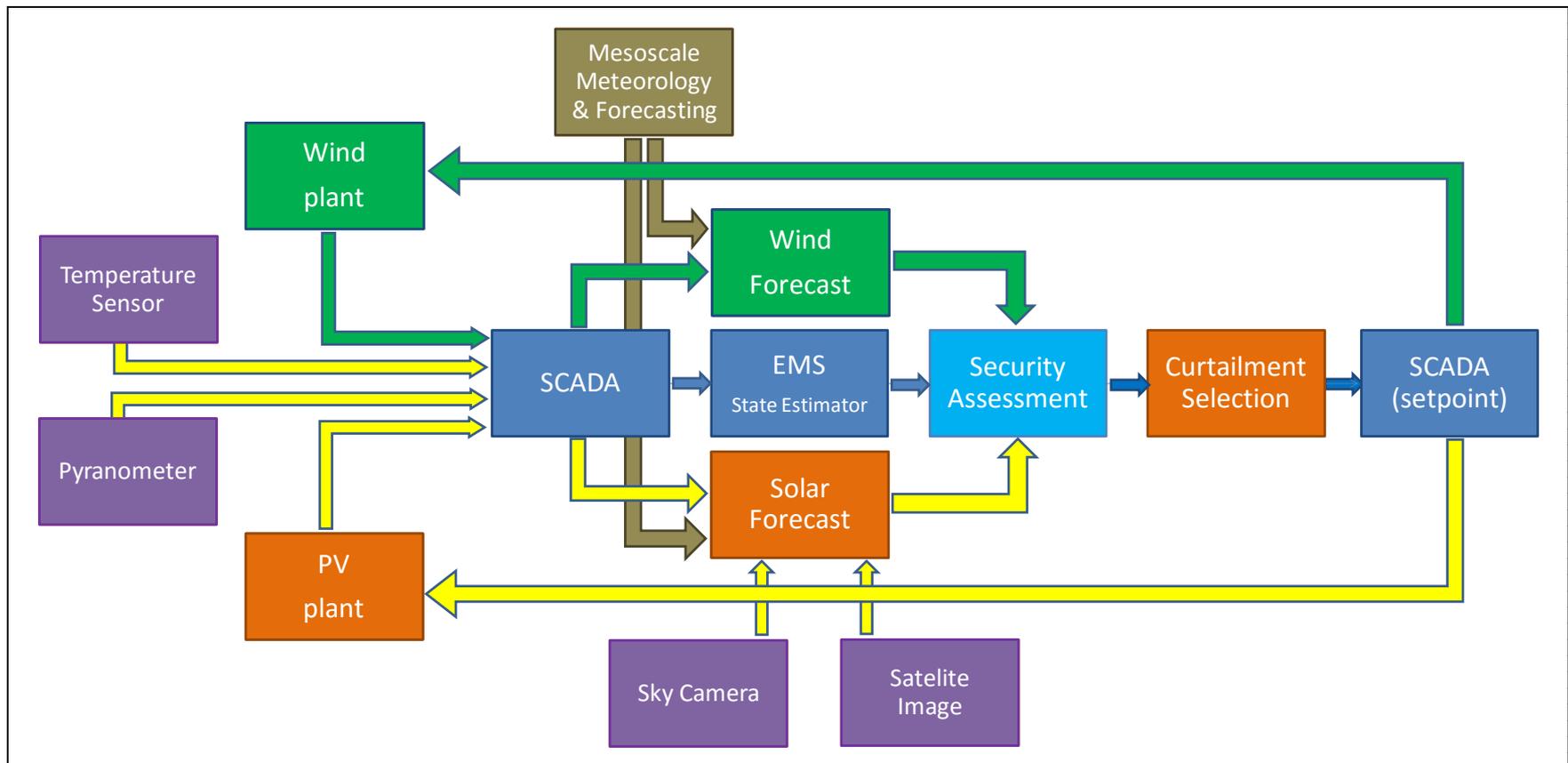
## Wind power forecast assessment (#7 providers, 3 days)



## Wind and Solar Forecasting in Portugal – Status and Prospects

### Wind & Solar forecast with SCADA

- REN has meteorological sensor's at the substation that can improve the very short term forecast:



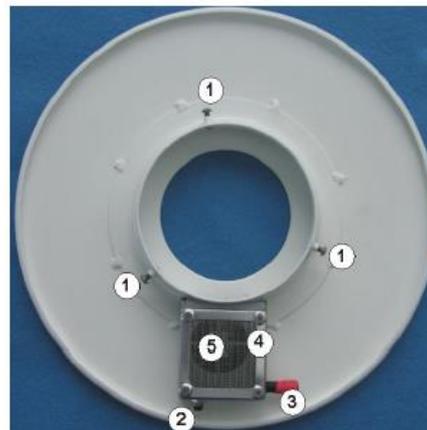
## Wind and Solar Forecasting in Portugal – Status and Prospects

### Sky Camera's in Portugal

#### 1. SRF-02 since May 2015 (Lisbon)

- Without solar shield
- With solar shield and ventilation

(Mid October 2015)

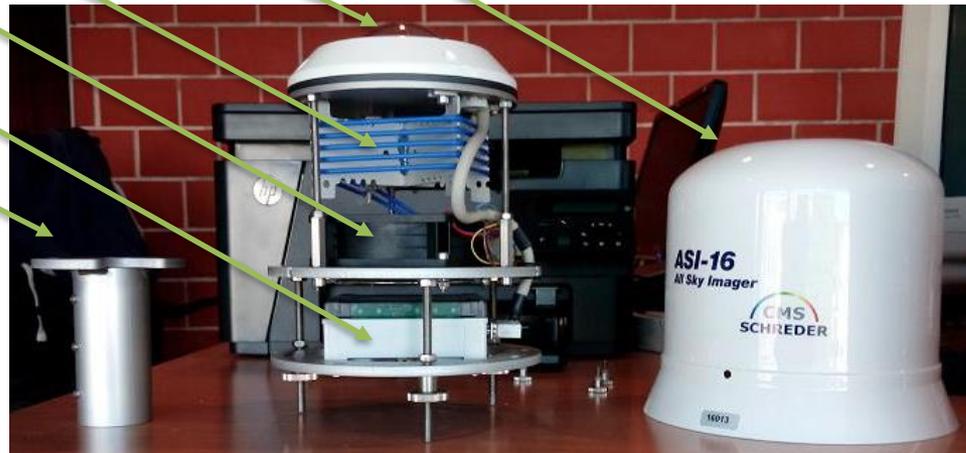


# Wind and Solar Forecasting in Portugal – Status and Prospects

## Sky Camera's in Portugal

### 2. ASI-16 since Oct 2016 (Alentejo)

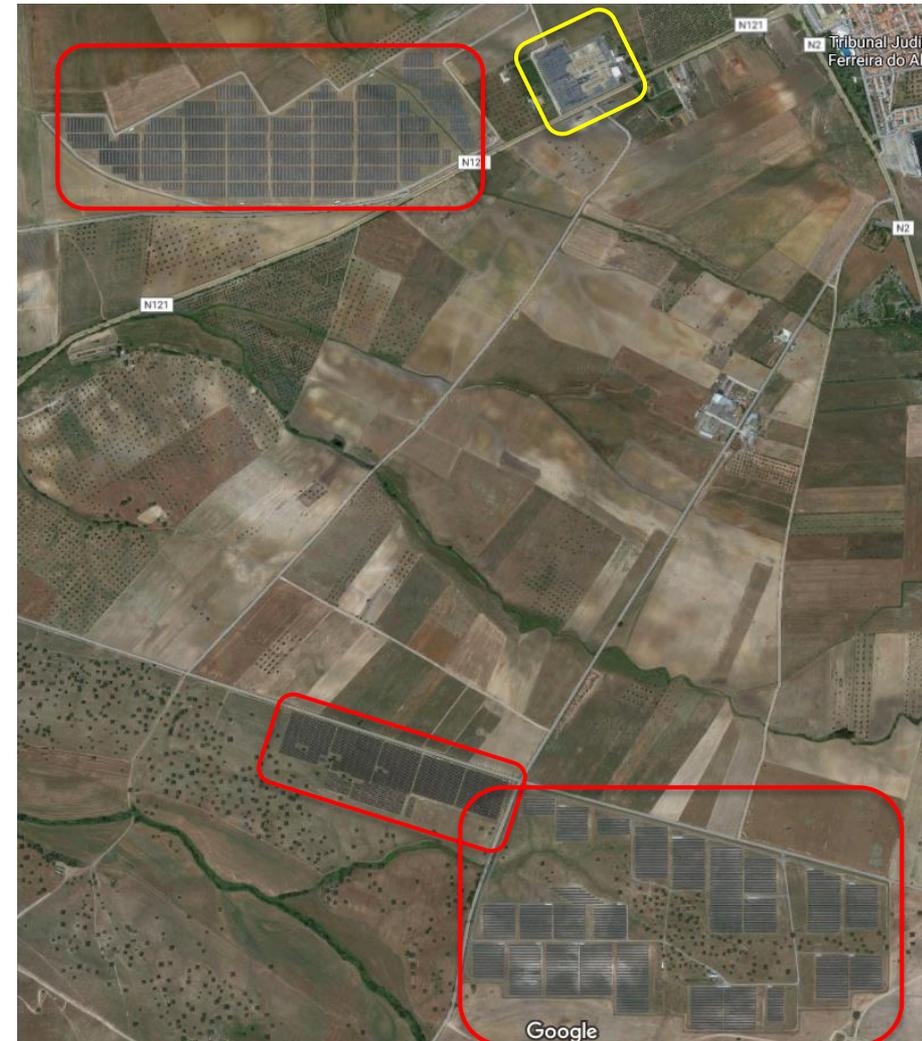
- Solar shield
- Camera
- Heating
- Ventilation
- CPU
- Support



# Wind and Solar Forecasting in Portugal – Status and Prospects

## Sky Camera's in Portugal

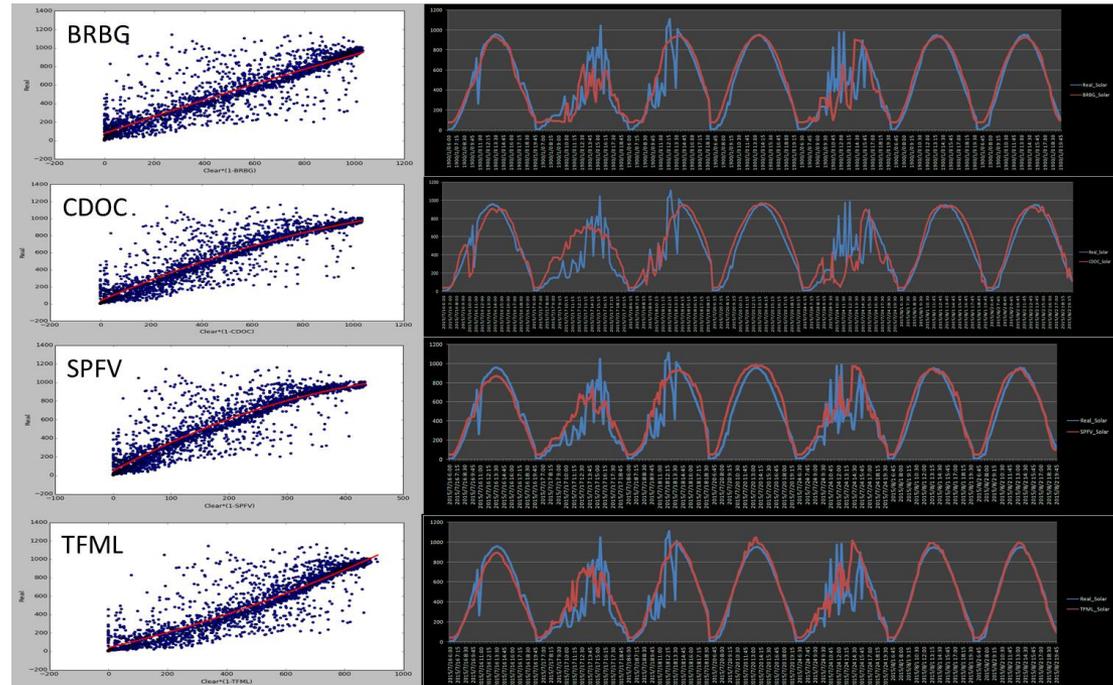
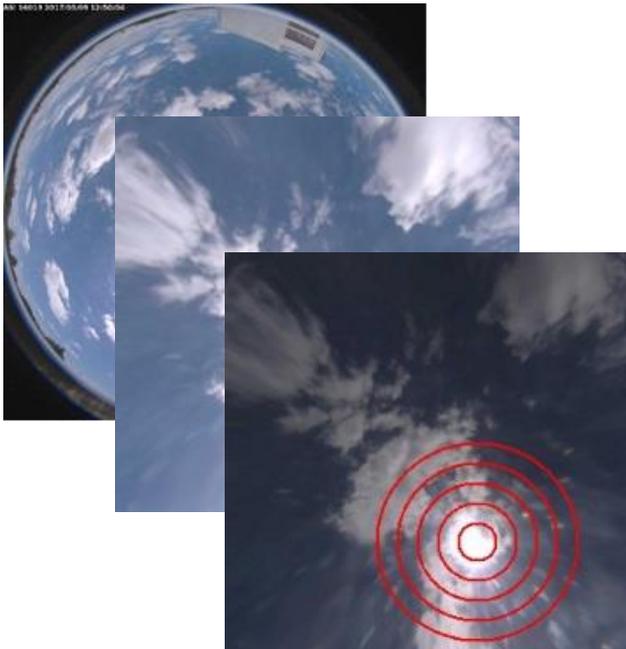
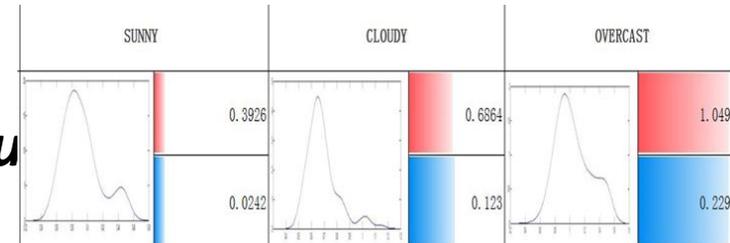
- *Ferreira do Alentejo*



# Wind and Solar Forecasting in Portugal – Status and Prospects

## Cloud Index – developed by R&D NESTER

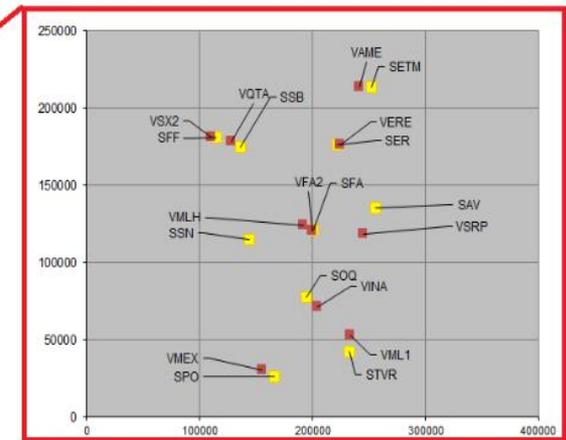
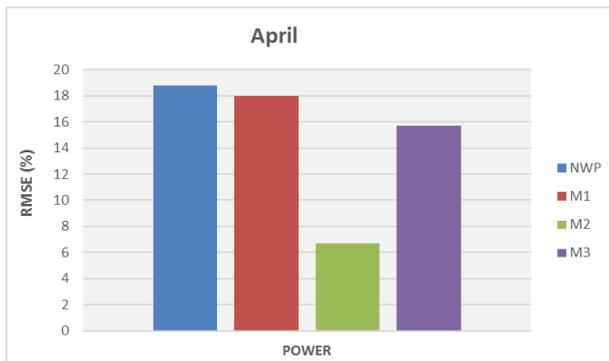
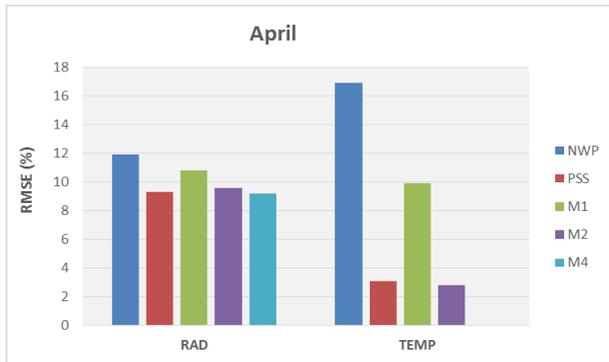
- **SPFV – Solar Pixel Solar Vector**
- **TFML – Texture Feature over Mean Lu**



# Wind and Solar Forecasting in Portugal – Status and Prospects

## Spatial and Time analysis

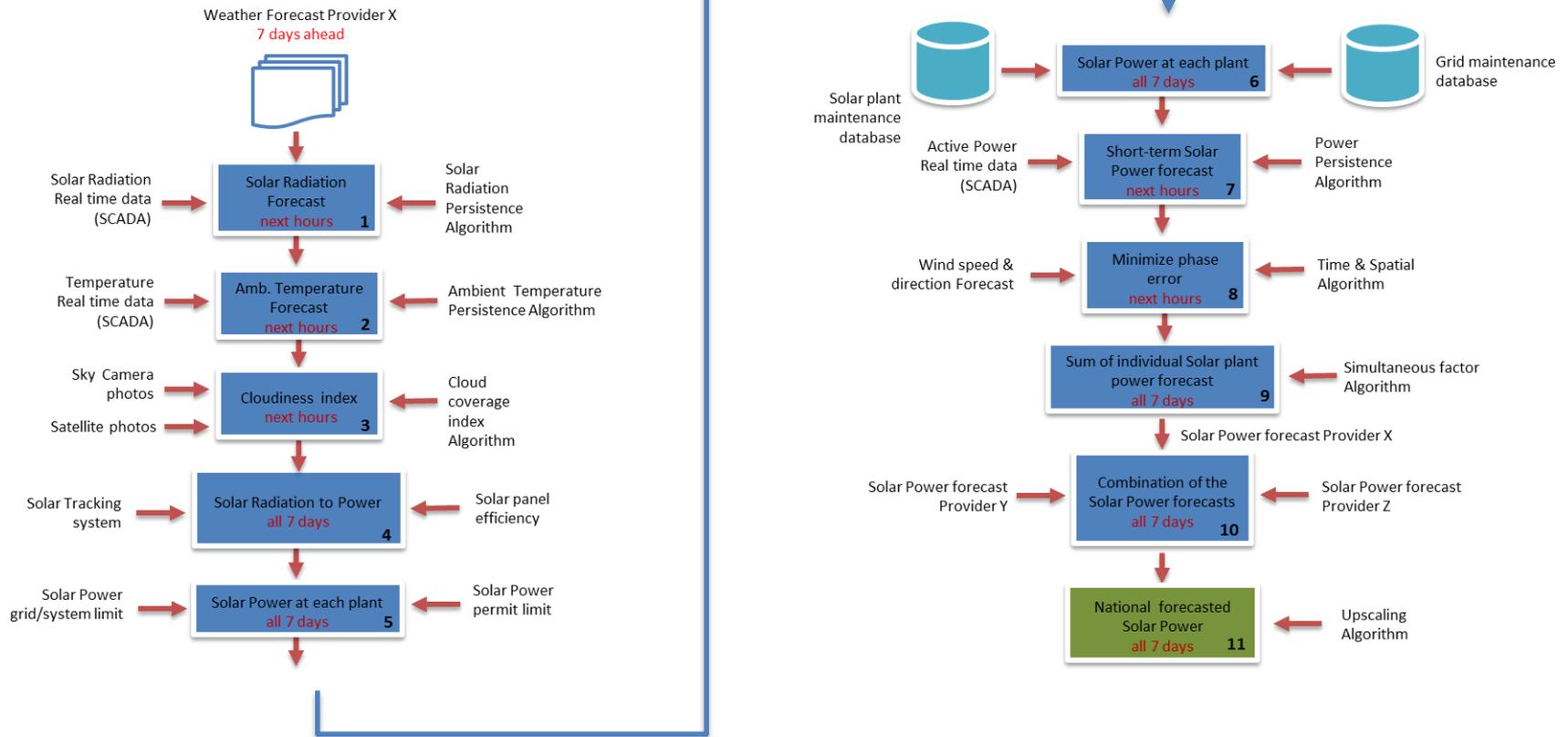
- *Solar Radiation*
- *Ambient Temperature*
- *Active Power*



■ TSO Substation  
📍 PV Plant

# Wind and Solar Forecasting in Portugal – Status and Prospects

## Solar Forecast Flowchart



# Conclusions

- **Spatial & Time algorithms can reduce the short-term forecast error, taking advantage of multiple site's with real-time data.**
- **Every new big PV plant is required to install a sky camera and send the photos automatically to the System Operator.**
- **The SO is requiring Power Forecast and not wind or solar radiation.**
- **Portugal is on the top list of wind integration, with almost no curtailment.**
- **Solar is the next big challenging.**

## Wind and Solar Forecasting in Portugal – Status and Prospects

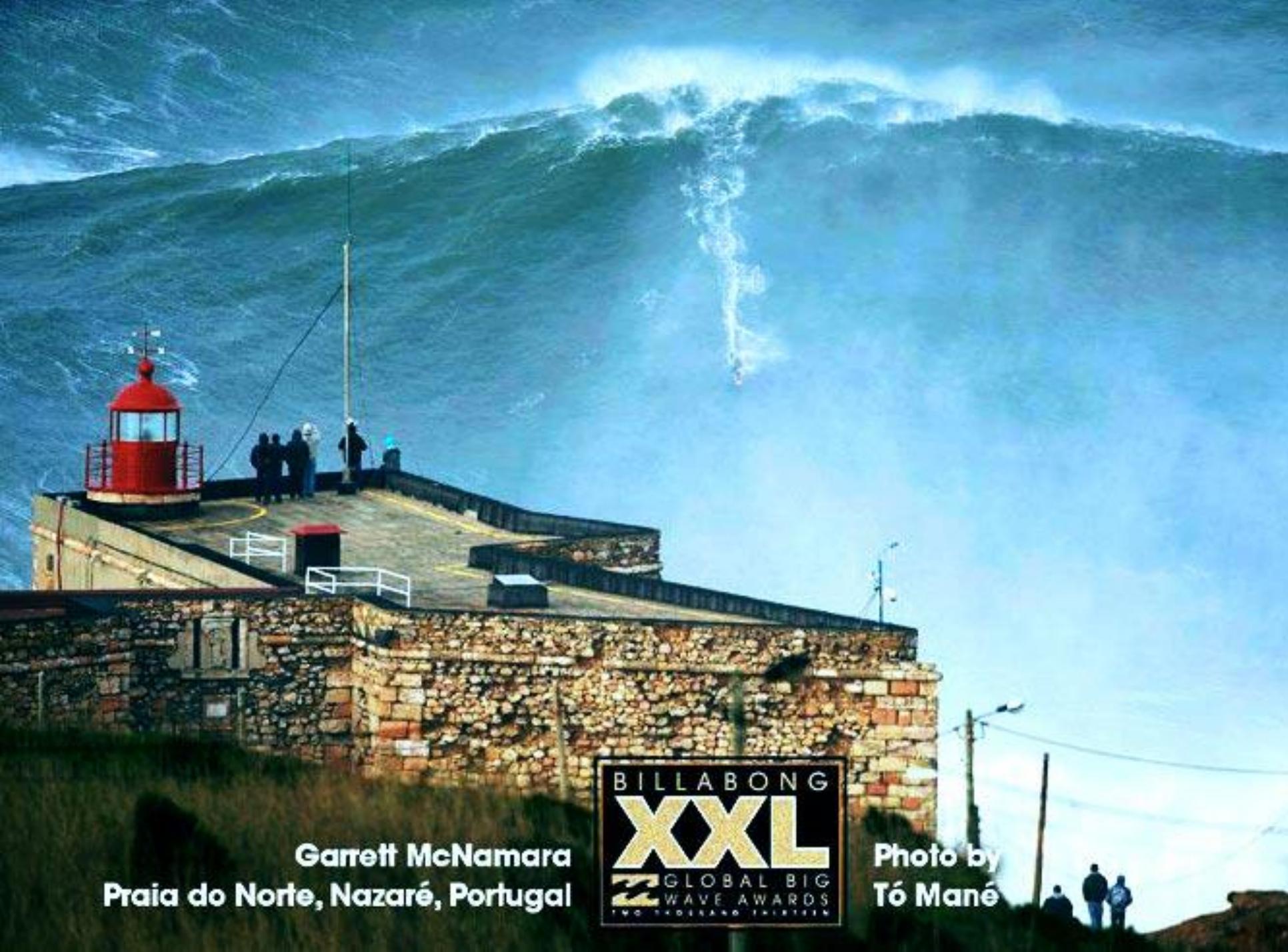
**Thanks**

**Obrigado**

**Any Questions?**

**Rui Pestana**

**[rui.pestana@rdnester.com](mailto:rui.pestana@rdnester.com)**



**Garrett McNamara**  
**Praia do Norte, Nazaré, Portugal**



**Photo by**  
**Tó Mané**



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A futuristic cityscape at night, featuring a prominent glowing bridge over a body of water. The bridge is illuminated with a bright, warm light, and its reflection is visible in the water. The background is filled with tall, illuminated skyscrapers, creating a vibrant urban skyline. Light trails from moving vehicles are visible on the road in the foreground, adding a sense of motion and energy to the scene. The overall color palette is dominated by warm, golden-yellow and orange tones, giving the image a futuristic and optimistic feel.

# CREATING A SMART ENERGY FUTURE

# Wind and Solar Forecasting in Portugal – Status and Prospects



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