



Experiences of REN in ensuring flexible on electric system

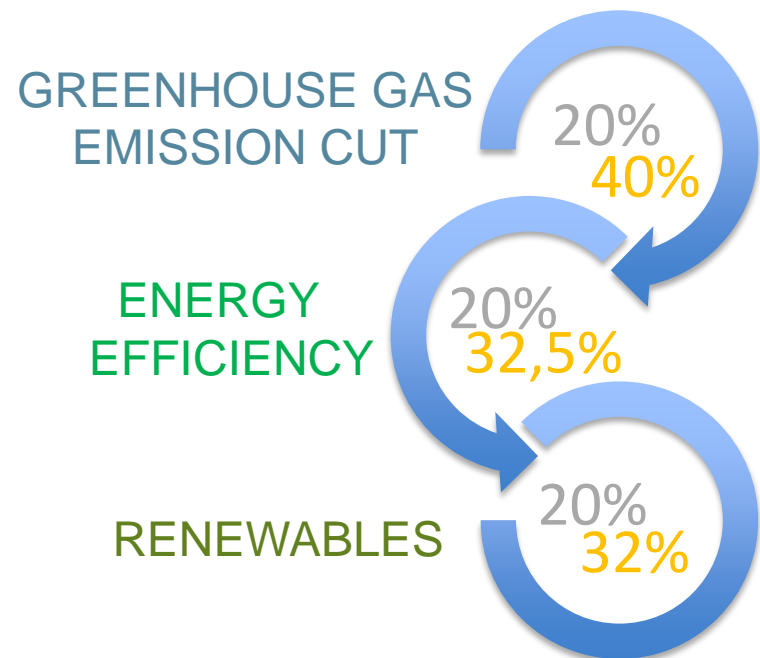
South East Europe Workshop on Grid Integration of Variable RES

Nuno Martins

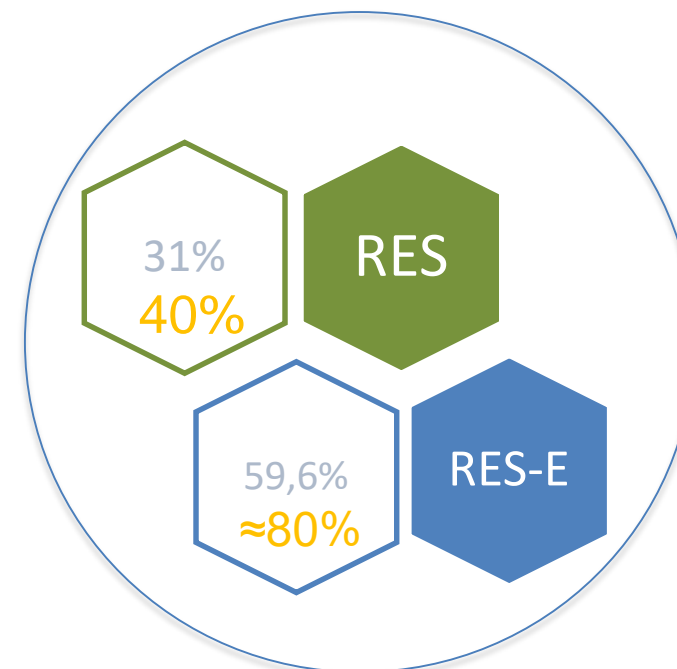
Vienna, 7 November 2018

Energy policy in EU and Portugal (2020 and 2030)

EU Targets for 2020 and 2030



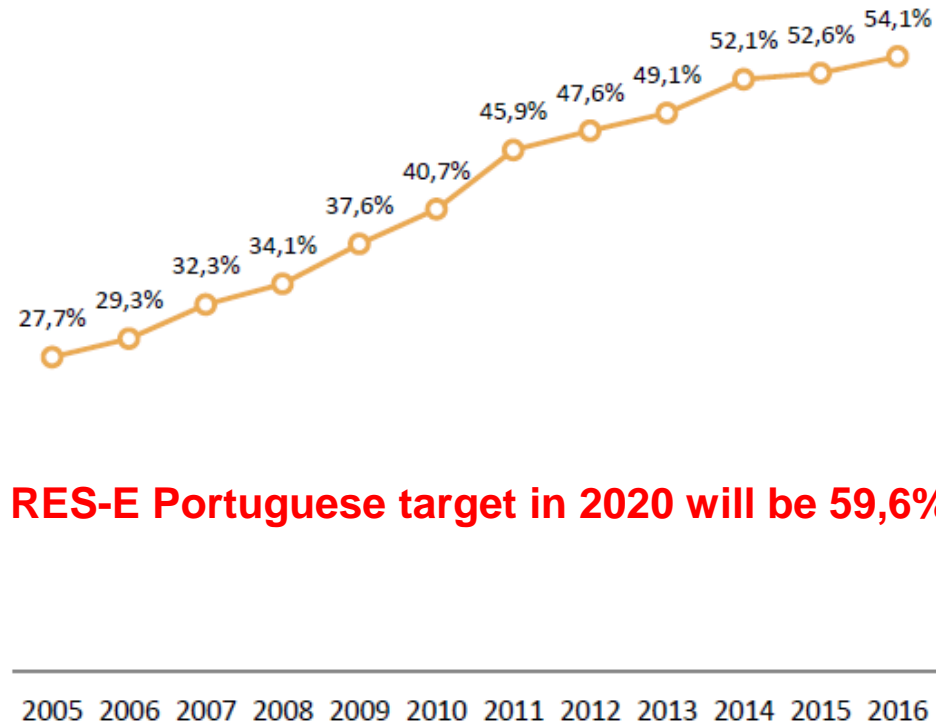
PT targets for 2020 and 2030



INTERCONNECTION CAPACITY / TOTAL INSTALLED CAPACITY
2020 ≥ 10% | 2030 ≥ 15%

Portuguese targets induces high penetration of renewable energy

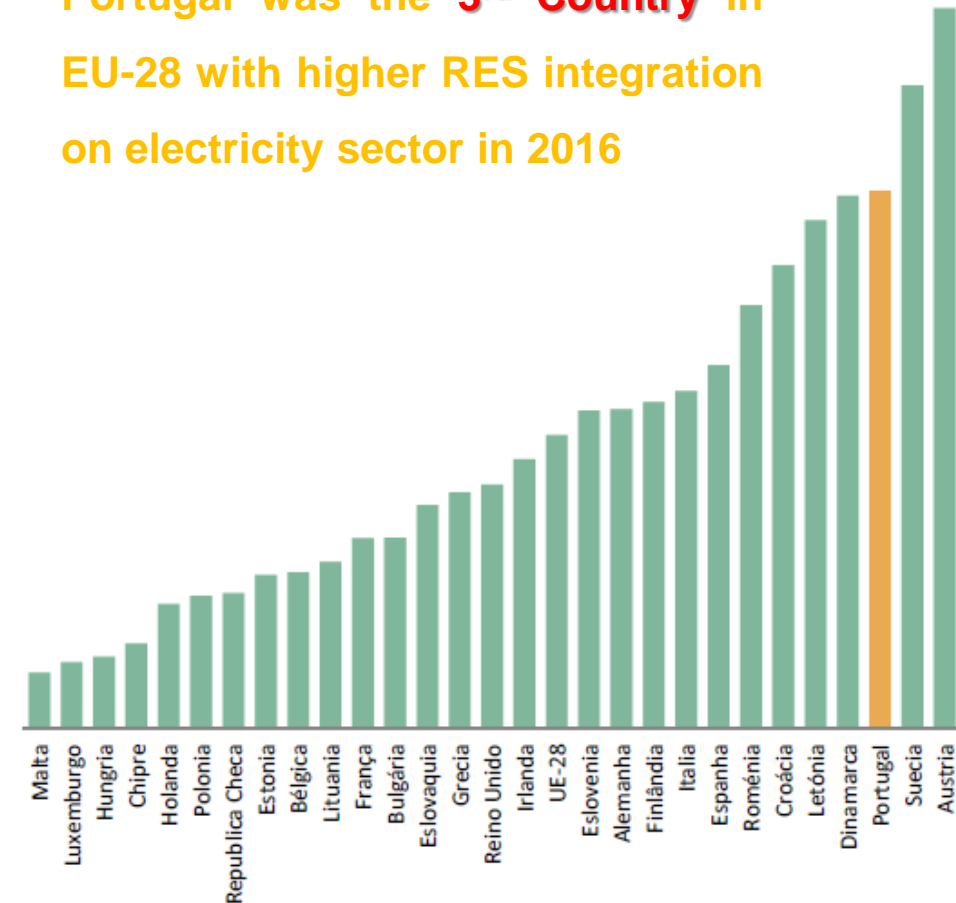
RES share¹ evolution on electricity sector until 2020 horizon



RES-E Portuguese target in 2020 will be 59,6%

Portugal position related with other EU-28 Member States in 2016

Portugal was the **3rd Country** in EU-28 with higher RES integration on electricity sector in 2016

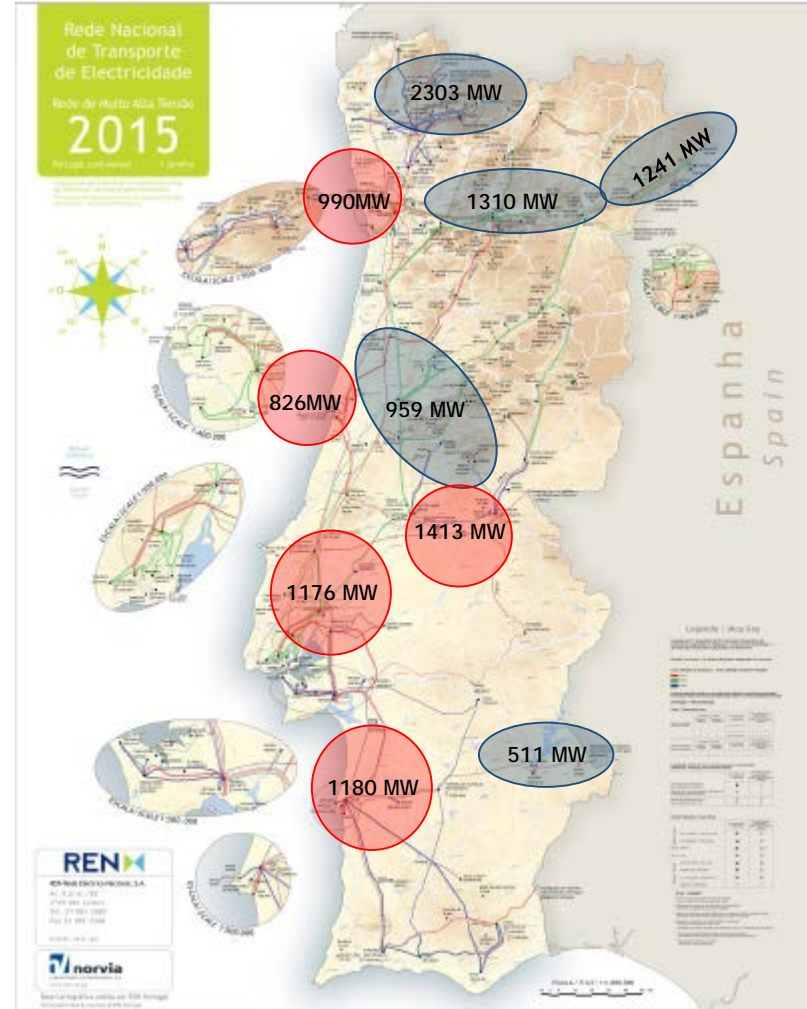


1: RES Share calculation according Eurostat methodology

Source: Eurostat, Direção Geral de Energia e Geologia (National Directorate of Energy and Geology)

Total generation capacity (end of 2017) % of peak load (*)

| Technology | Capacity (MW) | % of peak load (*) |
|--|------------------|--------------------|
| Renewable | 13 397 MW | 153% |
| ▪ Hydro (Small hydro included) | 7 193 MW | 82% |
| ▪ Wind | 5 090 MW | 58% |
| ▪ Thermal (CHP included) | 624 MW | 7% |
| ▪ Solar | 490 MW | 6% |
| Non-renewable | 6 403 MW | 73% |
| ▪ Natural Gas (CCGT) | 3 829 MW | 44% |
| ▪ Coal | 1 756 MW | 20% |
| ▪ CHP (Natural Gas) | 778 MW | 9% |
| ▪ Other | 40 MW | 0% |
| Total | 19 800 MW | |
| Total installed pumped capacity | 2 698 MW | |
| Annual consumption in 2017 | 49,6 TWh | |



- **Dispatchable** 12 368 MW (62%)
 - Hydro
 - Natural Gas (CCGT)
 - Coal
- **Non-dispatchable** 7 432 MW (38%)
 - Wind
 - Solar
 - Small hydro
 - CHP
 - Other

Source: REN

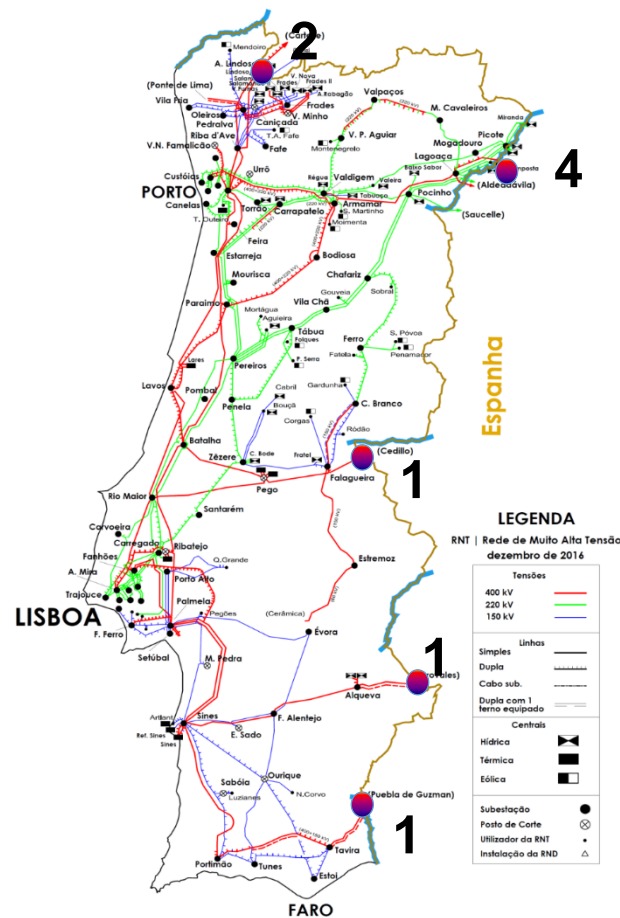
● - Thermal (classic)
● - Large Hydro

Source: REN

(*) Peak load - January 2017:
8 770 MW

Maximum generation - January 2017:
11 370 MW

Transmission network overview (end of 2017)



| | |
|---------------|-------|
| Circuits (km) | 8 907 |
| 400 kV | 2 714 |
| 220 kV | 3 611 |
| 150 kV | 2 582 |

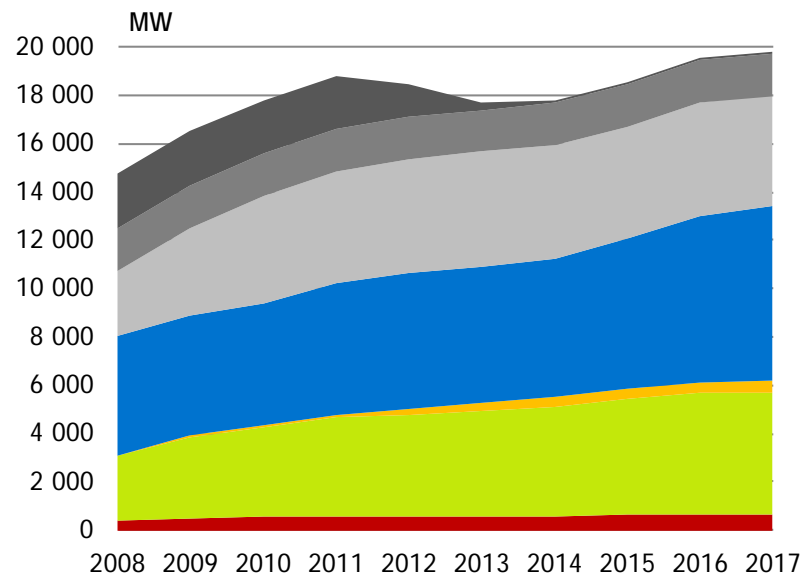
| | |
|----------------------|---------------------------|
| Interconnections (#) | 9 ● |
| | (6x 400 kV and 3x 220 kV) |

| | |
|----------------------|-----|
| Transformer stations | 68 |
| Switching stations | 14 |
| Transformers | 203 |
| Shunt reactors | 10 |

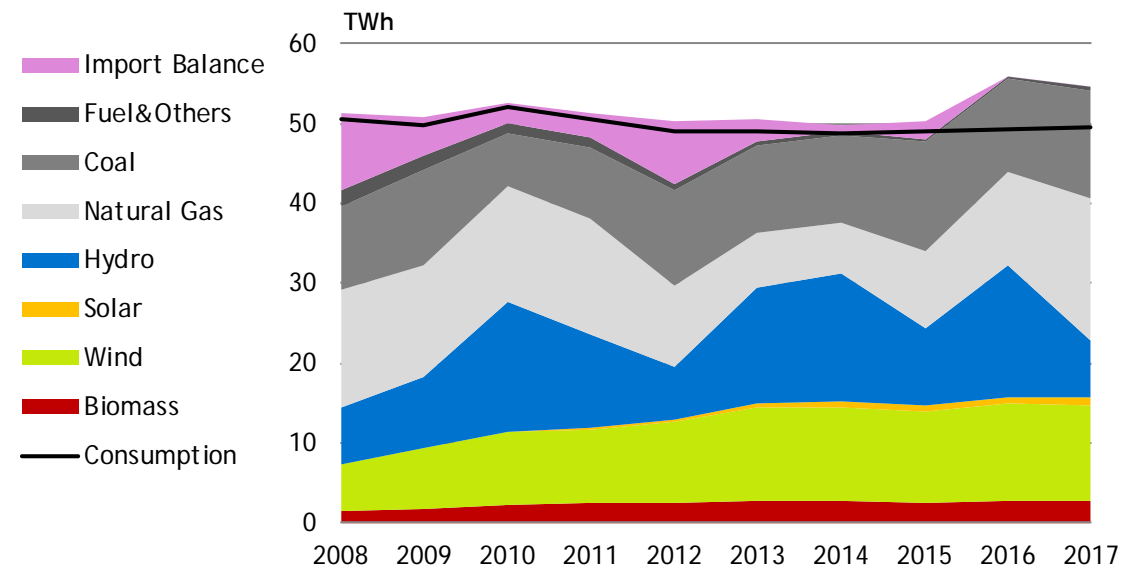
Source: REN

Installed generation capacity and demand supply mix

Installed generation capacity



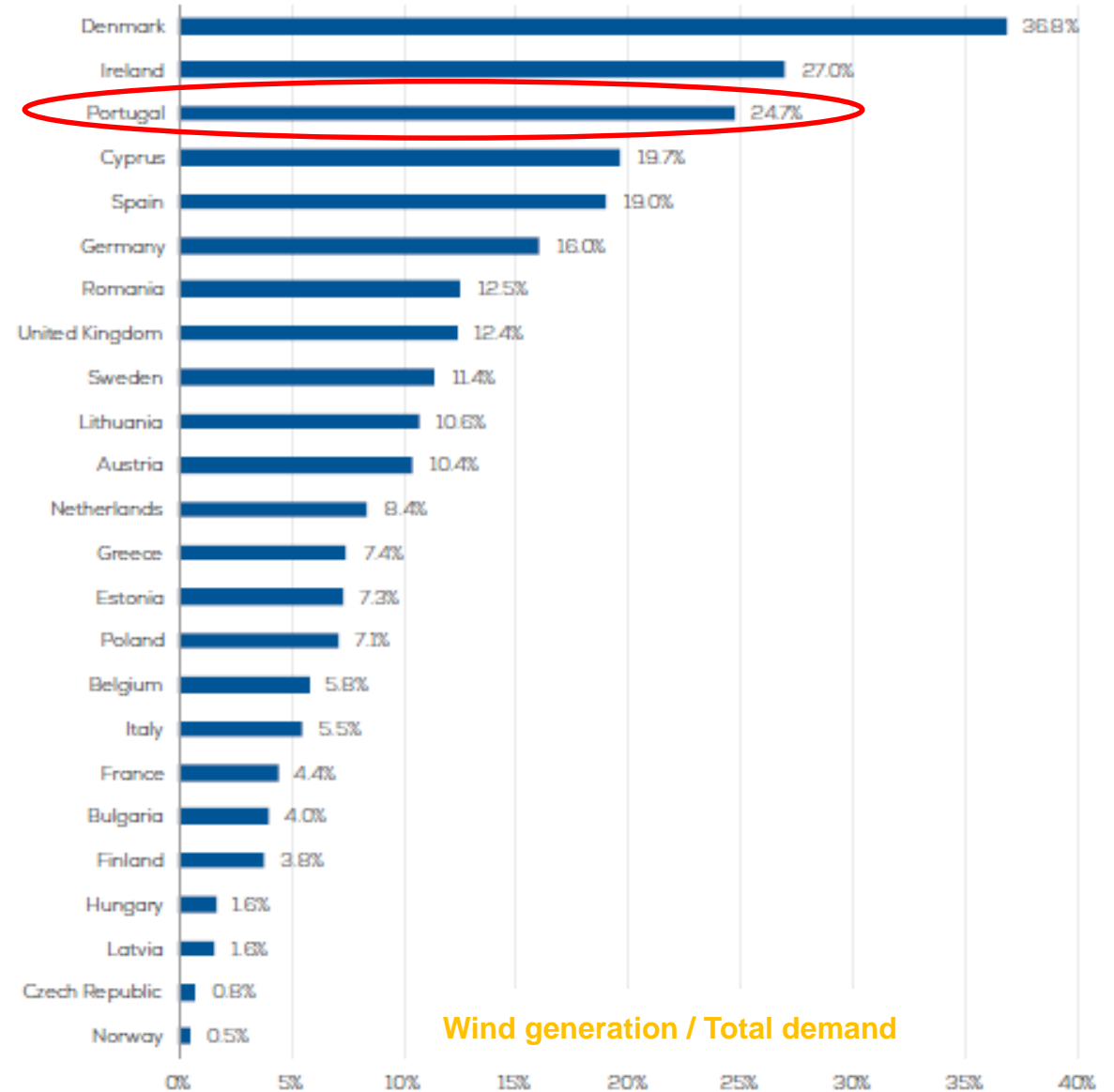
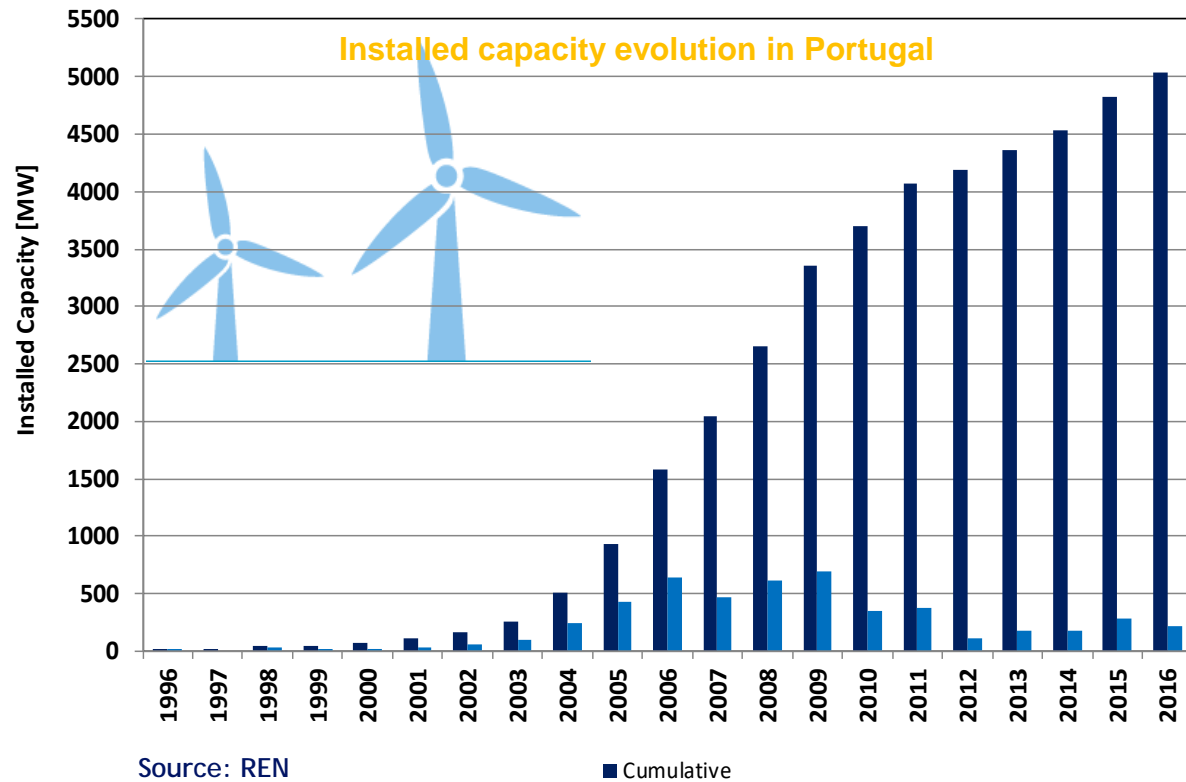
Demand supply

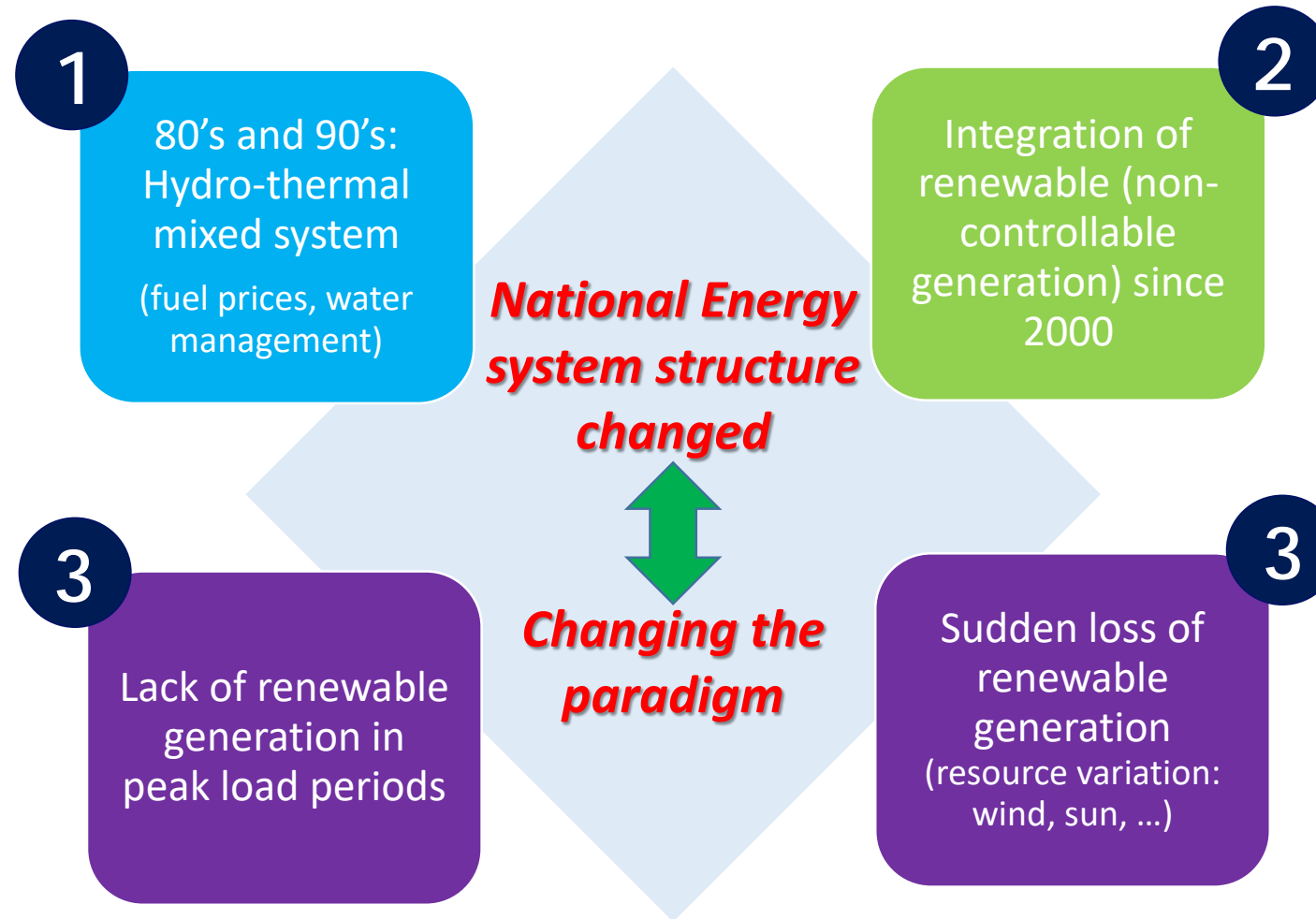


Source: REN

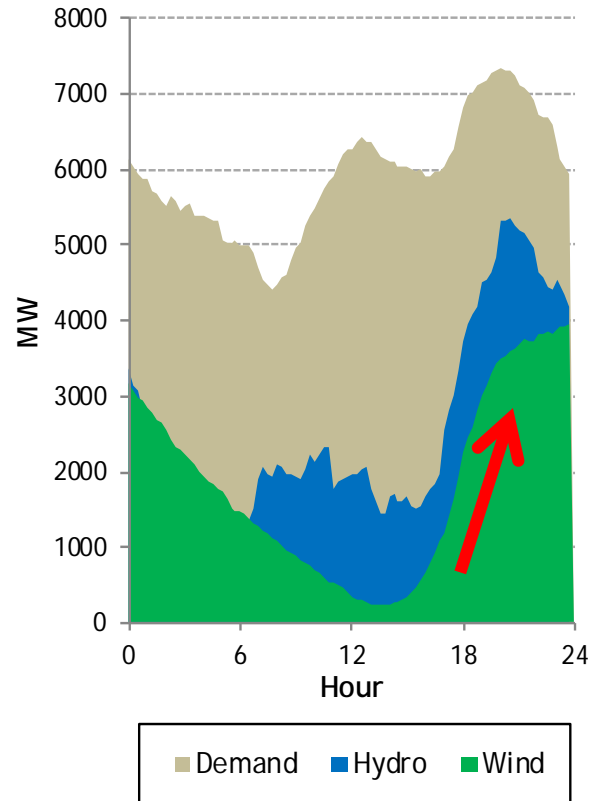
YEARLY → hydro is highly dependent on wet/dry regime, whilst wind is more consistent

Wind penetration rates and position related with European countries (2016)

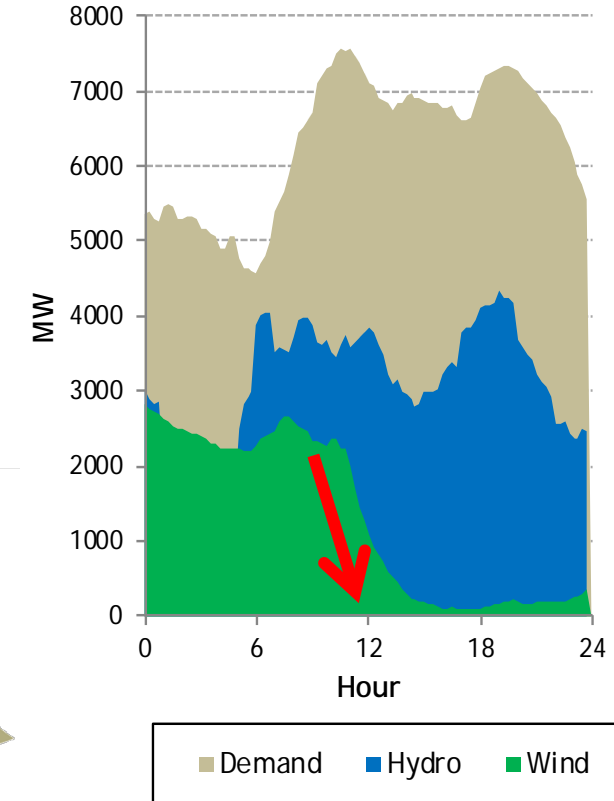




Wind generation increase



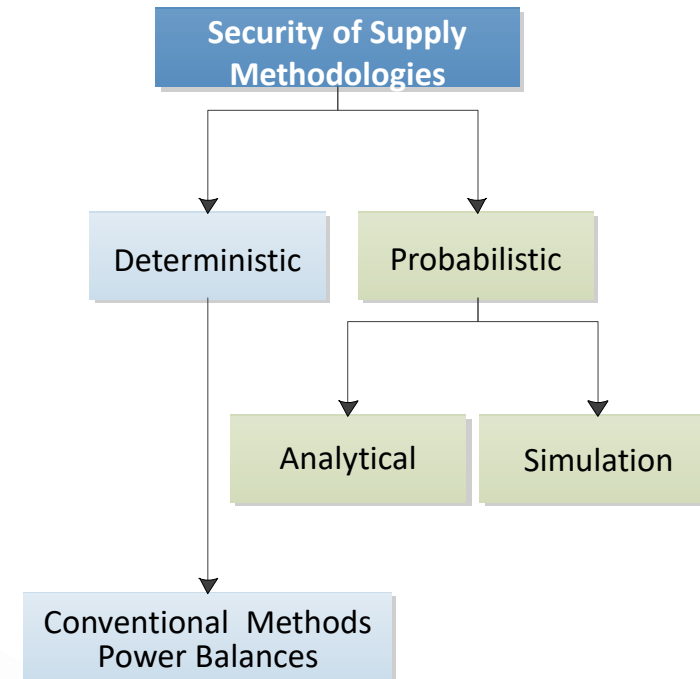
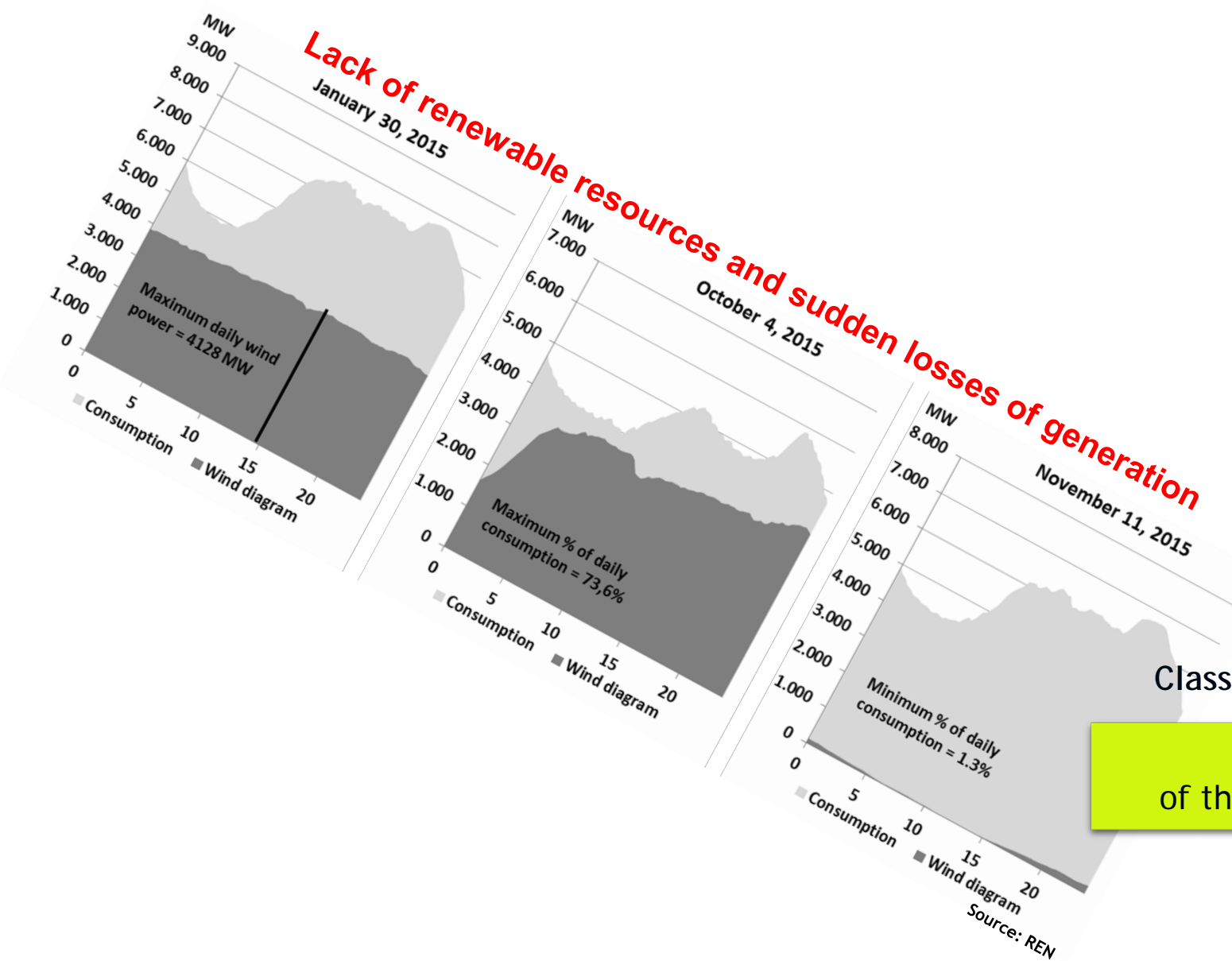
Wind generation decrease



High variation
1000 MW/h

Source: REN

SHORT-TERM → hydro (with reservoirs and pumping) is very flexible to cope with wind volatility



Classical probabilistic models have limitations

Don't allow the evaluation of the power system operational reserve needs

Innovative methodologies (Mora® Model)

Integration of high levels of intermittent generation

Security of supply impact on adequacy

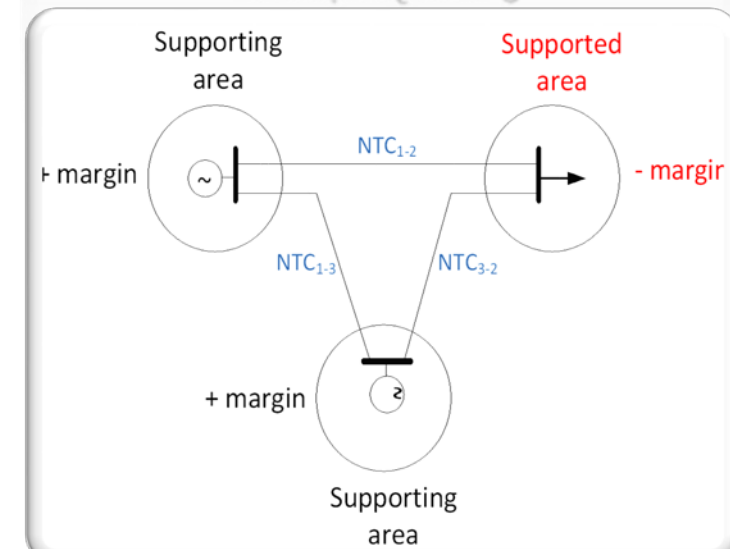
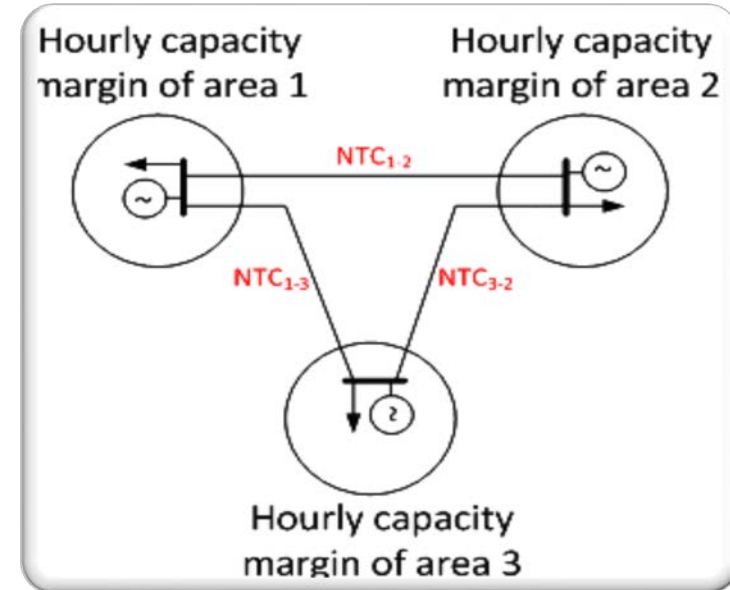
Operational reserve needs (security analysis)

Deal with uncertainties:

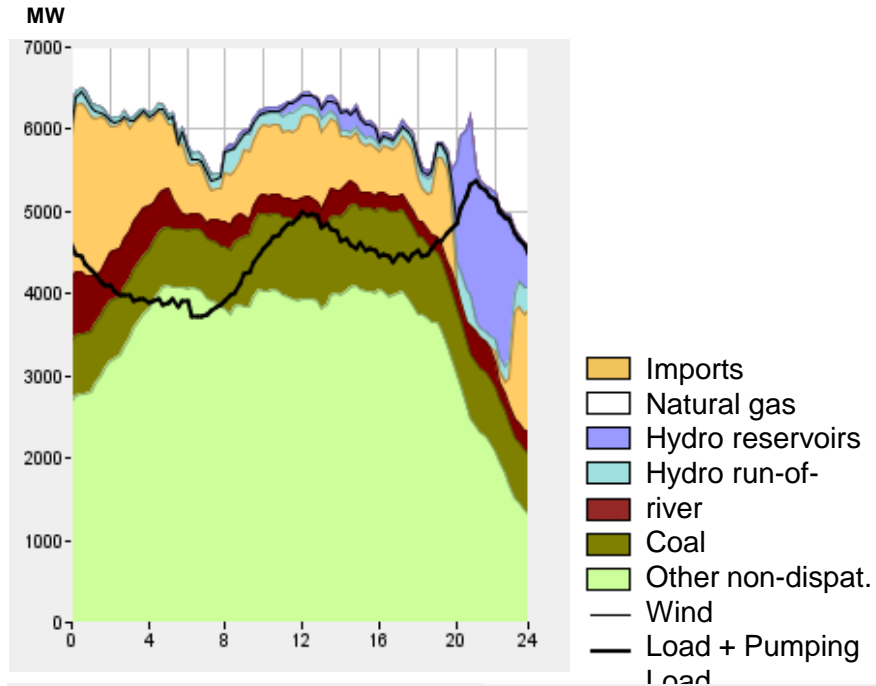
- Load
- Wind
- Hydrology
- Generators unavailability
- Internal grid and interconnection

Results:

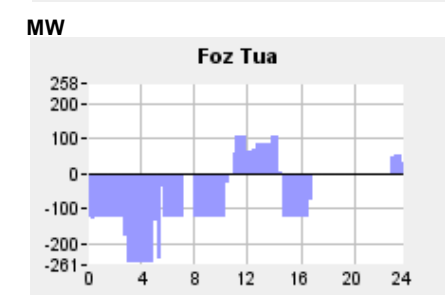
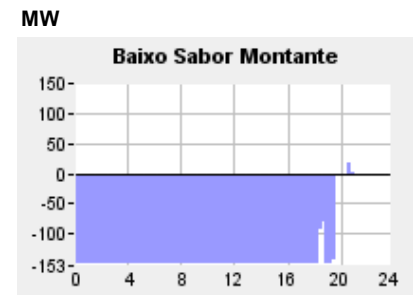
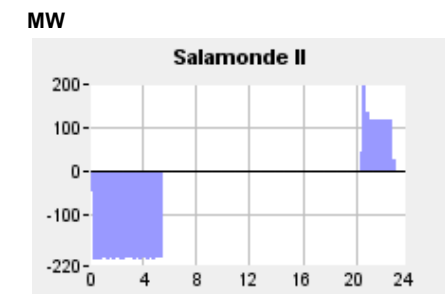
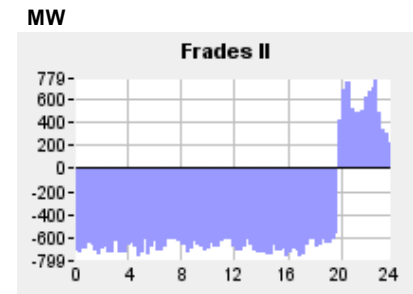
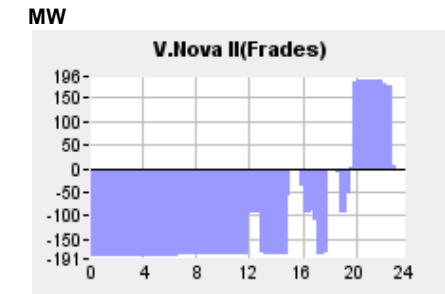
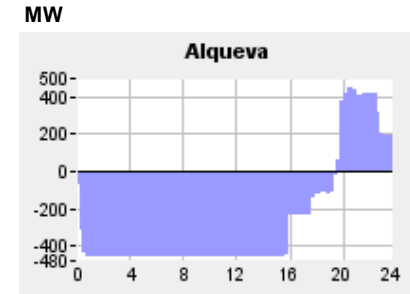
- Conventional probabilistic reliability indices, which represent the level of risk to the security of electricity supply
- Probability distributions of each indices
- Security of supply indices may include the effects of operating reserve (in)adequacy
- Renewable energy loss risk during base load periods



Load diagram 30th April 2017

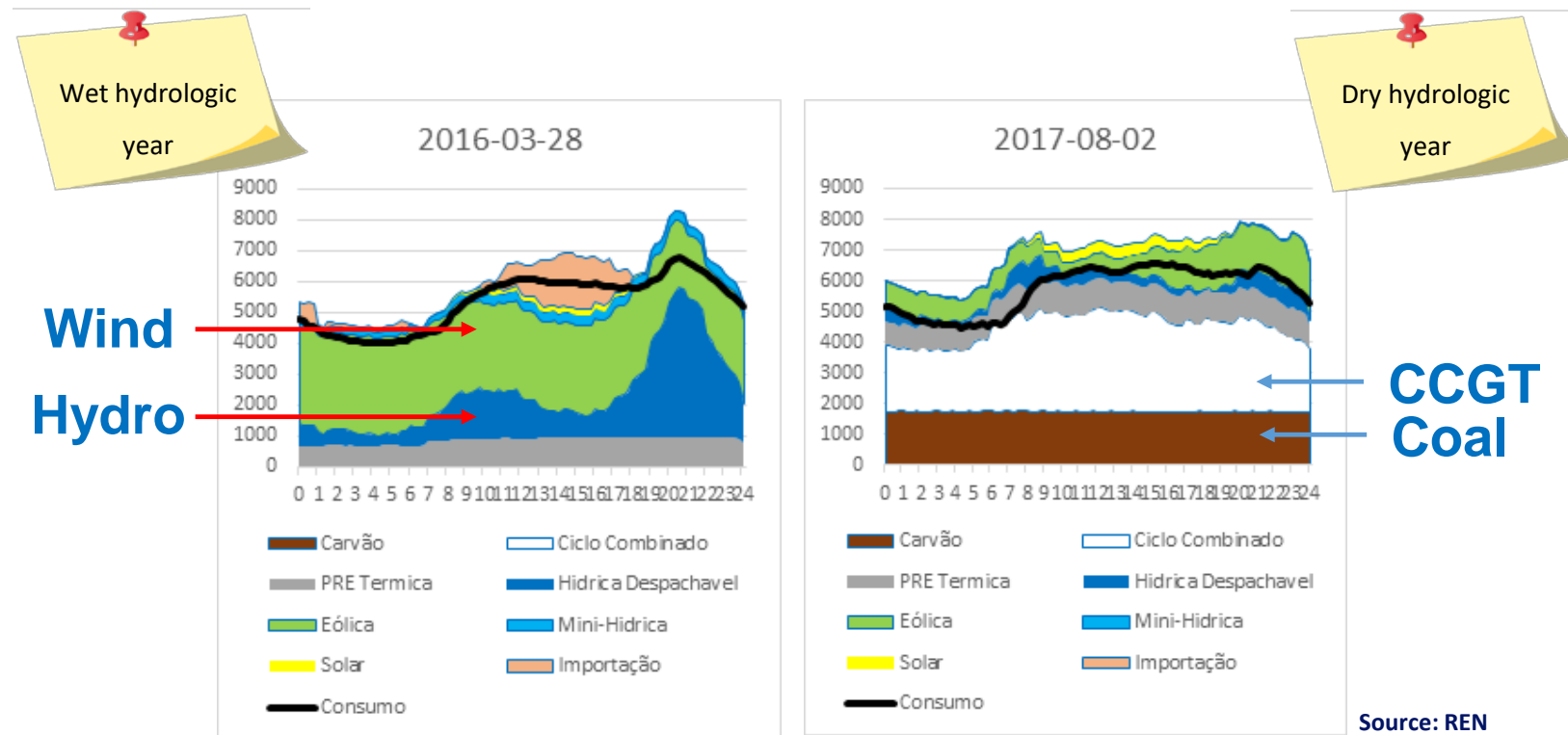


The role of Hydro Pumped-Storage



Source: REN

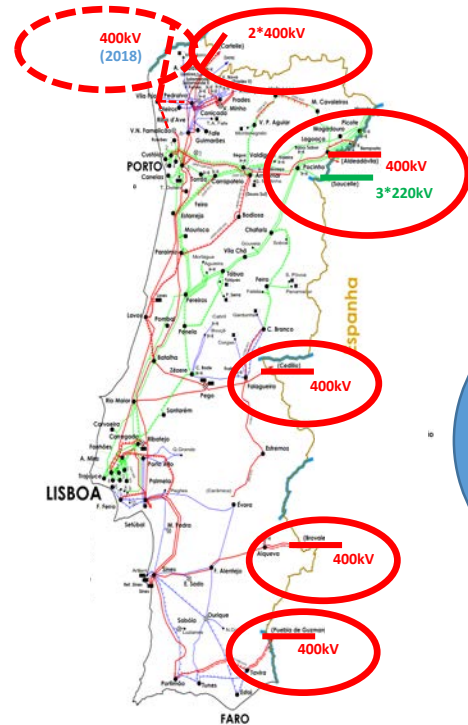
Currently renewables may supply more than 100% of Portuguese demand during some periods
Pumped-storage contribute to avoiding energy spillage



Utilization of CCGT and coal power plants as backup technologies depends on hydro production availability and market conditions

Portuguese Transmission Grid

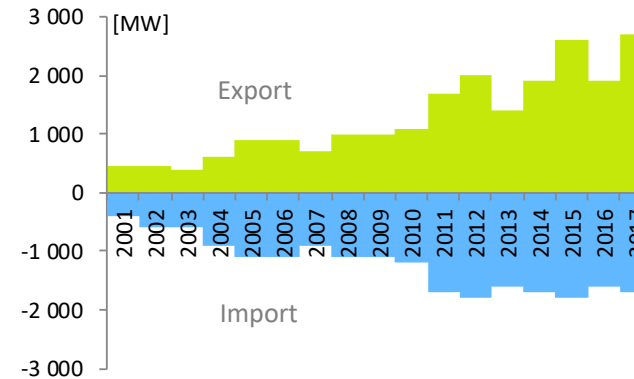
| INTERCONNECTIONS | |
|--|--|
| EXISTING | PLANNED (2021) |
| <ul style="list-style-type: none"> 6x 400 kV AC OHL 3x 220 kV AC OHL | <ul style="list-style-type: none"> 1x 400 kV AC OHL |



Creating value for the Market

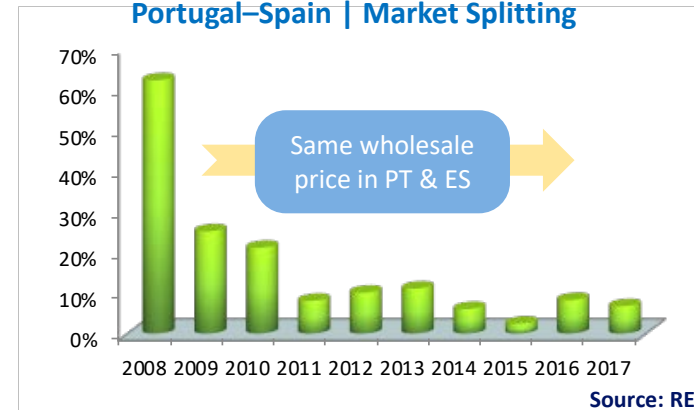
TARGET NTC (2021)
3 000 MW
 (>10% of Generation)

Portugal–Spain | Net Transfer Capacity¹

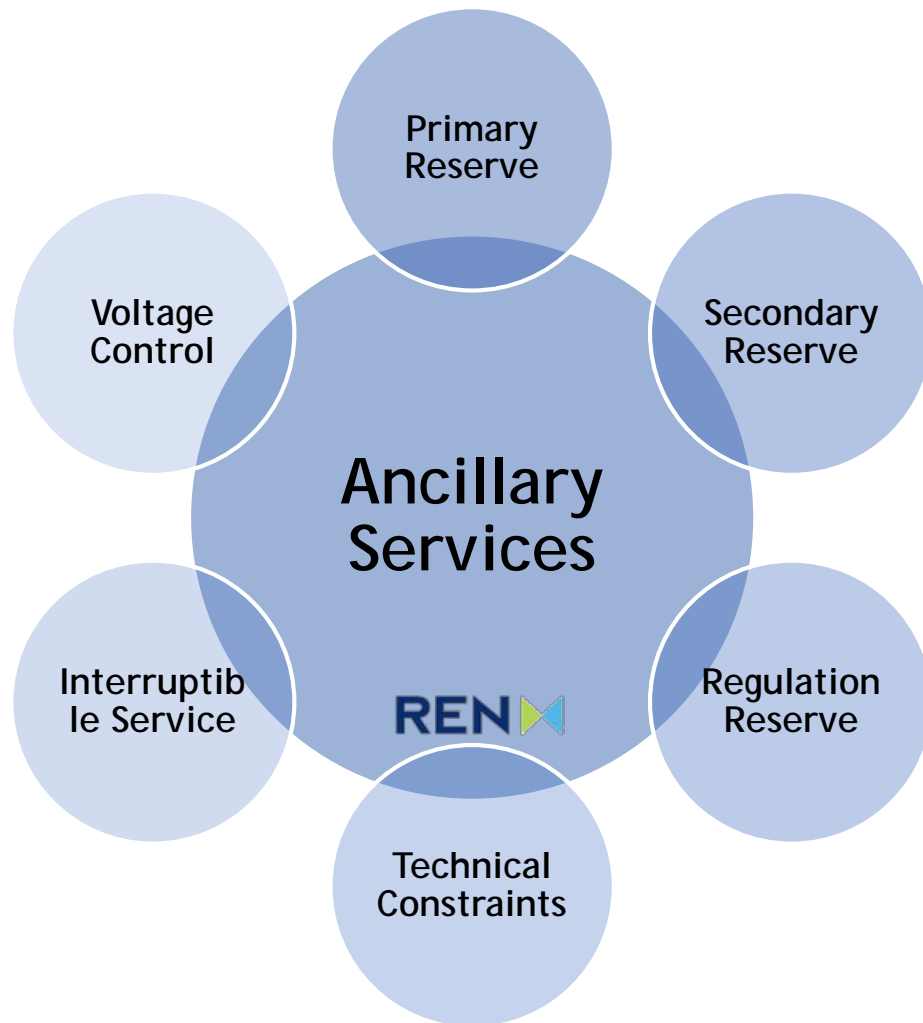


1. Minimum at more than 75 % of the time

Portugal–Spain | Market Splitting



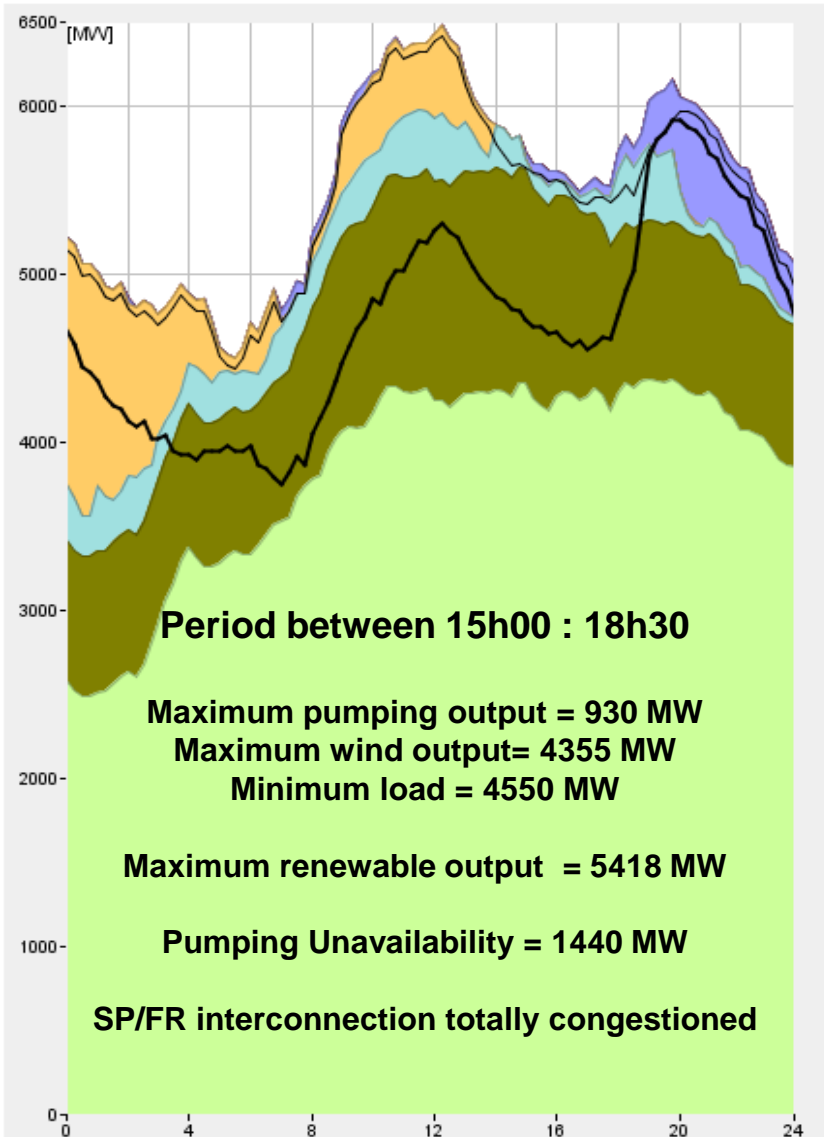
Interconnections increase Security of Supply and Market Integration and contribute to avoiding energy spillage (export energy to neighbor systems)



- ✓ Aims at keeping the balance between generation and demand at all times
- ✓ Managed by the System Operator
- ✓ Different types of operating reserves

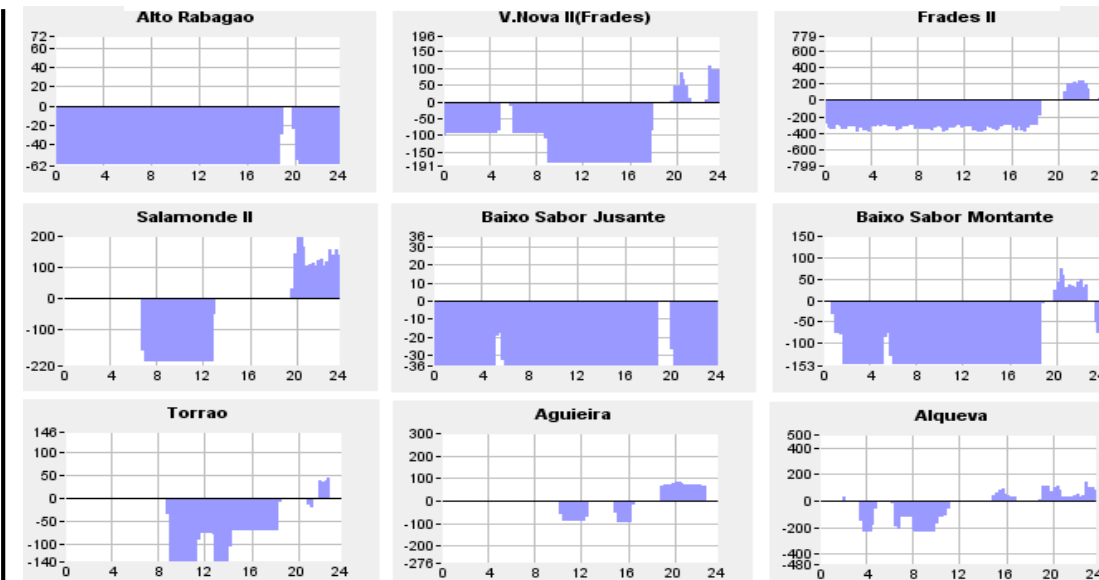
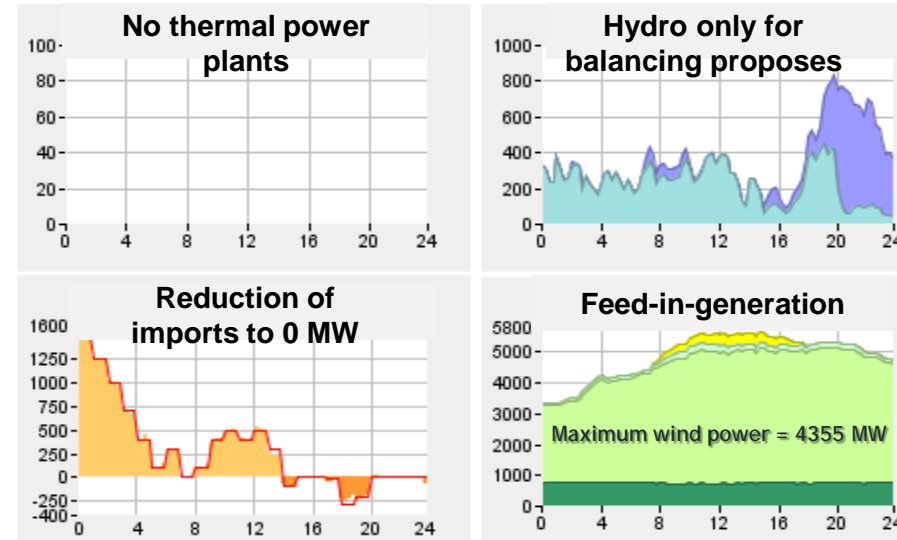
Intensity of use depends on good demand and production estimation

Approximately 90MW of wind curtailment accordingly DGE Order nº8810/2015



- Wind
- Import/Export balance
- Hydro Reservoirs
- Hydro Run of river
- Feed in tariff - Renewables
- Coal
- Consumption

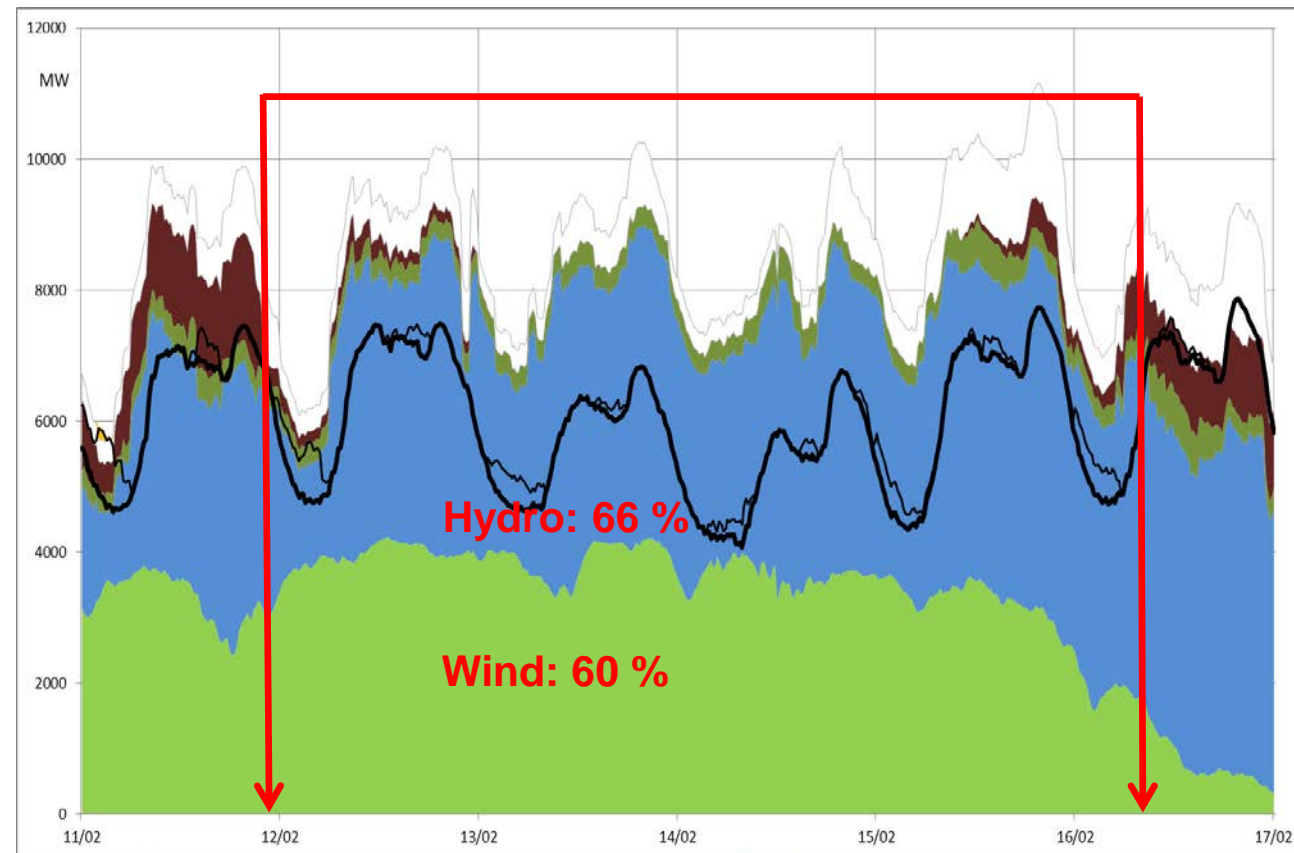
The role of Hydro Pumped-Storage



Source: REN

TSO needed to mobilise downwards reserve during this period. Strong and constant restrictions to mobilise downwards reserve were responsible for depleting system reserves (namely pumped hydro storage)

Renewables generation was sufficient to supply demand and enabled exports over 106 hours



Conclusions

Portuguese case study shows that the successful integration of renewable energy is supported in the following main achievements:

- ✓ **Effective energy policy design**
- ✓ **New long-term system security of supply methodologies**
 - **The role of pumped-hydro technologies to provide flexible reserve and energy storage**
 - **Adequate backup capacity (CCGTs) to face wind variability**
- ✓ **New planning processes and methodologies and improvement on transmission grid capacity (focus also on interconnections)**
- ✓ **Global TSOs cooperation in order to keep stability, reliability and power quality. Wind curtailment only occurred in one time**

In a near future, Sector Coupling (interaction between gas and electricity) will also allow good renewables integration. P2G technologies increase renewables seasonal storage

REN 

Thank you

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