

# Transmission and Distribution Grids Key Enablers for the Energy Transition

EEM25  
May 29, 2025

# RES targets

EEM25  
May 29, 2025

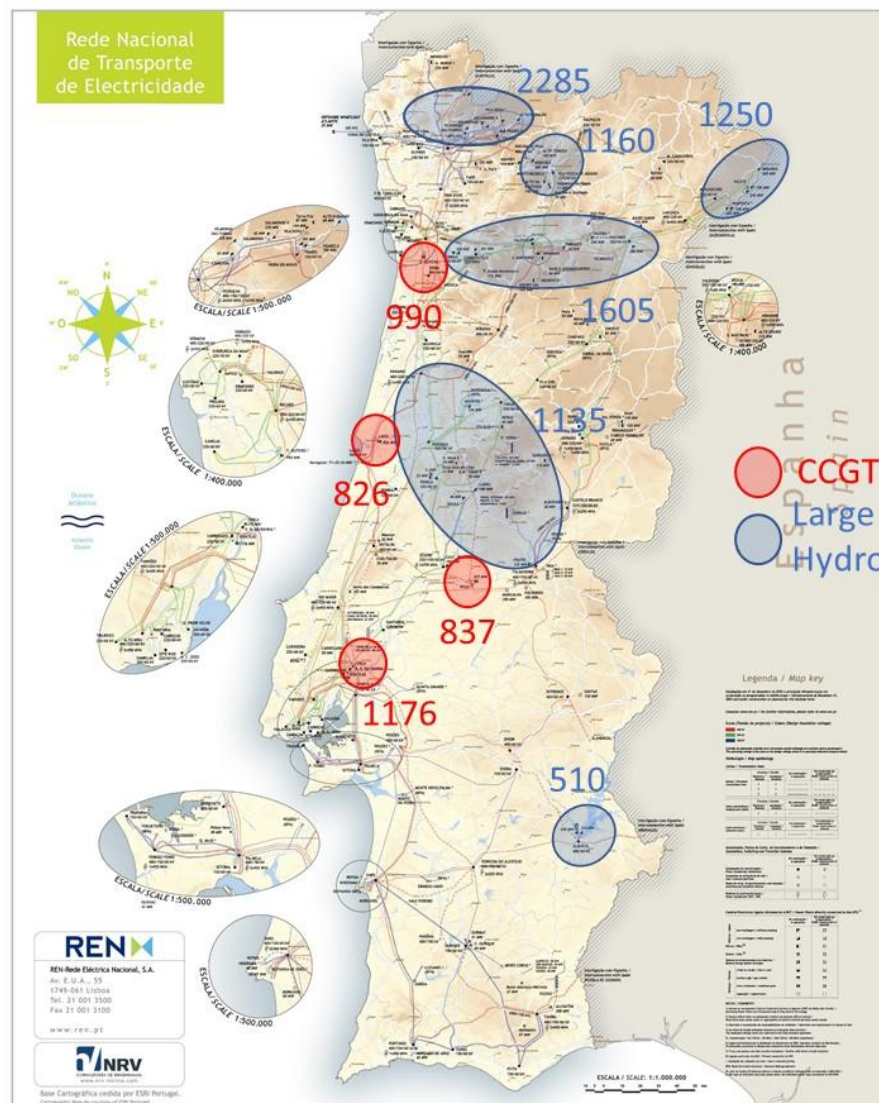


## Portugal: total installed generation capacity per technology

		% of peak load (*)
<b>Renewable</b>	<b>18 364 MW</b>	<b>189%</b>
▪ Hydro (Small hydro included)	8 376 MW	86%
▪ Wind	5 408 MW	56%
▪ Thermal (CHP included)	707 MW	7%
▪ Solar	3 872 MW	40%
<b>Non-renewable</b>	<b>4 448 MW</b>	<b>46%</b>
▪ Natural Gas (CCGT)	3 829 MW	39%
▪ CHP (Natural Gas)	605 MW	6%
▪ Other	28 MW	0%
▪ <b>Total</b>	<b>22 813 MW</b>	
▪ <b>Total installed pumped capacity</b>	<b>3 585 MW</b>	
▪ <b>Annual consumption in 2024</b>	<b>51,4 TWh</b>	

(\*) Peak load - January 2024:  
9 739 MW

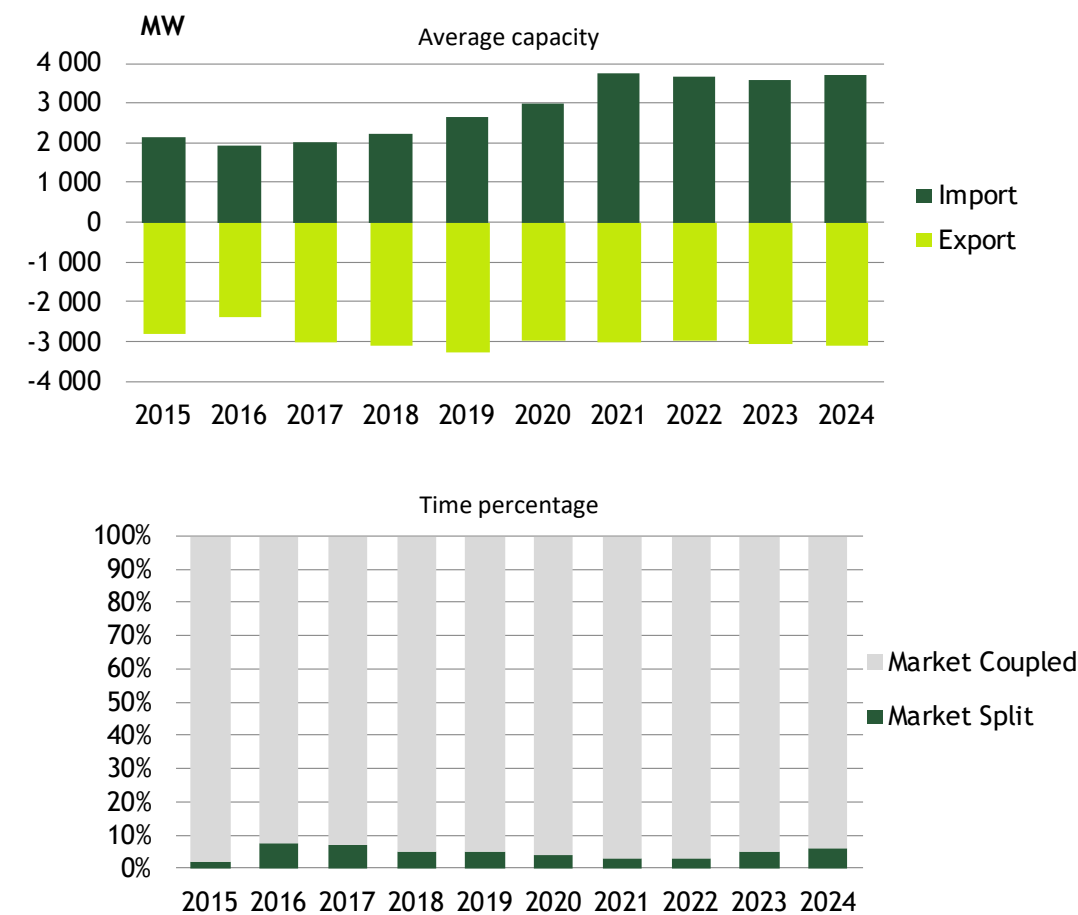
Maximum generation - January 2024:  
12 082 MW



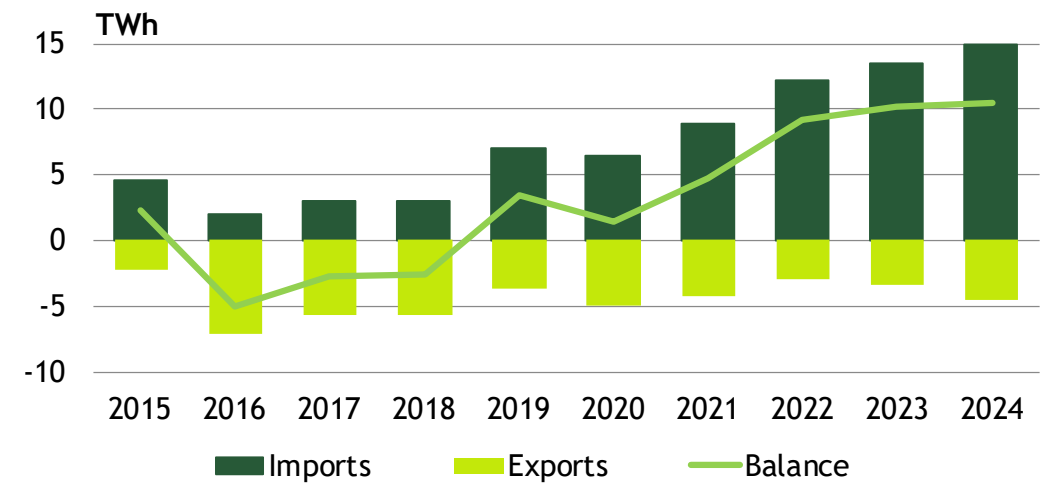
- **Dispatchable** 12 112 MW (53%)
  - **Hydro**
  - **Natural Gas (CCGT)**
- **Non-dispatchable** 10 701 MW (47%)
  - **Wind**
  - **Solar**
  - **Small hydro**
  - **CHP**
  - **Other**

## Portugal e a strongly interconecte system in Iberia

### 2015 - 2024 | Market and interconnection capacity



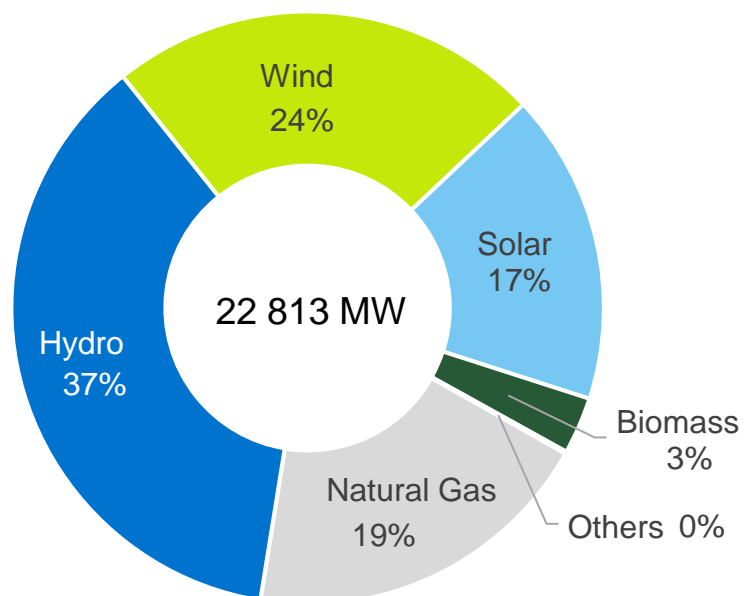
### 2015 - 2024 | Interconnections energy flows



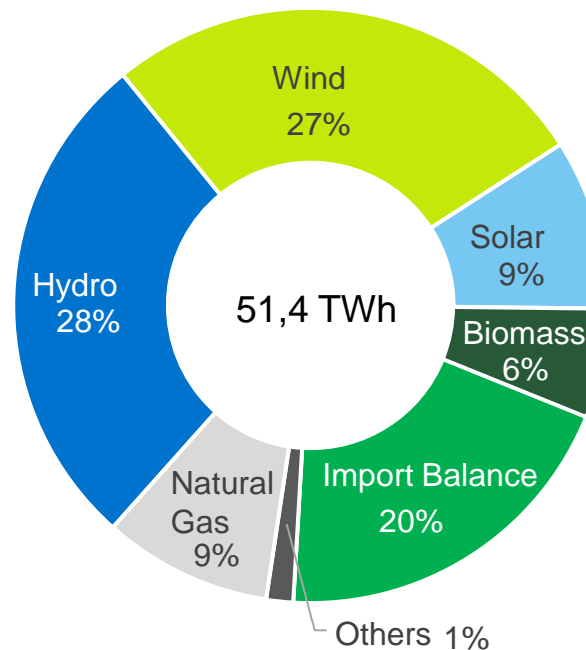
## Portugal: generation mix and total consumption in 2024

Integration of renewables and power system data

### Installed Capacity



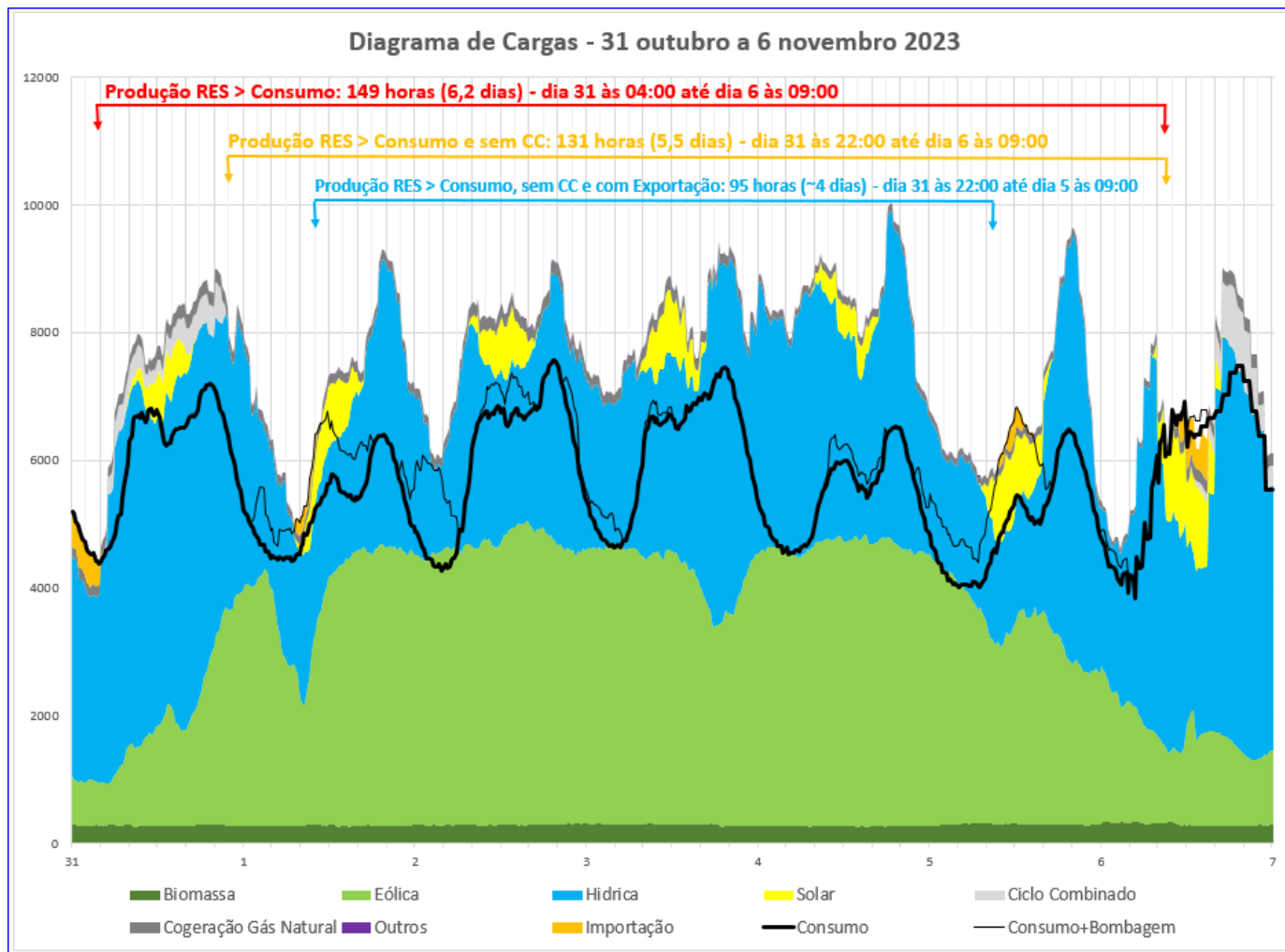
### Final Consumption



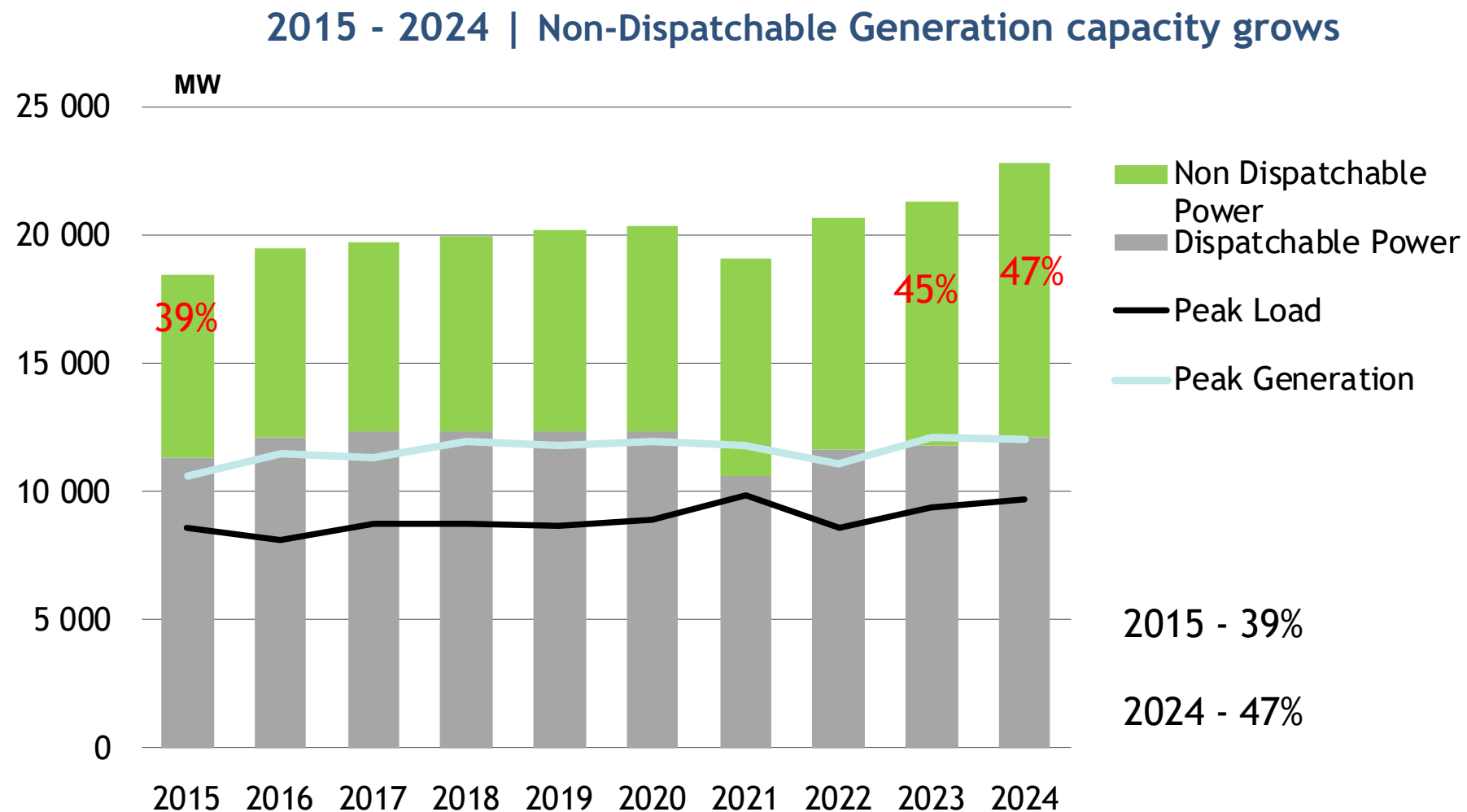
Source: REN

## Portugal: Multiple days (6,2) fully covered by renewables with a strong presence of wind and hydro

### Integration of renewables



## Integration of renewables and power system data – Non dispatchable growth



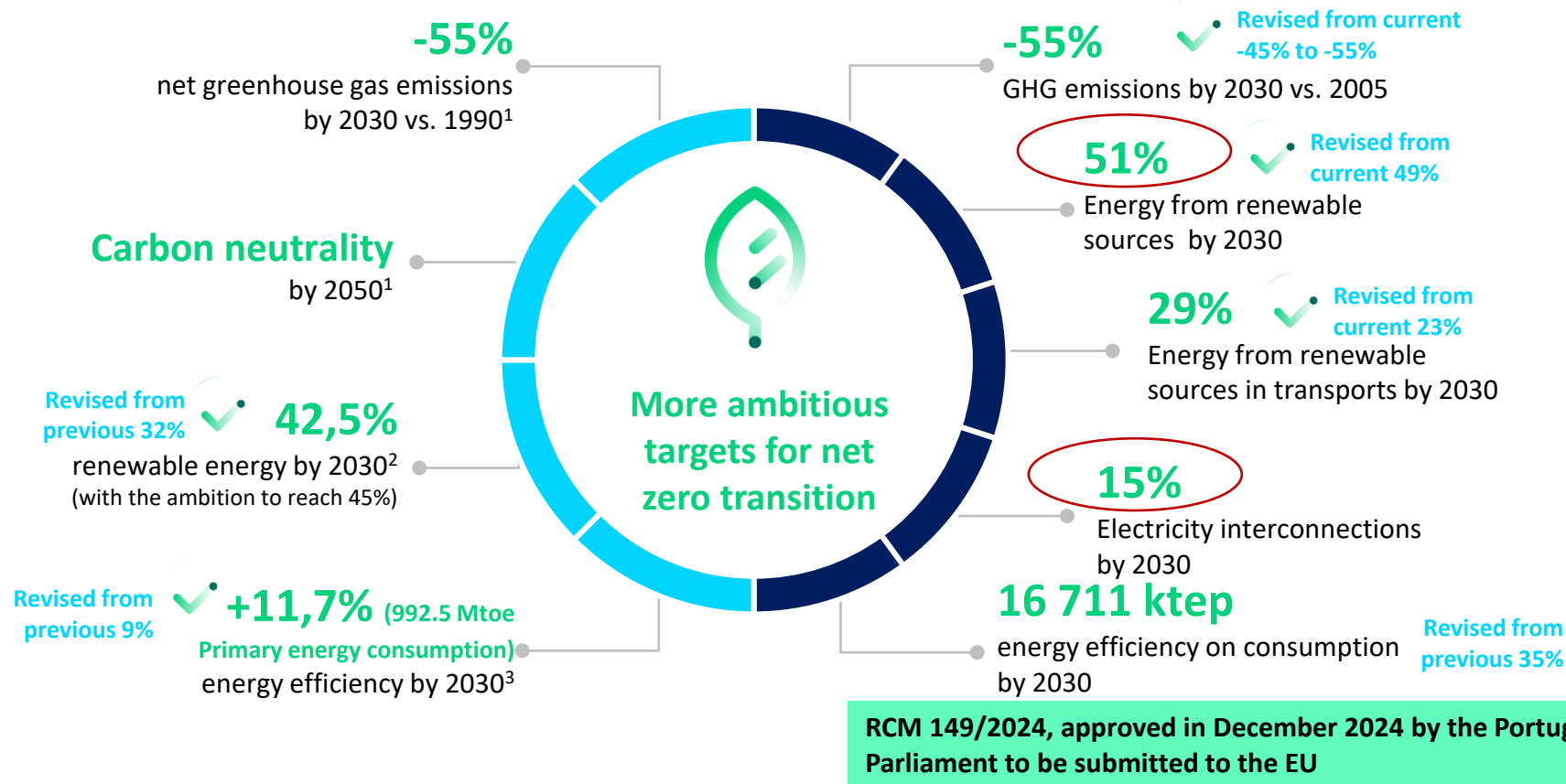
## European and National energy policies are setting more ambitious targets for decarbonization requiring for electricity 93% RES compared with present 70% in 2024 and average 60%



The EU is setting more ambitious targets towards a net zero transition



Portugal is adapting **PNEC 2030** to cope with new EU targets

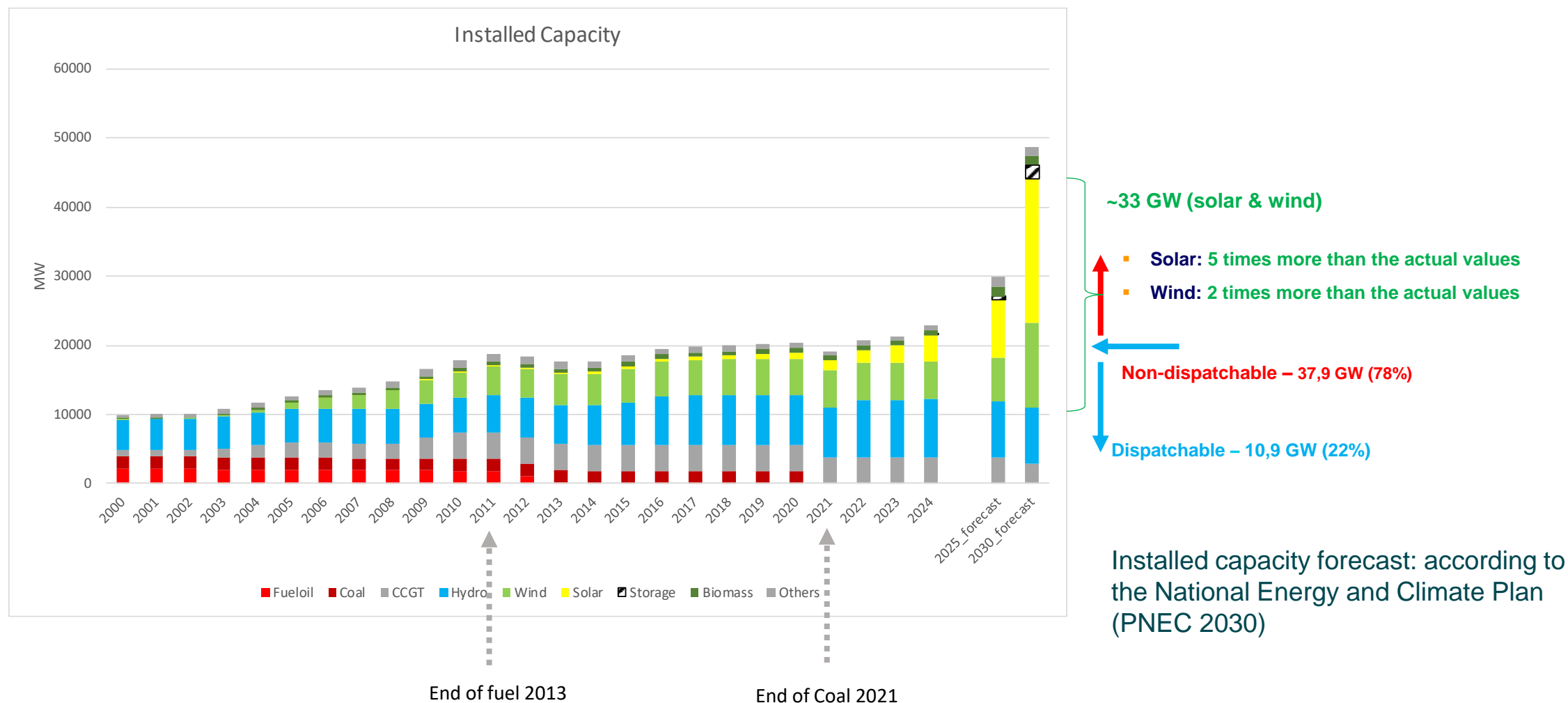


1. European Climate Law, 9 July 2021; 2. Revised Renewable Energy Directive, September 2023; 3. Revised Energy Efficiency Directive, September 2023



## Dispatchable & Non-dispatchable: evolution of the installed capacity and PNEC 2030 forecast

Integration of renewables and power system data







# Energy Sector challenges

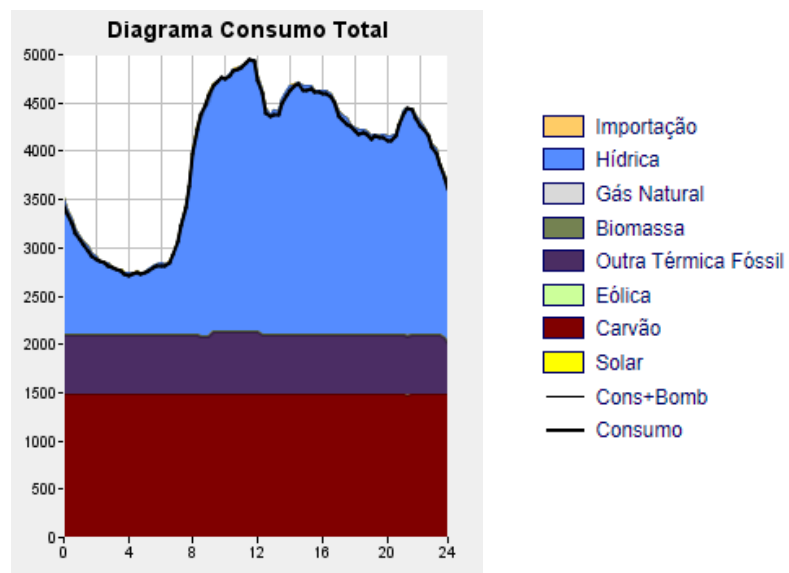
EEM25  
May 29, 2025



## Flexibility needs: the energy transition is setting a new paradigm in the energy mix and the energy market

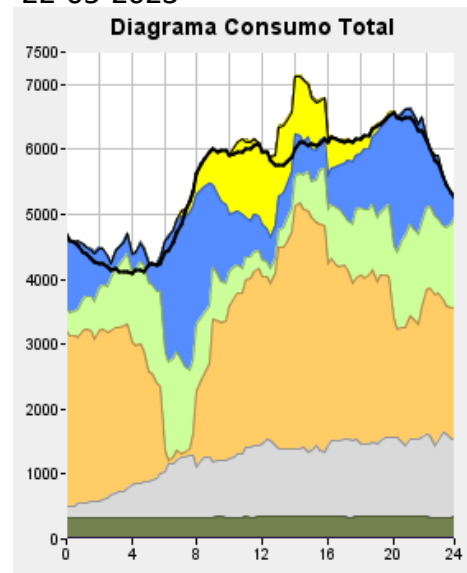
Energy Transition → Integration of variable and non-dispatchable renewable energy

day load diagram at the Expo 98 opening day

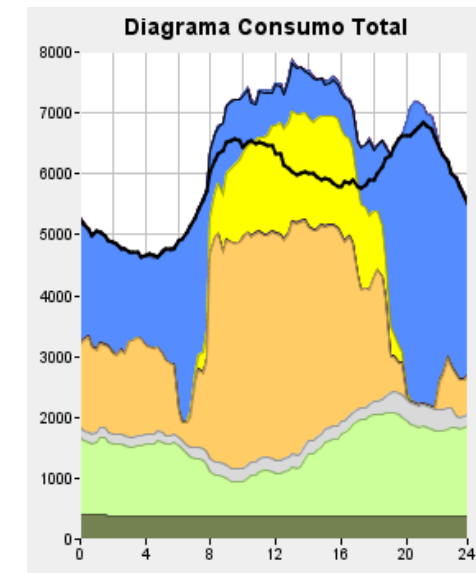


the same diagram 25 and 26 years later

22-05-2023



22-05-2024

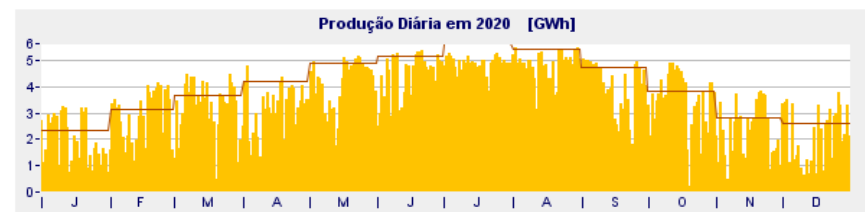
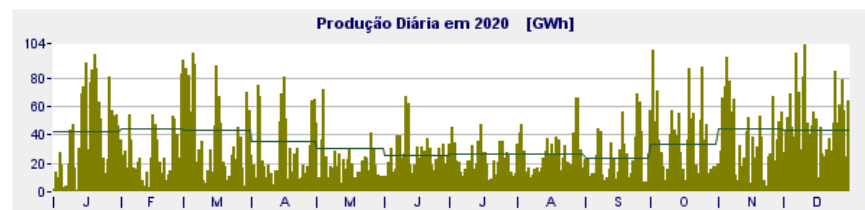
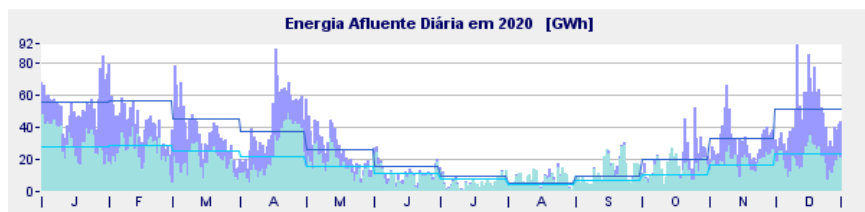


Source: REN

## Security of supply: storage need >> the role of hydro Pump storage, batteries and flexibility

Variability of renewable energy: impact in the security of supply

### Variability of renewable energy



Fonte: REN

#### Hydro

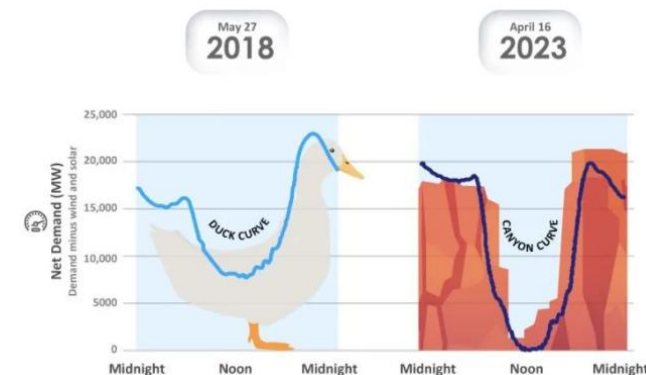
Albufeiras  
Fios de Água  
Reg. Med. F. Água  
Reg. Med. F. Água  
+ Alb.

#### Wind

Produção  
Regime médio

#### Solar

Produção  
Regime médio

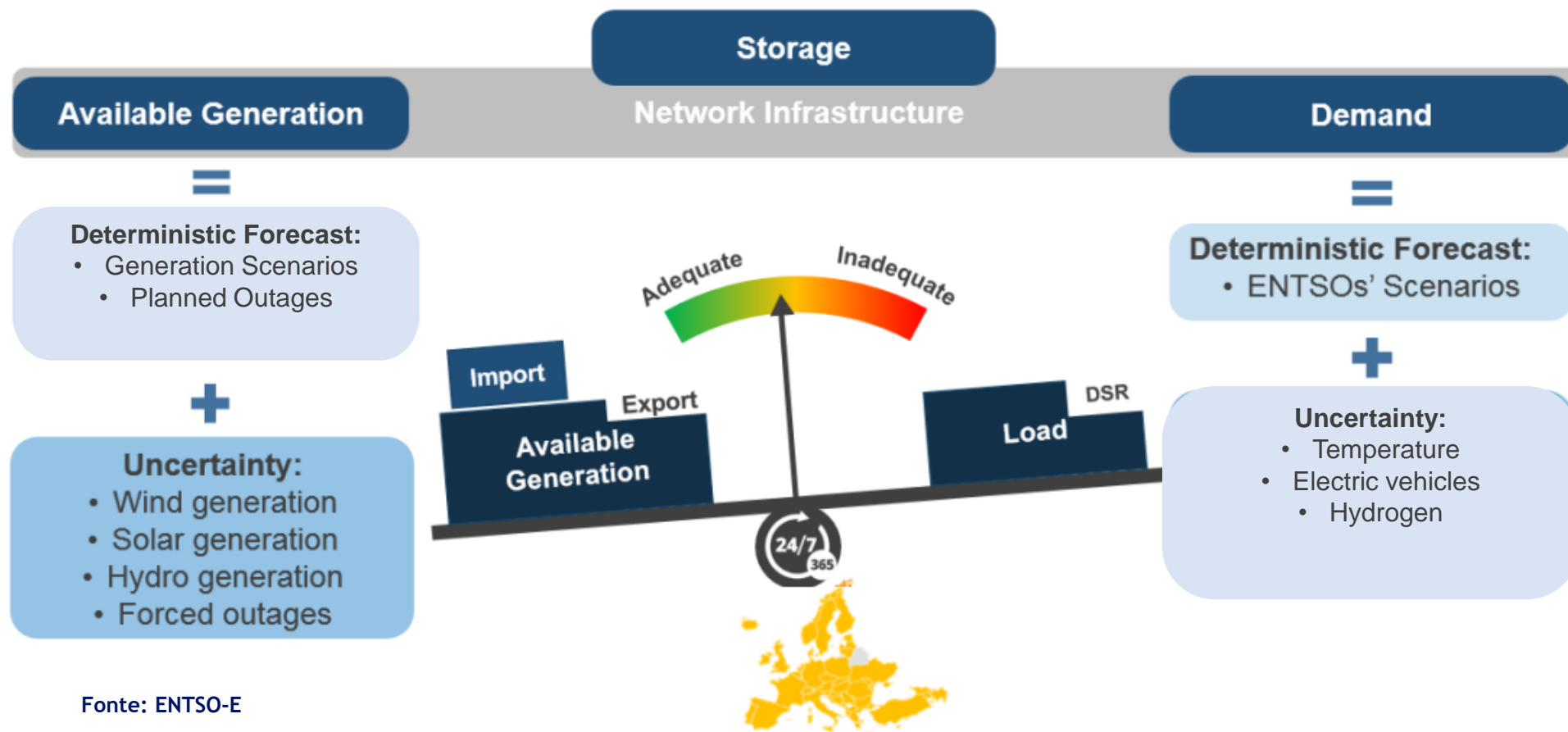


Fonte: <https://www.powermag.com/>

- Integration of growing variable and non-dispatchable renewable energy is paramount
- Decommission of dispatchable power plants
- New challenges as prosumers and electric mobility weight is growing



## Security of Supply: managing uncertainties



## Flexibility needs: new tools and strategies

### **Picasso & MARI – Project Pilots for active participation at aFRR/mFRR market (manual/automatic Frequency Restoration Reserve)**

- Extend mFRR/aFRR services to wind, solar, small hydro, industrial consumers and storage.
- Extend mFRR/aFRR services to small installations (<1MW), such as storage, PV, wind and domestic consumers

### **R&D Projects with universities**

- Study to solve network congestion using flexibility services (consumption, generation, storage) → IST
- Study of the potential operational reserves providing to SEN by Electric Vehicles (V2G) and other Consumers (DSR) → INESC TEC

### **Dynamic Line Rating SCADA optimization**

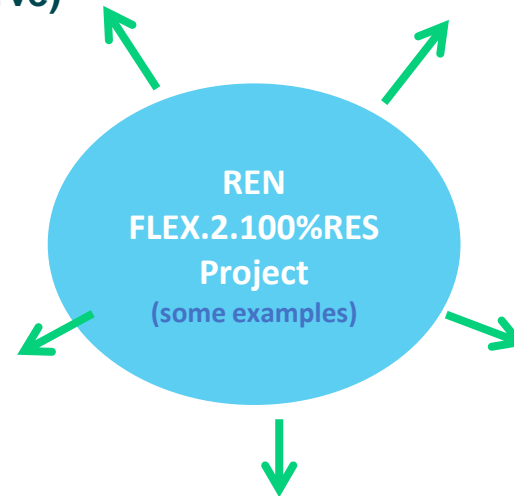
- Provide SEN with new tools appropriate to the new reality and operational challenges with high Renewable integration and DSR
- Provide more transmission capacity to enable more flexibility in grid operation and greater integration of Renewables

### **Pilot for Frequency Containment Reserve (FCR) services**

- Promote wind, solar, small hydro and storage in the participation of the primary regulation service (Frequency Containment Reserve - FCR)

### **Future Black Start**

- Evaluate the renewable generating power plants and storage systems potential to contribute for the restoration system in case of total or partial blackout situation. (focus on the 2030 horizon)



Competitiveness: new heavy loads looking for grid connections present a new paradigm

ZGP Sines	Distr.	Trans.
Grid connection capacity previously awarded	0,1	1,3
New grid capacity awarded (via Decree-Law n.º 80/2023)	0,1	4,9
Total Public Grid connection (~2/3 historic peak load) = 6,4 GVA		

CAPEX for the transmission grid reinforcements = 536 M€ (three steps: 2026, 2029 e 2031)

New 'Zonas de Grande Procura' (zones of high demand)

Resulting from innumerable requests for grid connections of new consumers facilities with high power loads, already exceeding what was awarded in Sines, one may expect further new ZGP in Portugal mainland, such as:

- Rio Maior – Pegões axis
- Pego/Abrantes – Castelo Branco axis, and also
- 2<sup>nd</sup> edition of Sines

New concentrated loads with hundreds of MW and high load factors (most notably for data centers and H2 production), directly connected to the transmission grid, present a new challenge to the grid and system management.

## Grid development challenges | Key figures

- New OHL circuits = **3700 km** + 440 km (440 km related to the Complementary Projects of the new 10y Plan)
- New substations = **18** + 9 (9 related to the Complementary Projects of the new 10y Plan)
- New power transformers = **5300 MVA** + 170 MVA (170 MVA related to the Complementary Projects of the new 10y Plan)
- Total RES connection capacity awarded but not yet connected (incl. ~7 GVA from 1<sup>st</sup> and 2<sup>nd</sup> Solar PV Agreements) = **13,5 GVA**
- Total RES connection capacity requested by the 3<sup>rd</sup> batch of Solar PV Agreements (to be awarded) = **~6,1 GVA**
- Total additional RES connection capacity = **~4,5 GVA**
  - Previously approved 10y Plan = 800 MVA
  - Reserved at Sines grid node = 800 MVA
  - Assigned to CCGT Tapada do Outeiro (foreseen to be decommissioned by 2029) = 1100 MVA
  - New 10y Plan (for approval) = 1850 MVA

Grid conditions for PNEC 2030 Solar PV targets can be achieved, whilst for onshore wind new capacity is proposed together with hybridization projects using currently and foreseen capacity for other technologies, namely solar and hydro.





# System management Challenges

EEM25  
May 29, 2025

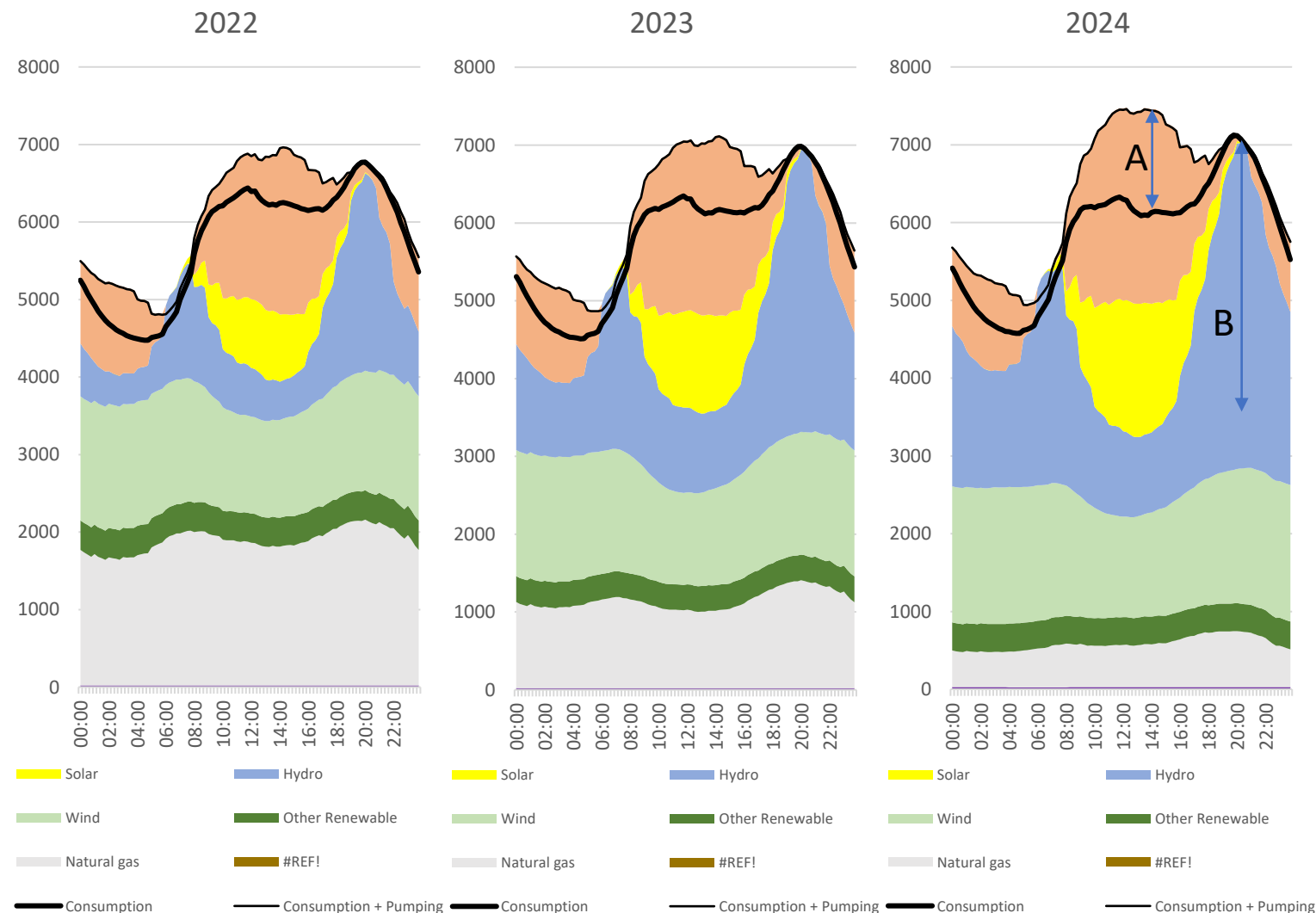
Hydro-pumping delivers an efficient storage market tool: “Charging” during solar peaks and late night surplus, while delivering early morning and evening peak relief.

## Portuguese Year Daily Average

- The night peak is the strongest
- Demand plateau during the daylight period
- Solar share growth is visible
- Pumping is stronger with daylight (solar)
- Hydro, solar and imports reduce gas use
- Stronger hydro role

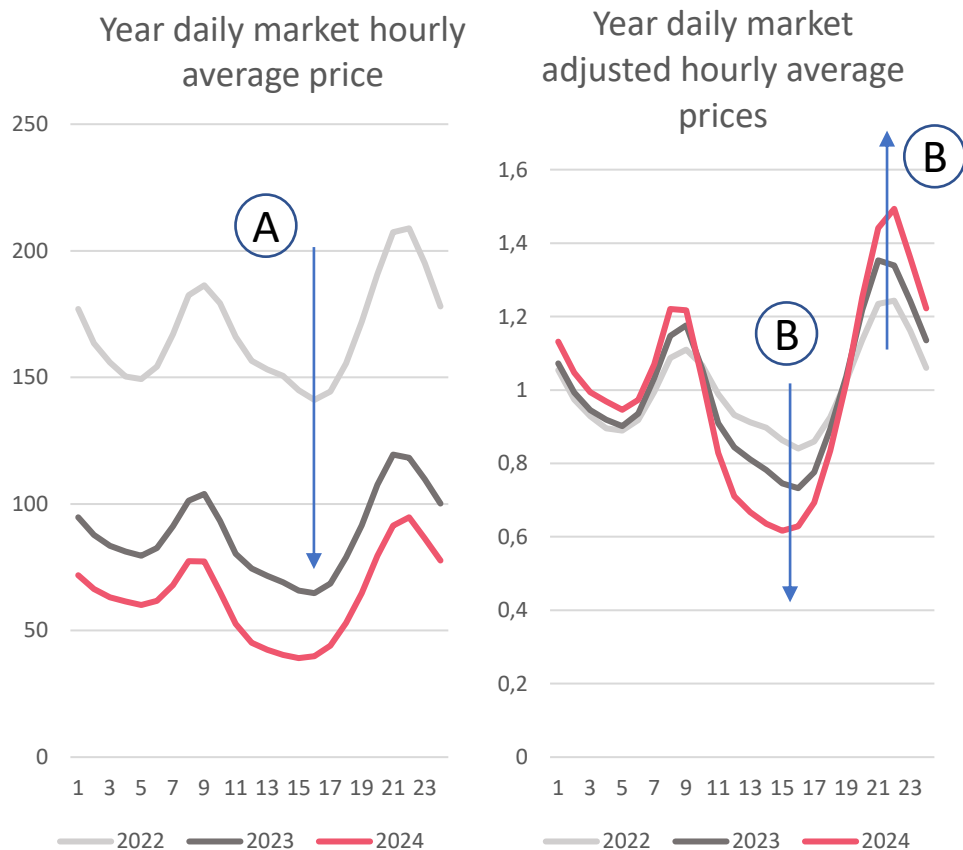
**Hydro Storage works as a market stabilizer:**  
 “Charges” at a moderate rate (A)  
 “Fast Delivers” and modulates stored capacity (B)

Hydro pumping total capacity 2024: 3,8 GW  
 Portuguese consumption Peak: 9,7 GW

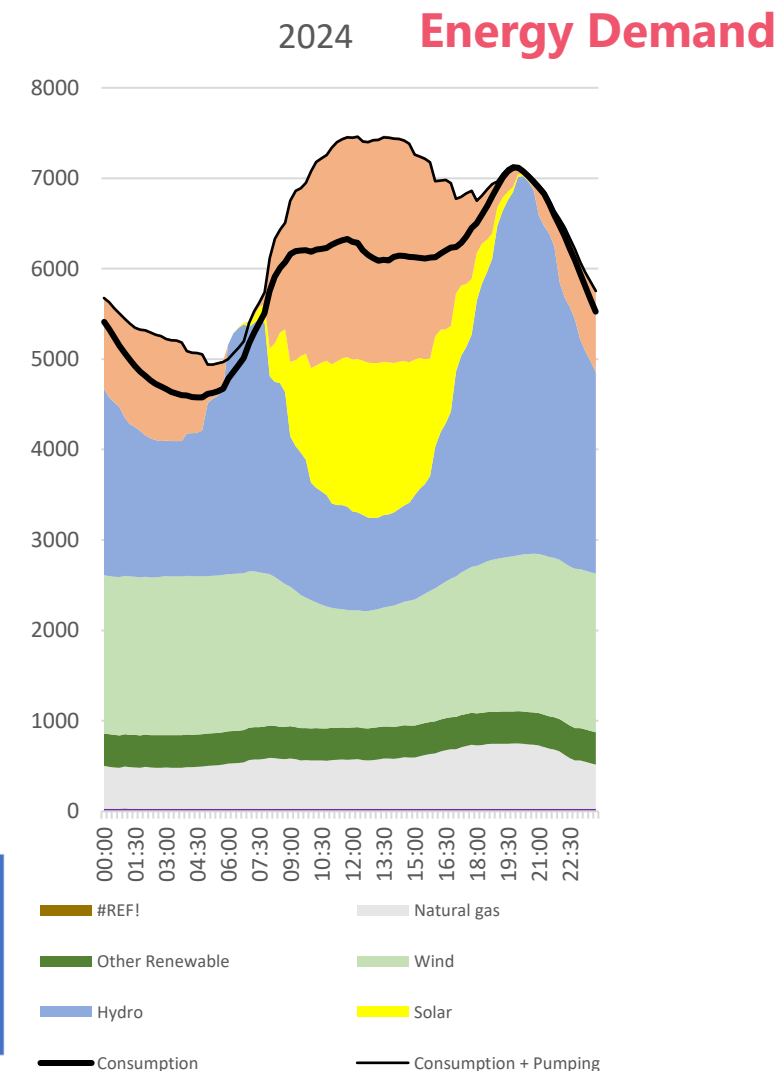
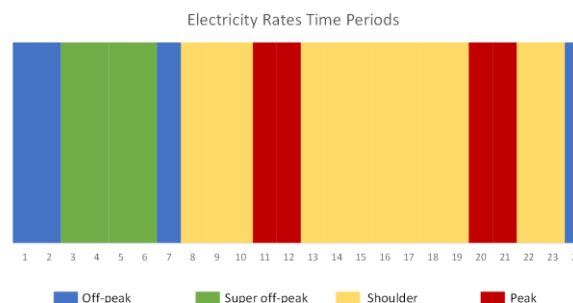


Tariff structures are not reflecting new market realities: A new regulatory dilemma – priority to network efficient cost/use or priority to market demand? An integrated action is urgent

## Market Prices



- A Daily and Intraday market Prices are decreasing
- B Price profiles are coincidental however max-min range is widening Y/Y
- C Low market prices during peak hours require particular tariff incentives. Regulated tariffs incentivize night consumption





## TSO challenges for a sustainable transition – The Portuguese case - Challenges of Dispatching Center System Operation

### Grid integration of high level of renewables – Critical factors

#### Grid connection procedure

- Transparent rules and clear requirements
- Compliance verification *ex ante*

#### Transmission grid development and modernization

- Grid spatial development accounting the renewable potential
- Increasing interconnection capacity for NTC improvement

#### System operation & management

- Advanced tools for RES forecast and network simulation
- Flexible energy mix (e.g. hydro with pumping and reservoirs)
- Enough Back-up CCGT power stations

#### Transmission grid maintenance

- Ensure adequate reliability levels
- Adopt best practices (towards condition based strategies)

#### Regulations and Grid Codes technical support

- Provide legislator technical support (e.g. RfG EU Code)
- National Transmission Grid Code (RTFC)





## TSO challenges for a sustainable transition – The Portuguese case - Challenges of Dispatching Center System Operation

### Our main (near future) challenges

---

1. The rapid growth of solar generation and the decommissioning of some “old” thermal power stations – **risks of adequacy** and **risk of lack of inertia and voltage control capability**;
2. The Consumption (Demand Side Management) and the Dispersed Generation (connected in the distribution grids) participation in the balancing and congestion management markets;
3. Cross border reserves exchange according to the European Balancing Market code;
4. The impact of new grid size storage with Batteries;

**and ... maintain the reliability of the European interconnected system in terms adequacy and security of supply.**



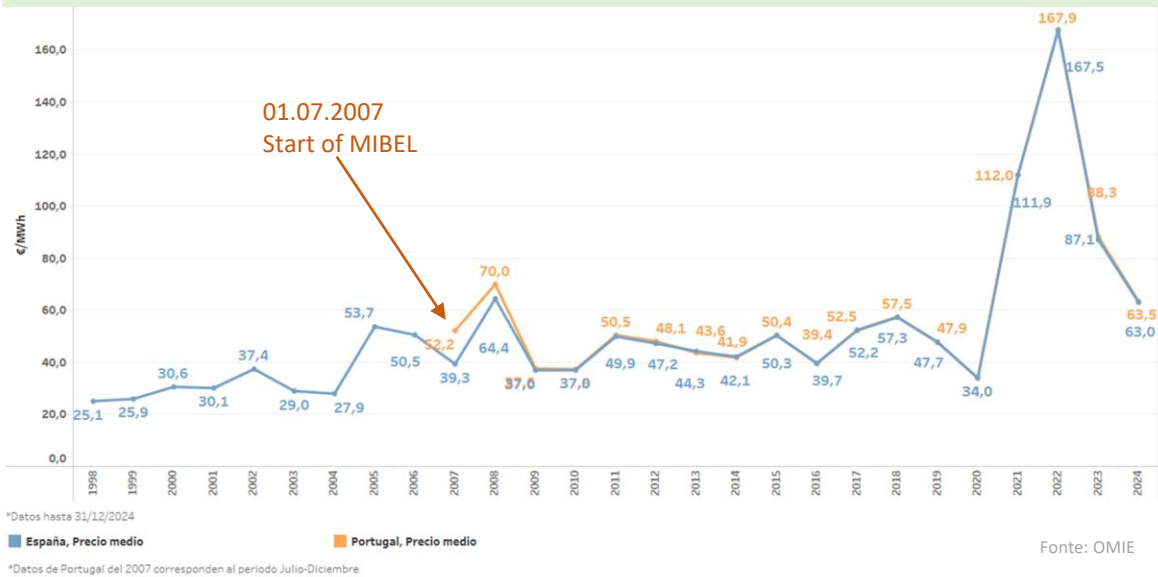
Market

EEM25  
May 29, 2025

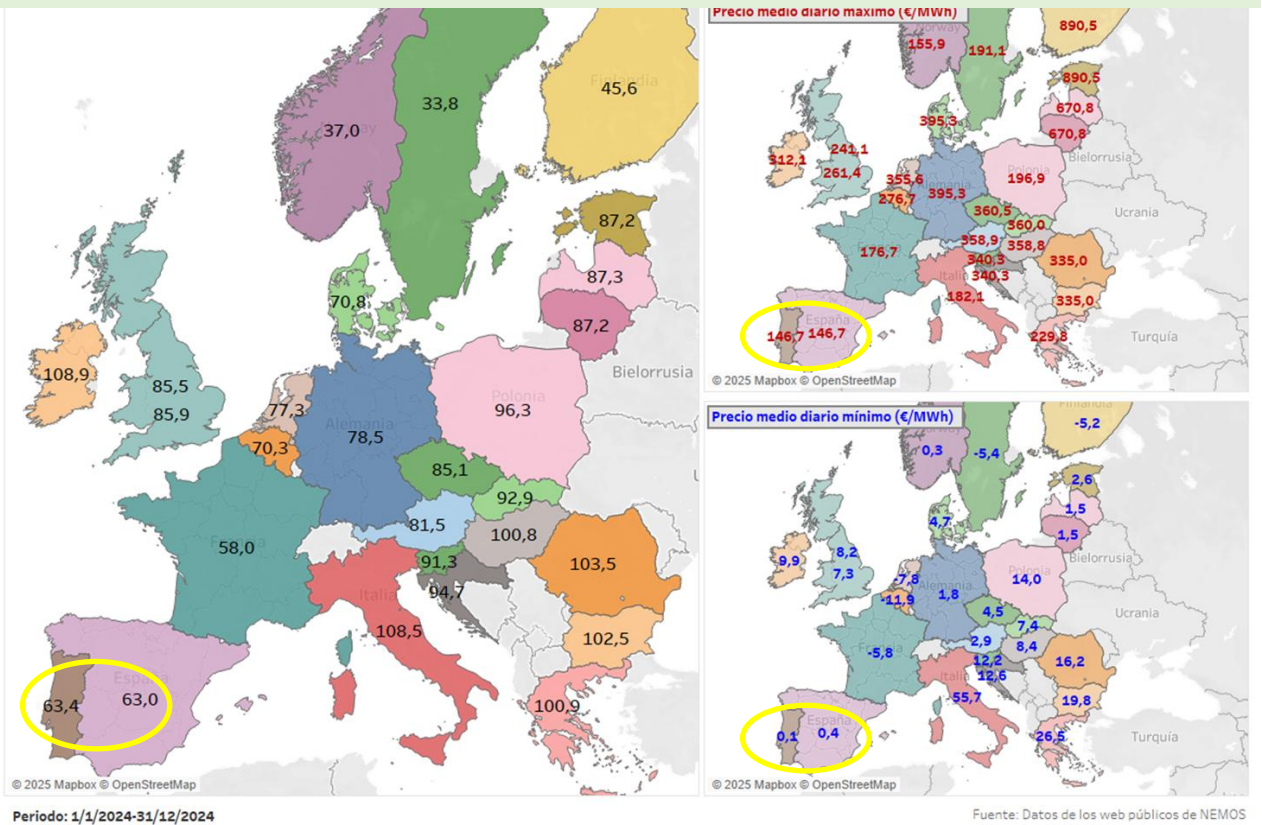


# OMIE Energy price evolution: convergence between Portugal and Spain

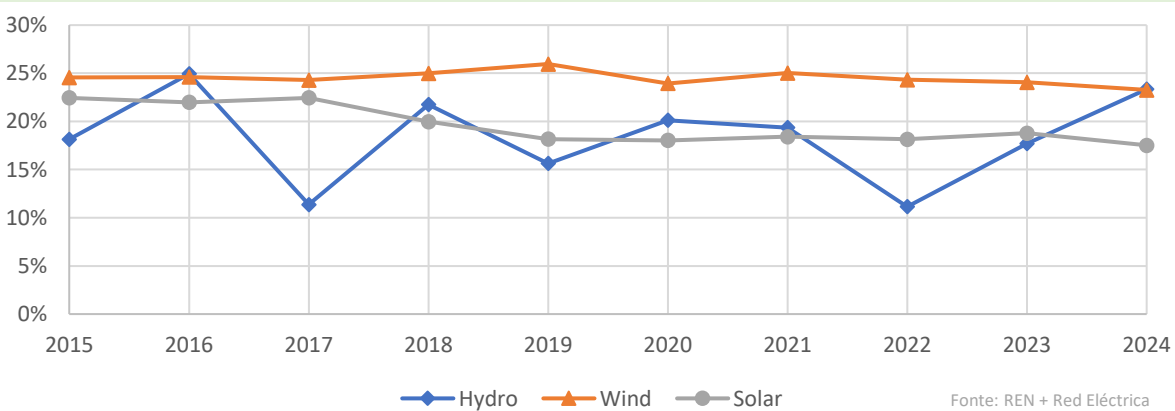
Annual average prices on the day-ahead market in Spain and Portugal (1998 to 2024)



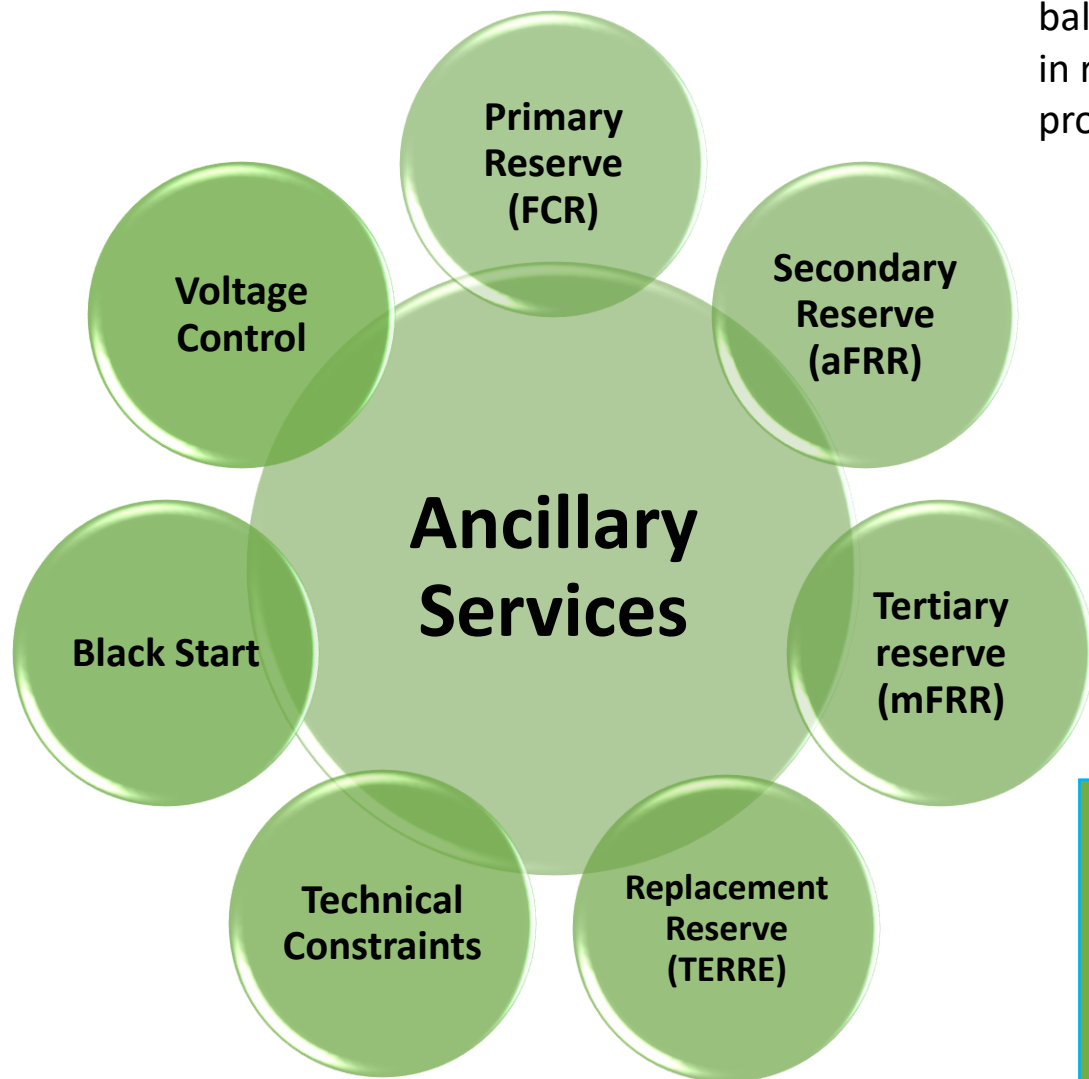
European average prices on the day-ahead market in 2024, per bidding zone (€/MWh)



Utilization of the Installed Capacity: Portugal + Spain (%)



## Balancing Market



Ancillary Services are intended to trade the energy needed for the permanent balance of production and consumption (balance between Supply and Demand in real time). These are carried out between the SEN Global Manager (GGS) and producers and/or consumers.

- The wholesale energy market will have lower prices year by year, so producers will capture less benefits (especially solar).
- In other hand, ancillary services will increase year by year the volumes needs (MWh) and the prices (compared with the wholesale market)



- So, the Renewable power plants (solar and wind) will increasingly obtain revenues by selling flexibility services in the Ancillary Services Markets to SEN, by market platforms managed by the GGS, and lower revenues from wholesale energy market.
- Ancillary Services represented in 2023 about 500 M€, 13% of wholesale market.
- In 2024, the Ancillary Services represented 25% of the wholesale market.



## Main conclusions

- The rapid growth of solar generation and the decommissioning of some “old” thermal power stations – increases risks of adequacy, lack of inertia and voltage control capabilities;
- New models for network planning and RES production capacity integration are required
- New challenges for network and system management
- Security of Supply is more relevant with massive RES integration in the grid in the next years, mainly solar
- Facilitate and promote the connection of new renewable generation and new large demand clients to the transmission grid
- Storage will be relevant to the balance between RES generation and Demand (short and medium term)
- Electric Mobility must be further analyzed in order to considered its role in the grid
- H2 and Renewable Gases will launch new challenges in gas infrastructures, and also in electricity infrastructures
- Maintain the reliability of the European interconnected system in terms adequacy and security of supply.

# Thank You



REN

EEM25  
May 29, 2025