TradeRES

New Markets Design & Models for
100% Renewable Power Systems

Reform the short-term markets and ancillary services

Based on the outcomes Case study D: Iberian (Portugal & Spain) electricity market

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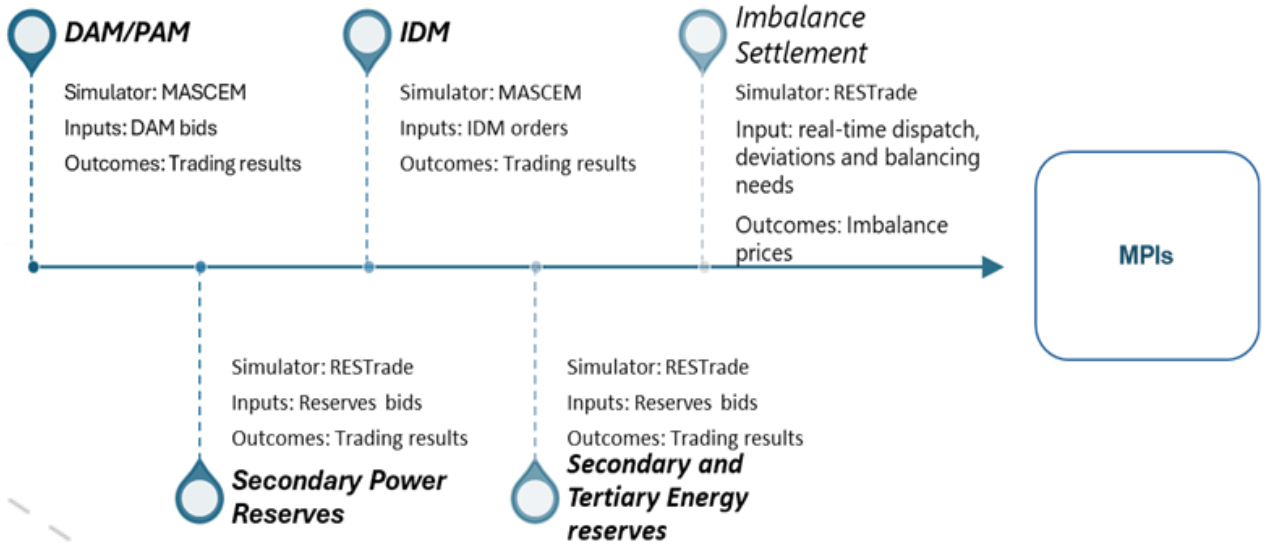
The MIBEL Case Study: A short-term market design for vRES

Research question:

How to make short-term markets more efficient to better integrate vRES fluctuations?

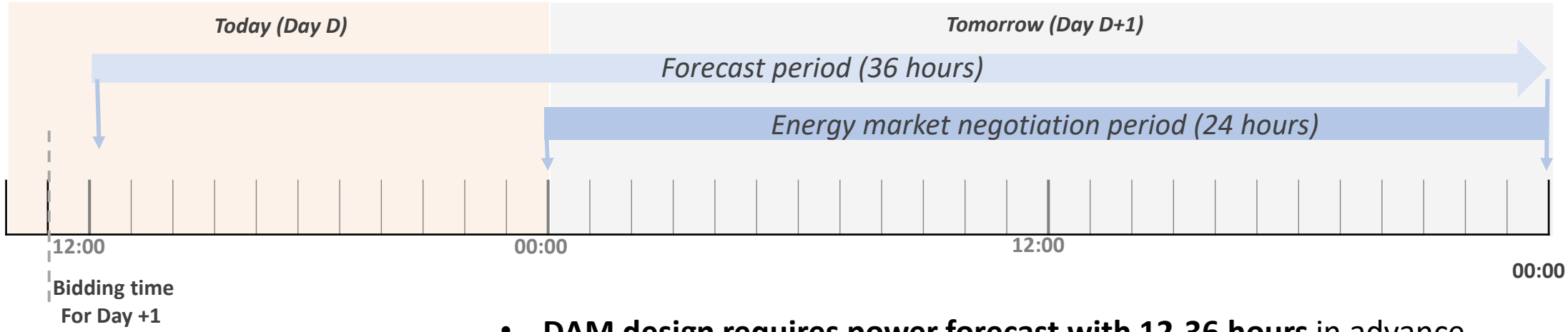


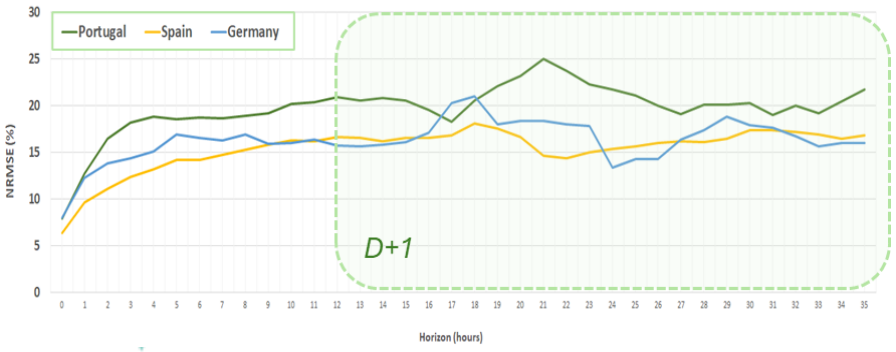
PAM: Period-ahead market

- **Day-ahead market (DAM)** - aims to achieve electrical energy transactions for the 24 hours of next day (D+1).
- **Intraday continuous market (IDM)**- aka single intraday coupling (**SIDC**) - enables continuous trading to refine positions and manage imbalances closer to real-time.
- **Balancing markets** – Secondary (SR) and Tertiary (TR) Reserves - agents to fix imbalances. Adjustment up to one hour before the delivery in tertiary reserves.

Market design components: DAM

Current situation:





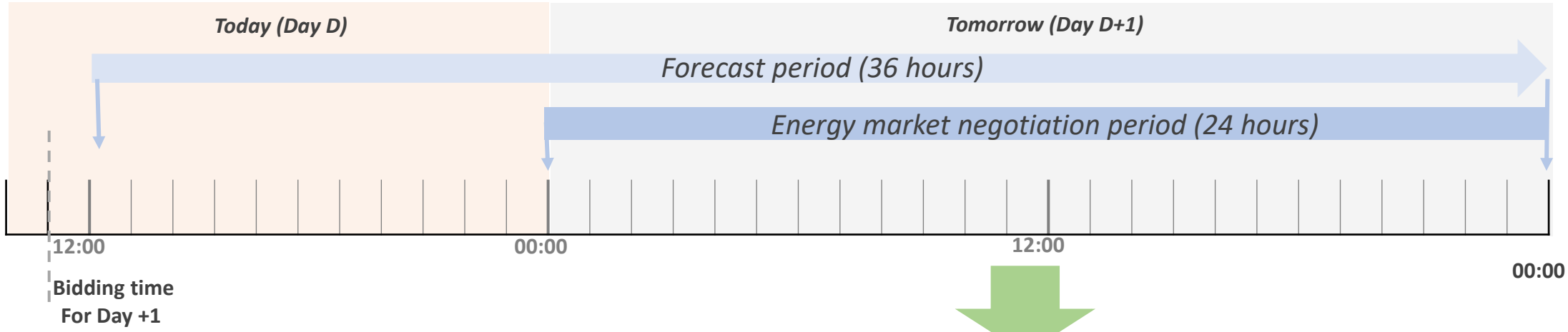
Wind power forecast errors for different time horizon

- **DAM design requires power forecast with 12-36 hours** in advance.
- The **forecasts' error for vRES and demand** increases significantly **with larger time horizons** resulting in substantial **imbalances in DAM**.

Challenge in DAM: time gap between bidding and first delivery jeopardizes the profitability of vRES.

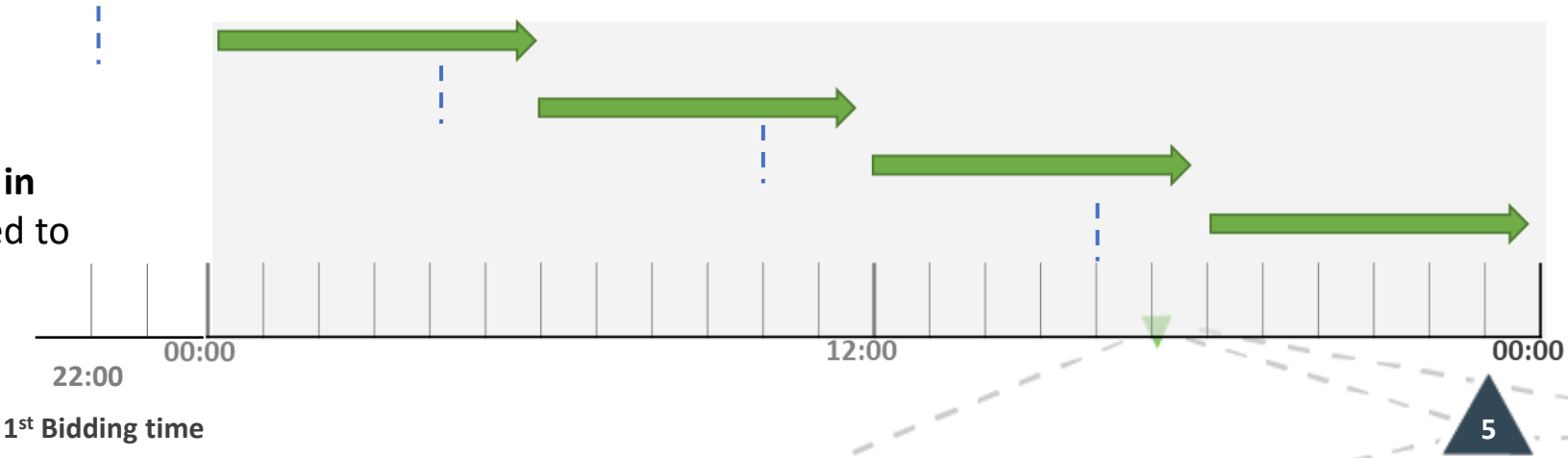
New market design: from DAM to PAM – Period Ahead Market

Shorter leading times - gate closures closer to real-time operation



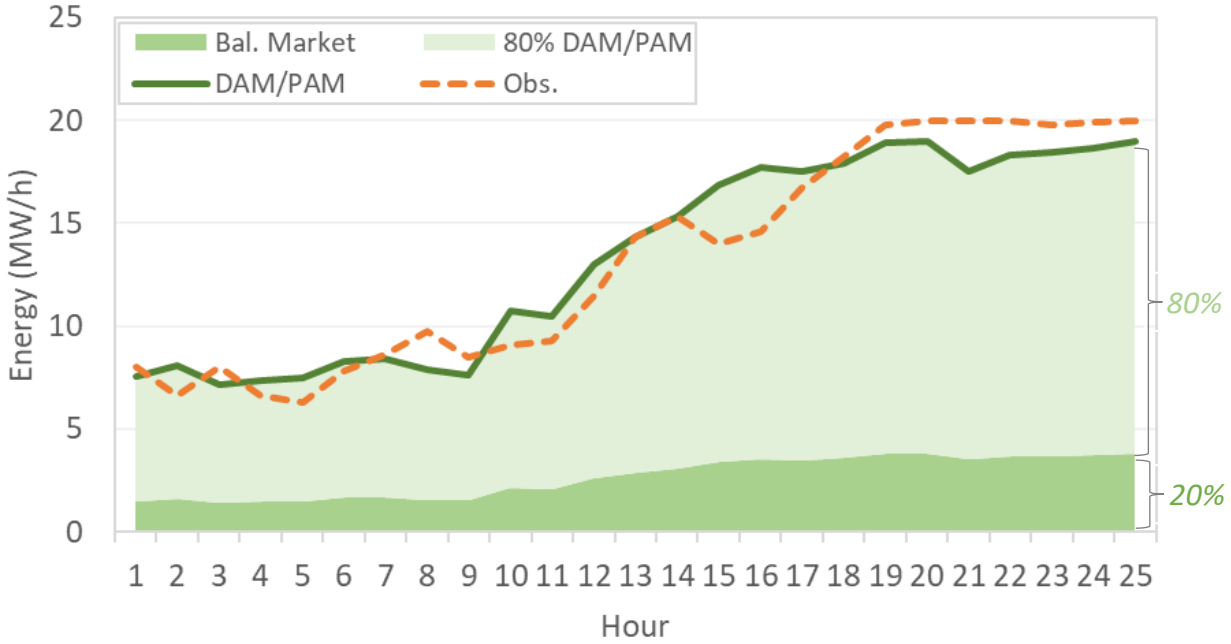
Period-ahead market, e.g.,:

- *6 hours-ahead x 4 times*
  - **Forecast errors** for wind and solar PV **in PAM are reduced up to 20%** compared to DAM.



vRES in short-term markets: passive vs active participation

- In future RES-dominated systems, an **active and dynamic participation of vRES players** across different electricity markets, **including balancing markets**, will be crucial for power system support
  - ➢ The benefits are multiple, also **enabling vRES players to diversify their revenues.**



Market participations studied in TradeRES:

***A) Passive Participation** of vRES players*

The power **forecast** for wind and solar PV **is fully offered into the DAM/PAM** (hourly periods);

***B) Active Participation** of vRES players*

The power forecast are divided as*:*

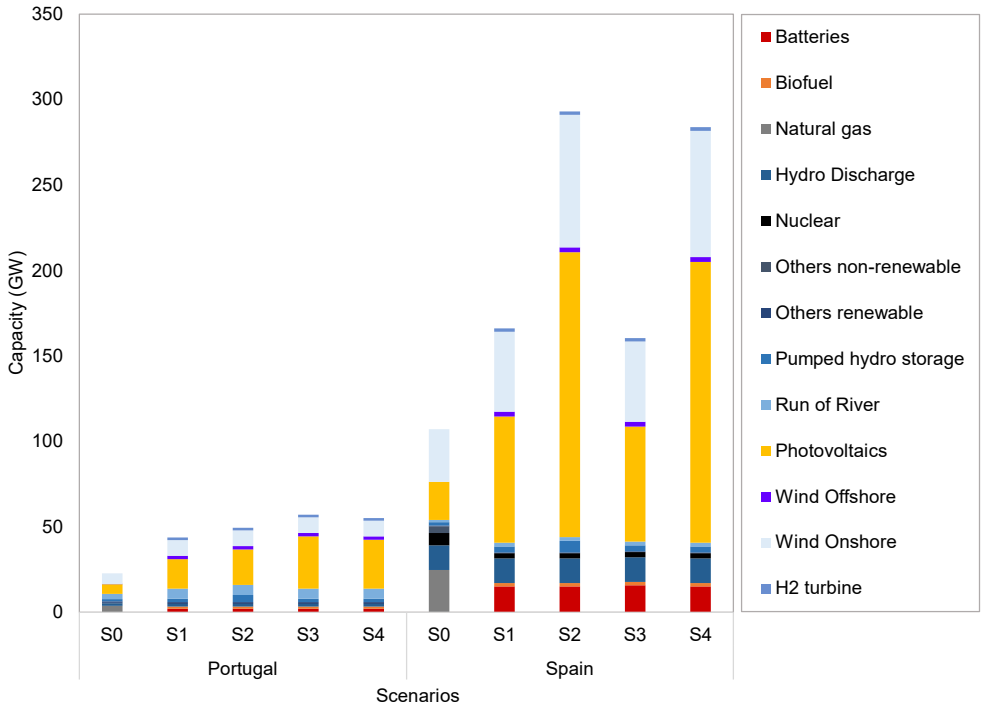
i) **20%** power **allocated for participation in balancing markets**;

ii) The **remaining 80% is bid** into the **DAM/PAM**.

Deviations of generation with respect to updated forecasts are **bided in the IDM**.

Simulations and input data

Scenario	Market Design	Simulation designation	Participation
S0	DAM + SR + IDM + TR	DAM	Passive
	PAM + SR + IDM + TR	PAM	
	DAM + SR + IDM + TR	DAM_Active	Active (*Simple*)
	PAM + SR + IDM + TR	PAM_Active	
S1	DAM + SR + IDM + TR	S1_DAM_Active	
S2		S2_DAM_Active	
S3		S3_DAM_Active	
S4		S4_DAM_Active	



S0 base	2030
S1 conservative	2050
S2 flexible	2050
S3 variable	2050
S4 radical	2050

The simulations **comprised different features with focus on vRES players**:

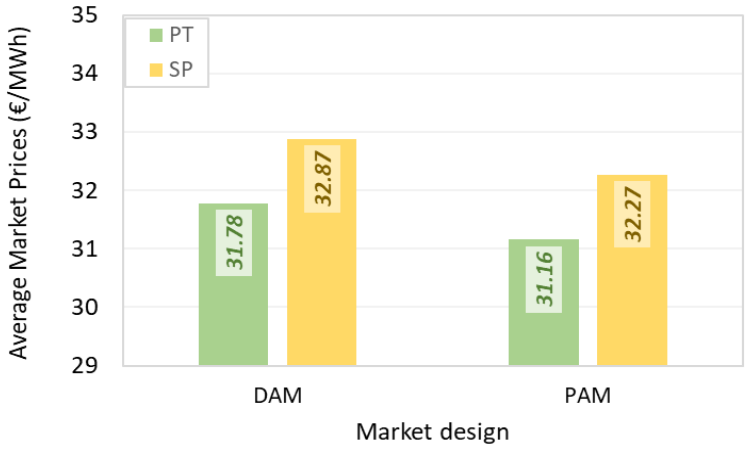
- **Day-ahead (DAM)** *vs* **period-ahead (PAM) market**;
- **Passive** *vs* **Active participation of vRES** in the electricity markets;
- Impact of **future ~100% RES power systems** using the scenarios from TradeRES (S1-S4).

TradeRES scenarios:

- Future energy mixes **dominated by solar and wind**;
- **Decommissioning of Coal** (SP), **Natural Gas** plants and other non-renewable technologies (PT & SP);
- **Reduction of nuclear** capacity (SP).

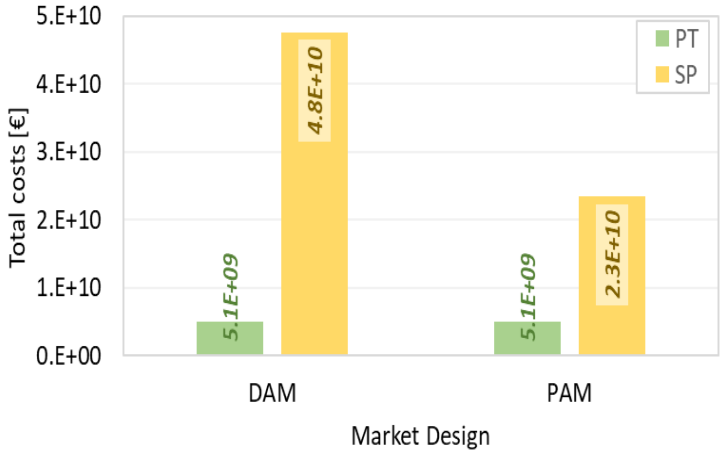
DAM *vs* PAM design in *S0* scenario: Market Performance Indicators (MPIs)

- **Average market price:**



lower relative price in PAM

- **System costs for dispatch:**



PAM has Lower dispatching costs

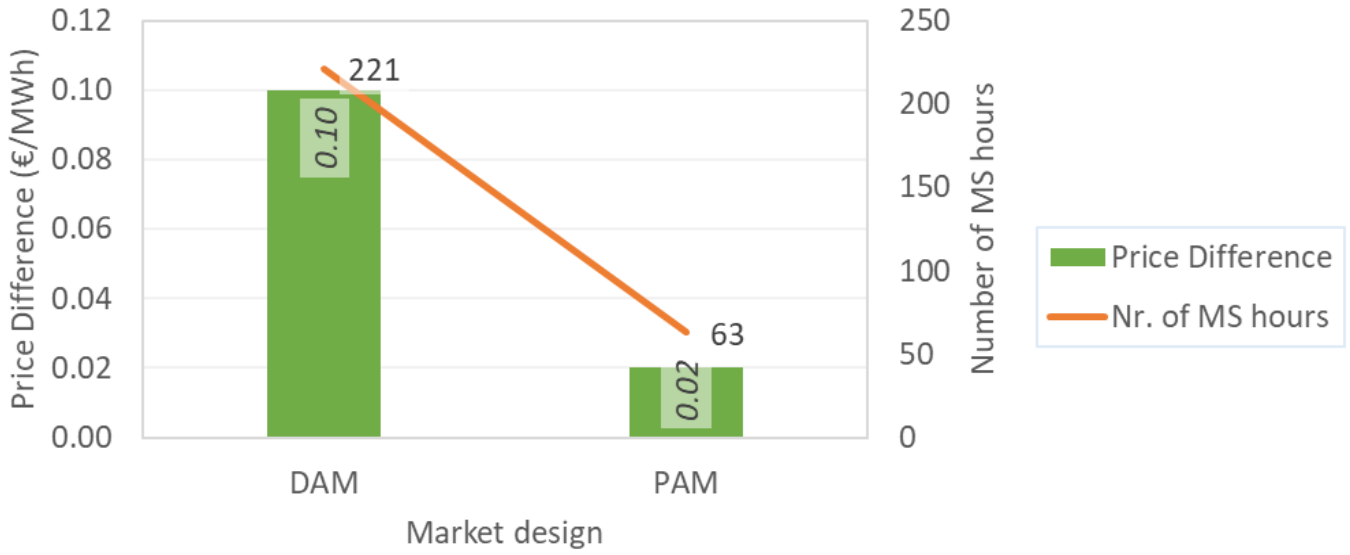
- **Costs for society:**

PAM has a high impact in SP, neglectable in PT

- **Compared to DAM,** the **PAM shows lower** *i)* **average market price, and** *ii)* **system costs for dispatch and costs for society**.
- Contrary to actual situation, **under ~100 RES average market prices will be slightly lower in Portugal than in Spain.**

DAM/PAM: impact on cross border trading (*S0*)

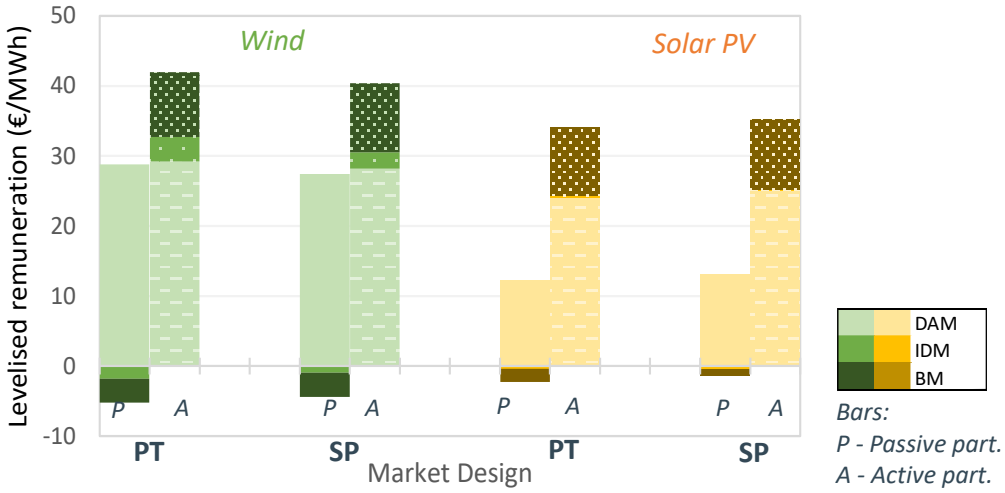
- **Price difference and market splitting (MS) hours between Portugal and Spain**



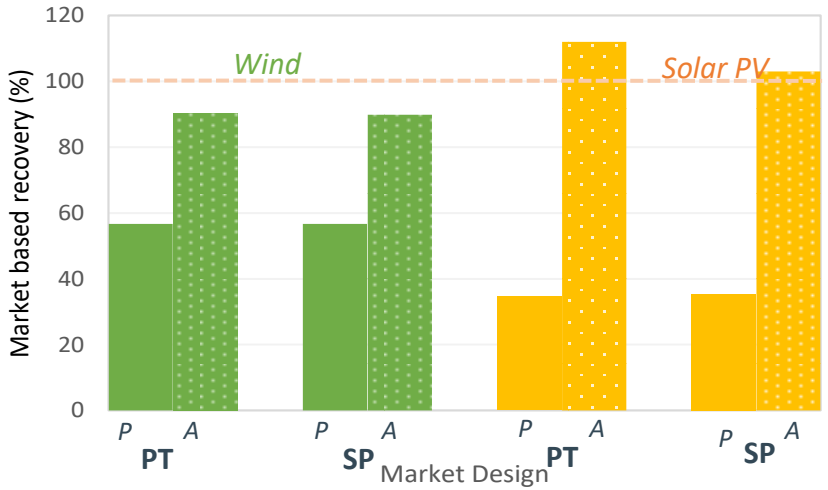
- vRES bids in the **PAM contribute to minimize market distortions observed in the DAM** by **reducing the hours with MS events and (strongly) improving price convergence** between Portugal and Spain.
  - ➢ Distortions often lead to frequent market-splitting events due to "virtual" cross-border congestion.

Passive *vs* Active participation: Impact in the remuneration of vRES technologies in different markets (*S0*)

- **Levelised remuneration**

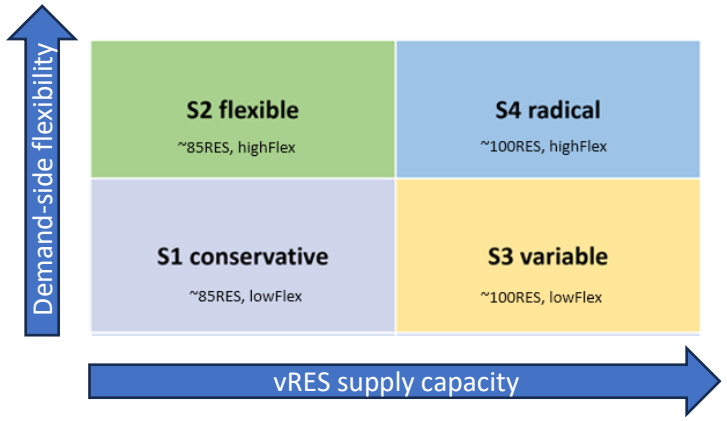


- **Market-based recovery**



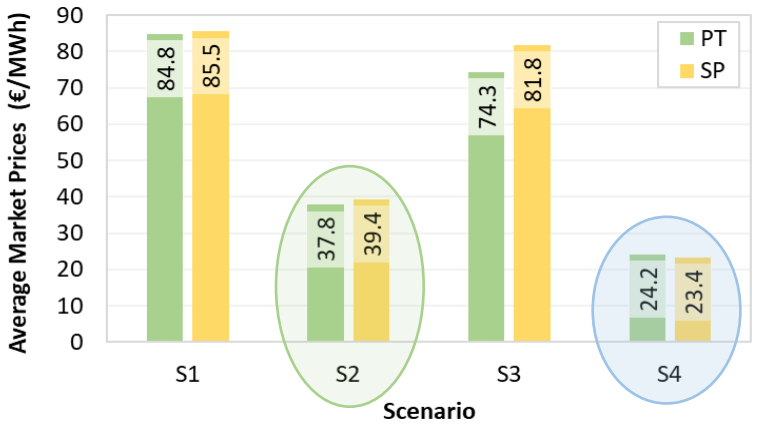
- **vRES active participation** led to an **increased market remuneration** through: *i)* **higher DAM/PAM prices**, and *ii)* (active) **participation in IDM and balancing markets**.

- **Active participation enables vRES players to recover all investment costs for solar PV** technology **and nearly 90%** of investment costs **for wind** in both countries.
  - However, t**hese benefits are associated with slightly increasing in overall system costs.**

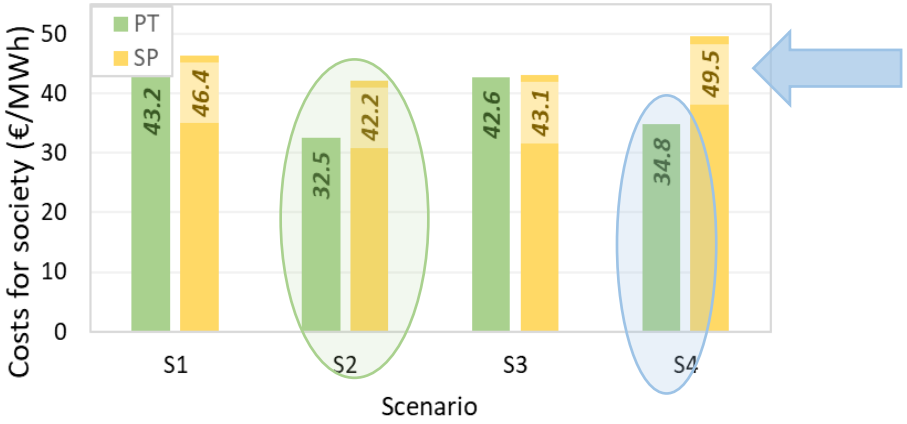


Market performance under nearly 100% RES power systems (*S1-S4*) 2050

- **Average market price:**

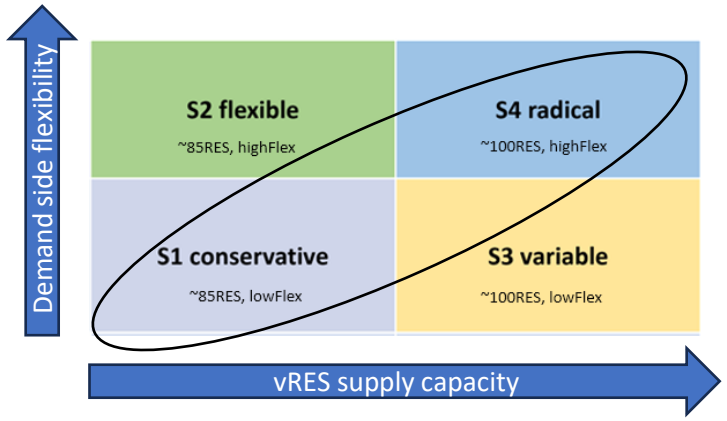


- **Cost for society:**

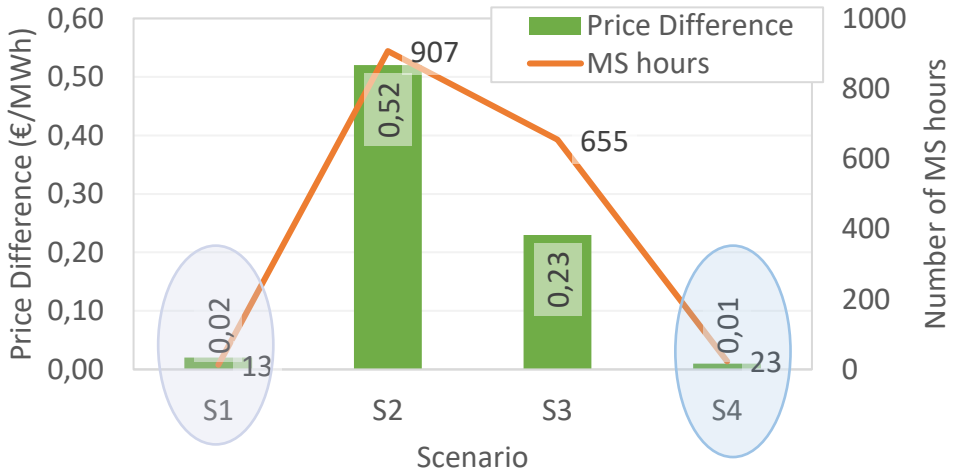


- **Scenarios with high** levels of sector coupling and demand-side **flexibility** (S2 and S4) **result in the lowest *i)* average market prices** and ***ii)* cost for society (SP S4 is high due to investment).**

Market performance under nearly 100% RES power systems (*S1-S4*) 2050



- **Price difference and market splitting (MS) hours between Portugal and Spain**



- Scenarios with **aligned demand-flexibility and investments in vRES (S1 and S4)** tend to be **more stable**, leading to **practically no MS events**.

Impact in the short-term markets: PAM, vRES active strategy and future scenarios

- **Demand** served **by vRES**: **Portugal**: 82% (S0) & 100% (S1-S4), and **Spain**: >60% (S0) 93% to 97% (S1-S4);

- A new market *design* as **PAM reduces balancing** needs**, penalties** and **curtailments**, contributing to **price harmonization of PT and SP zones**.

- **Active participation of vRES**, even with simple, non-optimal strategies, **reduces imbalances and boost remuneration and market value**.

- **vRES struggle to cover investment** costs without support, especially with **high demand flexibility**.
  - Efficiency vs Profit: Lower energy costs benefit society but challenge vRES in investment recovery.

- **Costs for society and dispatch decrease** significantly **from 2030 (S0) to 2050 (S1-S4).**
  - **Complementarity** between demand flexibility and vRES investments **is key for cost reduction** and stability.

Final notes on short-term markets

- **Market Splitting:** vRES power forecast errors contribute to "virtual" market-splitting in DAM; a 6h PAM helps reduce this.

- **Intraday Market (IDM):** Improving IDM with clearing at gate closure and vRES priority would support vRES participation. Current "first in, first out" penalizes vRES.

- **Power Reserves:** Separate procurement boosts competition and lowers prices. Including vRES helps offset deviation pressures and diversifies revenue.

- **Dynamic Procurement**: In ~100% RES systems, reserve needs should adjust based on forecasts and market conditions.

***While further work is necessary**, (e.g., developing strategic bidding or cost-benefit analyses), **this research shows that a** flexible **market design, like PAM with shorter gate closures and improved intraday and balancing mechanisms, enhance market efficiency and unlock full value of vRES in ~100% renewable systems**.*

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