TradeRES

New Markets Design & Models for 100% Renewable Power Systems

TradeRES Outcomes & Recommendations

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276

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System's adequacy and security of supply.

vRES derisking and support mechanisms.

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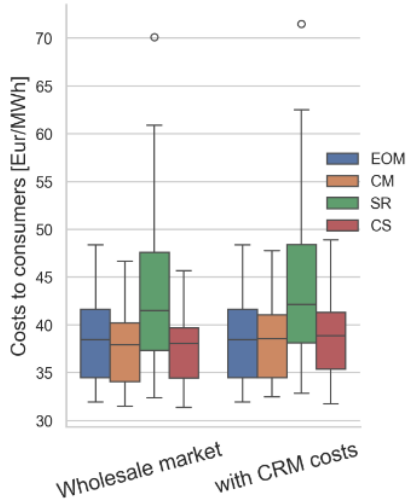
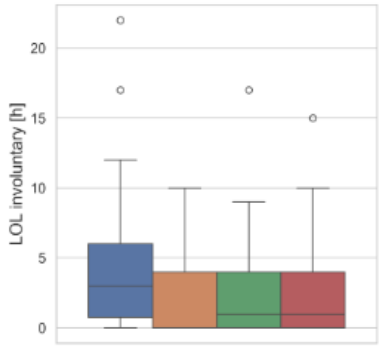
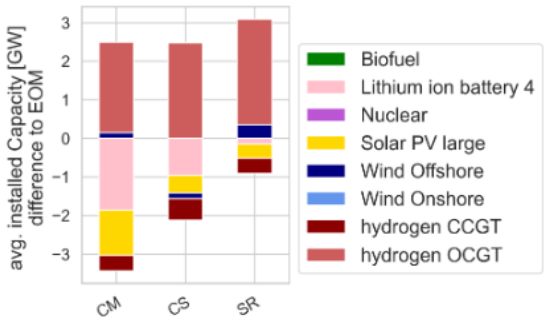
Can an energy only market enable adequacy in a decarbonized power system?

- **Capacity remuneration mechanisms (CRM) are needed** during and after the energy transition.
- **CRM increase investment in dispatchable technologies** while promoting the **robustness of the power system.** In overall **CRM have a small impact on system's costs**;
  - Strategic reserve can incentivize more flexibility but at the cost of more volatile prices;
  - Capacity subscription allows consumers to reflect willingness to pay for reliability, enabling more DSM;
  - Capacity market reduce wholesale market prices, adding **CRM payments results in similar costs to consumers as an EOM**;
- **Lower wholesale** market costs, and **similar costs to consumers as an EOM**;
- ***CRM application to (****hydrogen and/or) long-term* ***energy storage*** *technologies should also be investigated.*

Legend:
EOM - Energy Only Market
CM - Capacity Markets
SR – Strategic Reserve
CR – Capacity Subscriptions

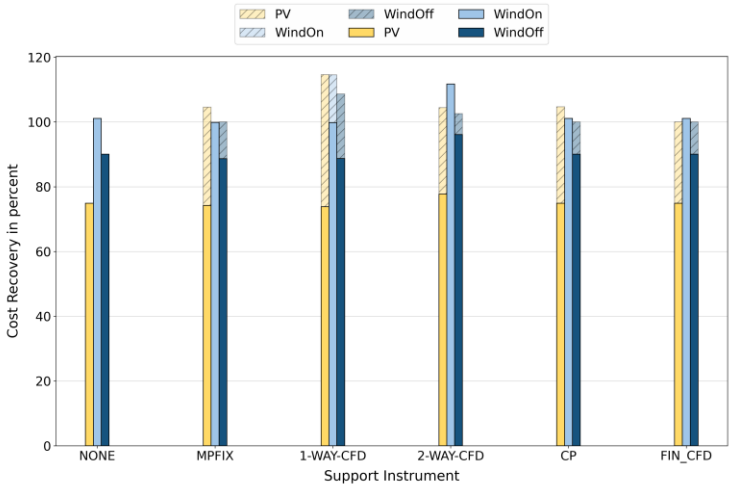






See Deliverables: D3.5, Ed.3; D5.3, Ed. 2; D6.5

vRES de-risking & support schemes



- **Design of effective support schemes to de-risk vRES Investments is needed.**
  - Trade-offs detected between securing stable revenues for investors, avoiding dispatch distortions, and minimising support costs for end consumers

However, CfDs must be carefully designed. TradeRES outcomes indicate:

- **Production-dependent CfD schemes (1 & 2 – way CfDs)** affect vRES curtailment and **can lead to over-support** due to the anticipation of clawback periods (in profitable investments);
- **Financial CfD can be an alternative…**
- … but investor risk associated should be further investigated;
- **Results are *highly sensitive* with regard to scenario assumptions;**
  - Especially regarding the hydrogen price & electrolysis dispatch suggesting a clear (and market-competitive) description of energy storage in subsequent research.

See Deliverables: D3.5, Ed.3; D5.3, Ed. 2; D5.4; D6.5

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Market Design Components:

Wholesale markets

Retail markets & ancillary system services

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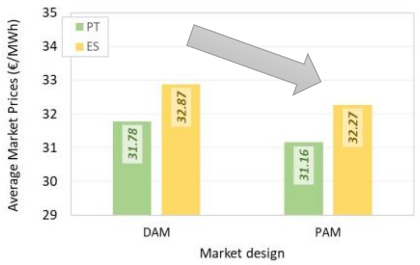
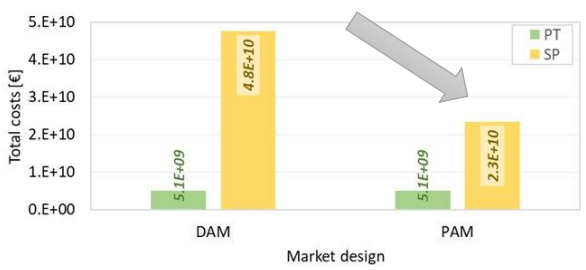
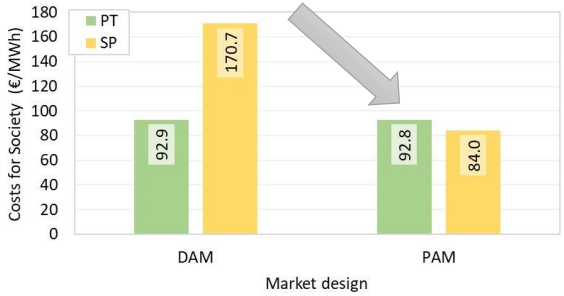
Wholesale market: DAM vs PAM towards real-time







- **All TradeRES scenarios** achieve high annual RES shares, resulting in **zero CO2 emissions in 2050**.
- Closer **to real-time trading (PAM - Period-ahead market)** was implemented with **good results**;
- A more **vRES-friendly clearing mechanism in the continuous intraday market (IDM) is recommended** and should be implemented;
- **Active & strategic participation of vRES in different markets**, should be incentivized;
- Future **Power Systems ~100% RES will be fully weather-depended**;
  - Conditions to **improve the accuracy of vRES power forecast systems** need to be enhanced;
  - **Electricity markets "timings" need being synchronized with meteorologic data** refreshment.

See Deliverables: D3.5, Ed.3; D5.3, Ed. 2; D6.5

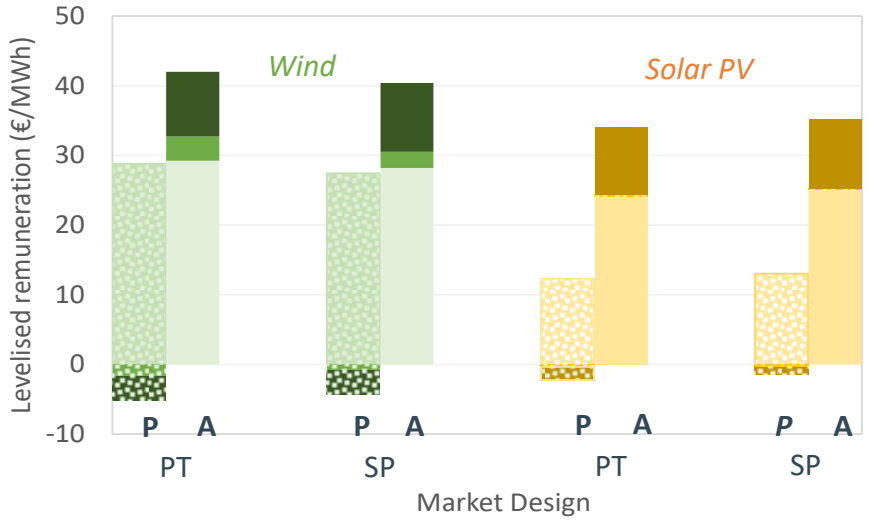
Retail Markets & Ancillary system services

Retail market design

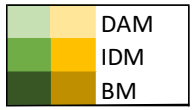
- Implement fully indexed tariffs for real-time local price signals

Ancillary system services

- **Dispatch costs significantly decrease** from 2030 to 2050;
- **Expand participation** to aggregated smaller players;
- **Adapt ancillary services** for enabling the **full participation of vRES players**
  - it leads to a **reduction in vRES imbalances (and system costs)** and increases their market value.
- Procurement of **secondary reserve should be dynamic & associated to vRES forecasts**
- An **imbalance settlement mechanisms that fairly reflects true costs** of these services should be implemented.



Bars:
P - Passive participation
A - Active participation



See Deliverables: D3.5, Ed.3; D5.3, Ed. 2; D6.5

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Other Market Design *Components*:

Transmission networks & cross-border trading;

Distribution Networks & Sector coupling;

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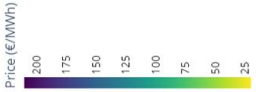
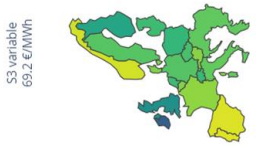
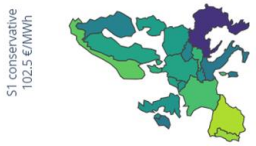
Other market *components*







- **Cross-border trade & Transmission networks:**
  - Grid enhanced technologies (GET) should be implemented: E.g. dynamic line rating (DLR) was used for MIBEL leading to a strong **reduction in market splitting and convergence or prices**;
- **Sector coupling:**
  - **Coordinated** market design for different energy vectors and **regulation across coupled infrastructures**
- **Distribution networks & Local Markets:**
  - **DSOs and Local Energy Communities** (LECs) will **play a critical role** with increasing decentralized vRES generation and electrification;
  - **LECs promote local energy balance enhancing efficiency** and resilience;
    - **Advanced trading mechanisms optimise LEC's benefits**. E.g. peer-to-peer trading and innovative models like reinforcement learning further minimise costs and improve system flexibility.
- **The European perspective**
  - Emergence of **"demand-side merit order ";**
  - **Investors in vRES and inflexible consumers** are (the more) **exposed to price risks;**

See Deliverables: D3.5, Ed.3; D5.2, Ed. 2; D5.3, Ed. 2; D5.4; D6.5

Synthesis of TradeRES Recommendations (1/2)

- **Wholesale market**

  Shorter lead times; Implementation of a **rolling time-horizon market clearing** process. Addition of high-resolution, near-term forward markets as a product to facilitate time arbitrage by storage units and flexible demand;

- **Retail market design**

  Real-time pricing to be implemented in the entire market, also for small consumers and prosumers; Option contracts for controllable, affordable power to protect consumers against price spikes;

- **Ancillary services**

  need to be (fully) reformed to allow **new resources such as vRES, storage and demand response to replace dispatchable plants**. Reform should be shaped to take the physical properties of vRES into account.

Synthesis of TradeRES Recommendations (2/2)

- **De-risking vRES. The need for support schemes:**

  Contracts for differences are needed during and after the transition. Their design **needs to be carefully researched**.

- **System adequacy:**

  CRMs are needed, both during and after the energy transition for energy generation and H2/storage capacity.

- **Sector coupling, transmission networks& Cross-border trade:**
  - **All energy vectors should be treated equally** with respect to CO_2 emissions and other externalities
  - GET, e.g. DLR - Dynamic Line Rating should be applied to maximize trading capabilities
  - Intra-day and **balancing markets should be coupled across borders**.
  - **Capacity mechanisms** should allow resources **from neighboring markets** to provide capacity.

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