



TradeRES

New Markets Design & Models for
100% Renewable Power Systems

The Iberian Case Study

RES Support Schemes in the Iberian Power Systems

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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



The Iberian (Portugal and Spain) Power Systems

Objective:

- To verify the economic viability of new power plant investments in energy-only markets:
 - without considering renewable support schemes or additional incentives
 - using the power plants capacity, energy consumption, electricity market designs, and prices recorded in 2019 → the year considered as the "starting point" in TradeRES project.

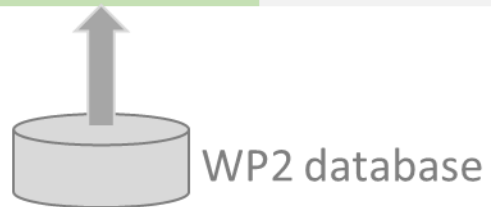
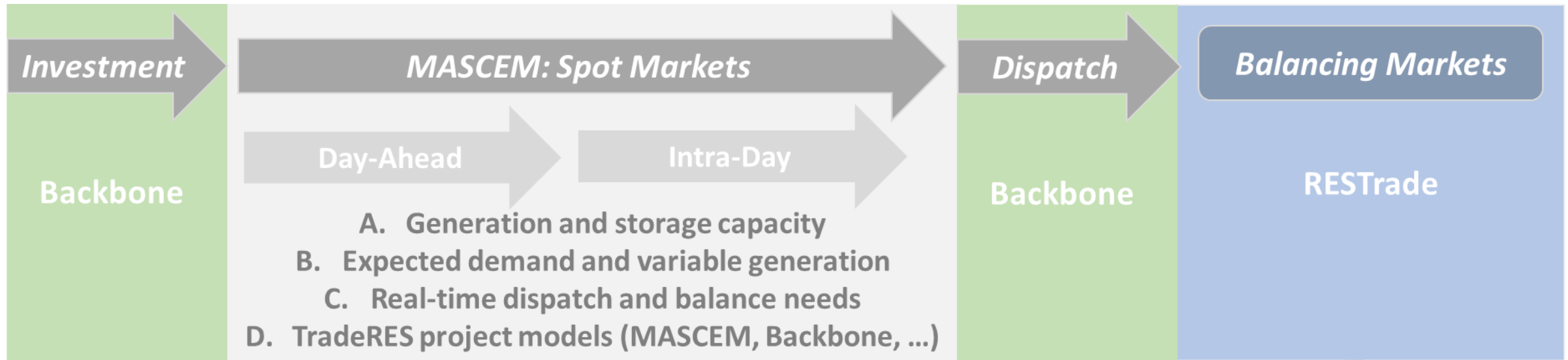


Can energy-only marginal markets remunerate power plants?



Simulation of Iberian Markets

Input Data





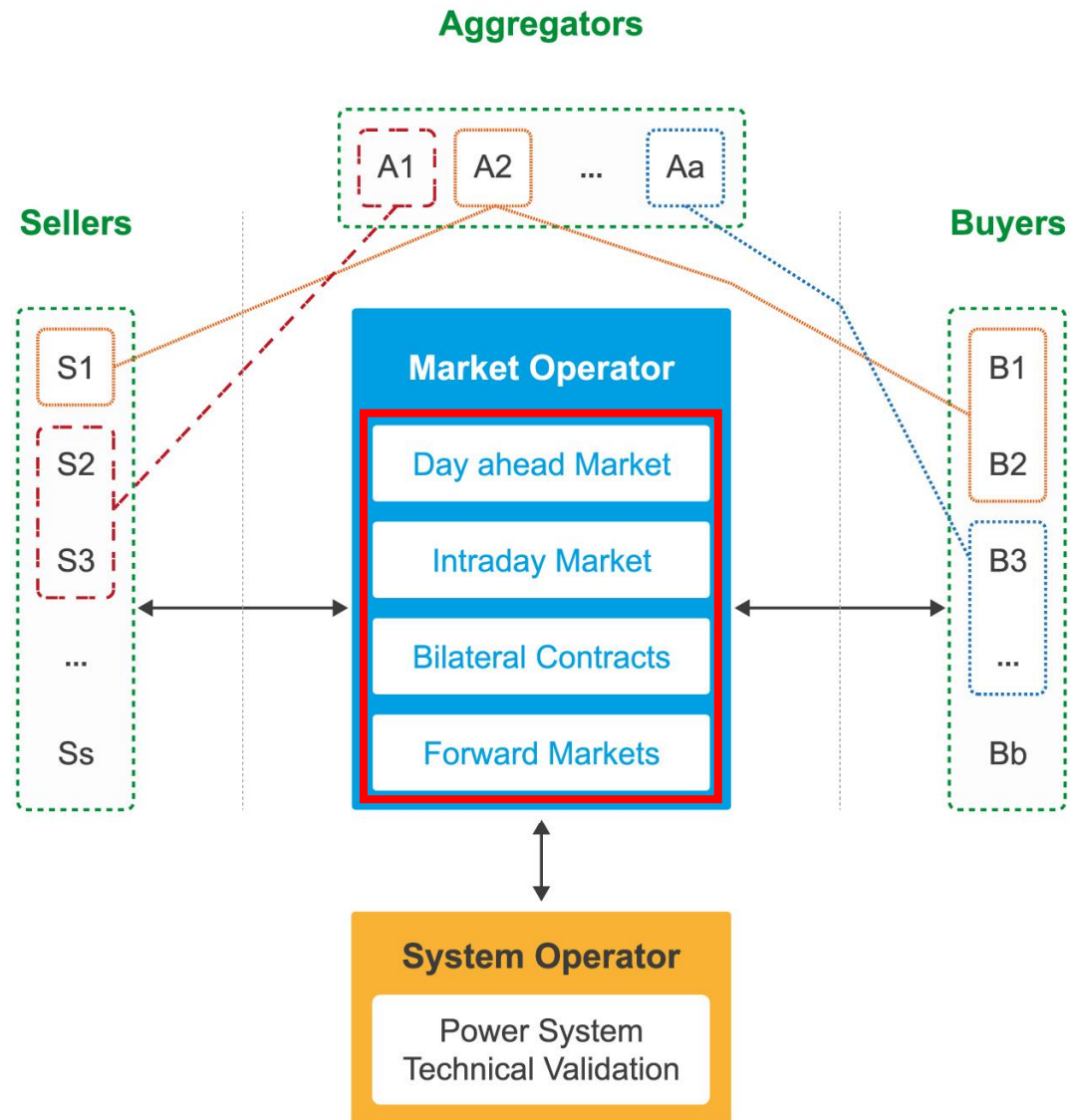
MASCEM

Multi-Agent Simulator of Competitive Electricity Markets

Gabriel Santos, ISEP



MASCEM Overview





MIBEL Overview

- Double-sided auction-based
- 24 hourly periods
- Day-ahead
 - 1 to 25 energy-price pairs per Bid
 - Complex conditions
- Intraday
 - Buyers can sell
 - Sellers can buy
 - Complex conditions
 - Auction-based vs Continuous (SIDC)
- Market splitting
 - If there is congestion in the cross-boarder lines

MIBEL



<https://www.omie.es/en/mercado-de-electricidad>





MASCEM integration in Spine Toolbox



Multi-Agent Simulator of Competitive Electricity Markets



<https://em.gecad.isep.ipp.pt/>



<https://pf.gecad.isep.ipp.pt/>



http://www.spine-model.org/spine_toolbox.htm
<https://github.com/Spine-project/Spine-Toolbox>





Find out more

1. Gabriel Santos, Tiago Pinto, Isabel Praça, Zita Vale, “MASCEM: Optimizing the performance of a multi-agent system,” Energy, vol. 111, pp. 513-524 (2016). DOI: [10.1016/j.energy.2016.05.127](https://doi.org/10.1016/j.energy.2016.05.127).
2. Tiago Pinto, Zita Vale, Isabel Praça, Luis Gomes, Pedro Faria, “Multi-Agent Electricity Markets and Smart Grids Simulation with connection to real physical resources”. In “Electricity Markets with Increasing Levels of Renewable Generation: Structure, Operation, Agent-based Simulation and Emerging Designs”. F. Lopes, H. Coelho (Eds). Springer Int. Publishing (2018). DOI: [10.1007/978-3-319-74263-2_11](https://doi.org/10.1007/978-3-319-74263-2_11)
3. Gabriel Santos, Tiago Pinto, Hugo Morais, Isabel Praça and Zita Vale, “Complex market integration in MASCEM electricity market simulator,” 2011 8th International Conference on the European Energy Market (EEM), Zagreb, Croatia, 2011, pp. 256-261. DOI: [10.1109/EEM.2011.5953019](https://doi.org/10.1109/EEM.2011.5953019).
4. Gabriel Santos, Tiago Pinto, Zita Vale, Hugo Morais, and Isabel Praça, “Balancing market integration in MASCEM electricity market simulator,” 2012 IEEE Power and Energy Society General Meeting, San Diego, CA, USA, 2012, pp. 1-8. DOI: [10.1109/PESGM.2012.6345652](https://doi.org/10.1109/PESGM.2012.6345652).
5. Isabel Praça, Carlos Ramos, Zita Vale and Manuel Cordeiro, “MASCEM: A Multi-Agent System that Simulates Competitive Electricity Markets”, IEEE Intelligent Systems, vol. 18, No.6, pp. 54-60, Special Issue on Agents and Markets, 2003. DOI: [10.1109/MIS.2003.1249170](https://doi.org/10.1109/MIS.2003.1249170)



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RESTrade: Balancing markets

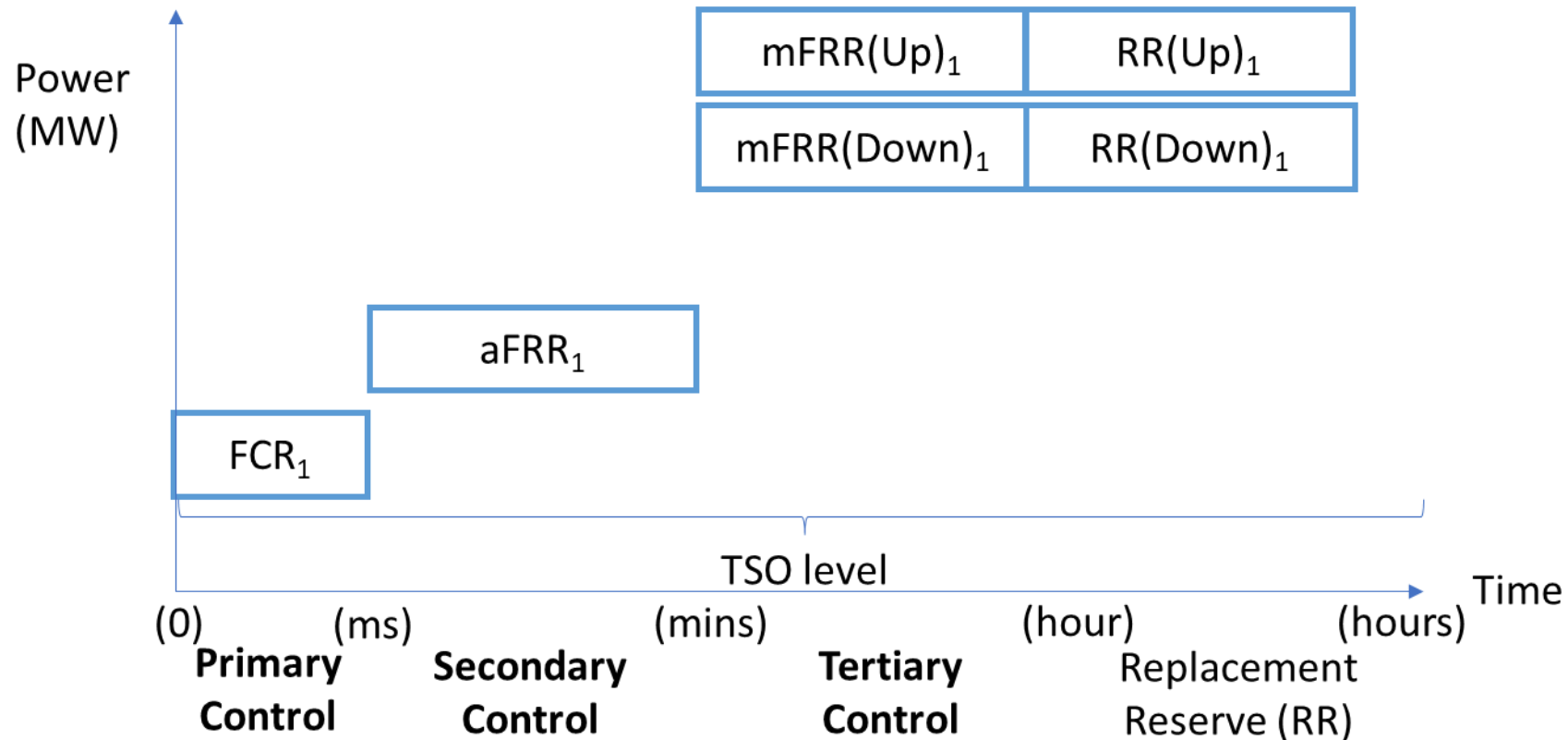


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Traditional Balancing Markets

Typical Balancing Markets managed by each country TSO



- Frequency Containment Reserve (FCR) aka **Primary** Control;
- Automatic-Frequency Restoration Reserve (aFRR) or **Secondary** Control;
- manual-FRR (mFRR) aka **Tertiary** Control;



Features of REStade Tool

aFRR Capacity market



ENTSO-E Secondary (aFRR) capacity procurement

Symmetrical based on the expected maximum demand

Portuguese Secondary capacity procurement

Asymmetrical based on the expected maximum demand
Upward capacity is the double of the downward capacity

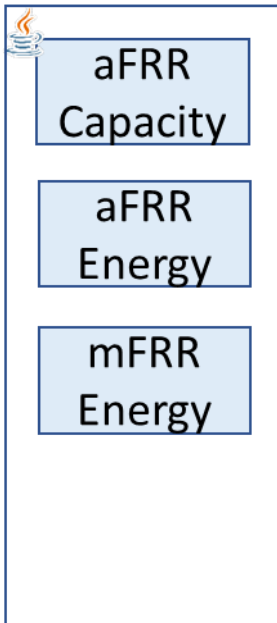
Dynamic Secondary capacity procurement New design

Based on variable generation and consumption forecasts
Separate procurement of upward and downward capacity



Features of REStade Tool

Market mechanisms



Marginal Pricing

Asymmetrical auction clearing

Pay-as-bid

Automatic match of opposite bids



Features of REStade Tool

Imbalance Settlement



Double-pricing Portuguese rule

Single penalty, all Balance Responsible Parties (BRPs) pay energy FRR.
No cash-flow (CFs) surplus or deficit to TSOs.

Single-pricing Nordpool/Spanish rule

Obtain imbalance direction, only BRPs that deviate in the imbalance direction directly pay energy FRR, others do not pay penalties. CFs surplus or deficit to TSOs.

Double pricing and penalty rule

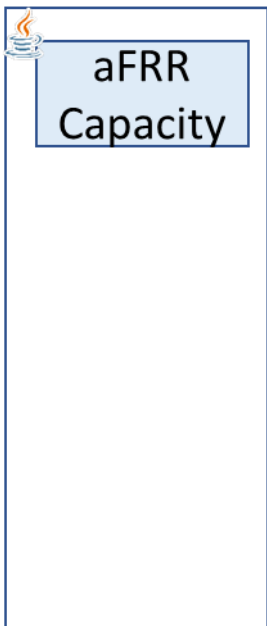
New design

BRPs directly pay the penalties of the FRR energy used to balance their deviations according to its direction. No CFs surplus or deficit to TSOs.



Features of REStade Tool

New market designs

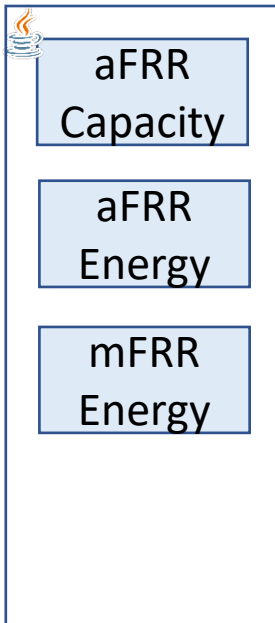


Separate procurement of upward and downward capacity



Features of REStade Tool

New market designs



Separate procurement of upward and downward capacity

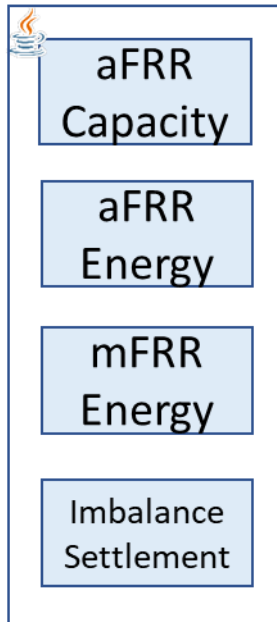
Rolling gate closures closer to real-time operation

Shorter products



Features of REStade Tool

New market designs



Separate procurement of upward and downward capacity

Rolling gate closures closer to real-time operation

Shorter products

Shorter market time units



Data and Results



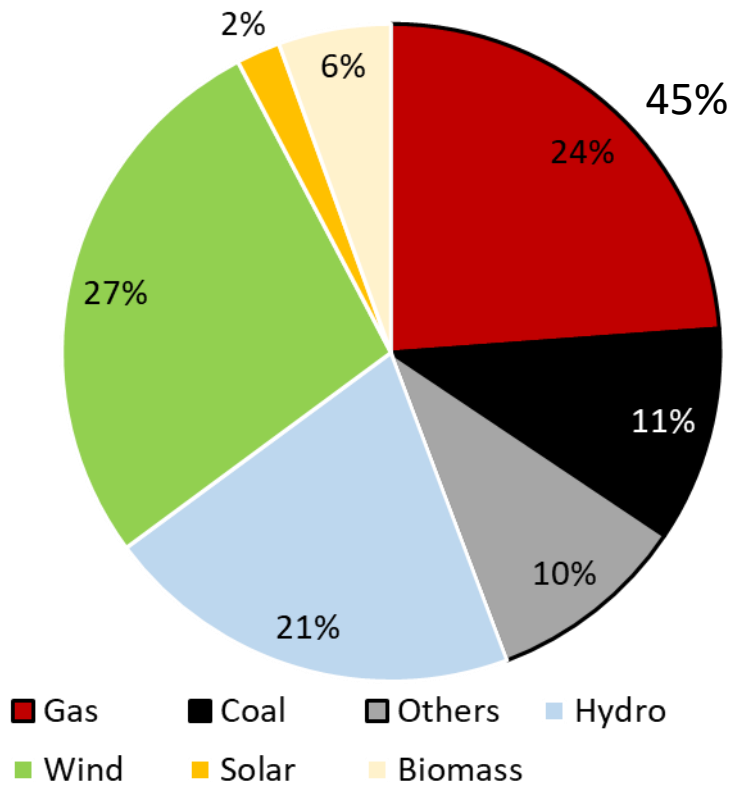
The Iberian Power Systems in 2019

2019 Capacity (MW)	Portugal	Spain
Coal	1 800	9535
Fuel oil	400	0
Natural gas	3 800	24 945
Nuclear	0	7 400
Hydro	7 000	14 796
Wind	5 400	23 507
Solar	2 000	7 018
Biomass	400	0
Other	430	1 038
Total Generation	21 230	88 239
Pumps	2 700	3 418
Interconnection	3 200	2 200

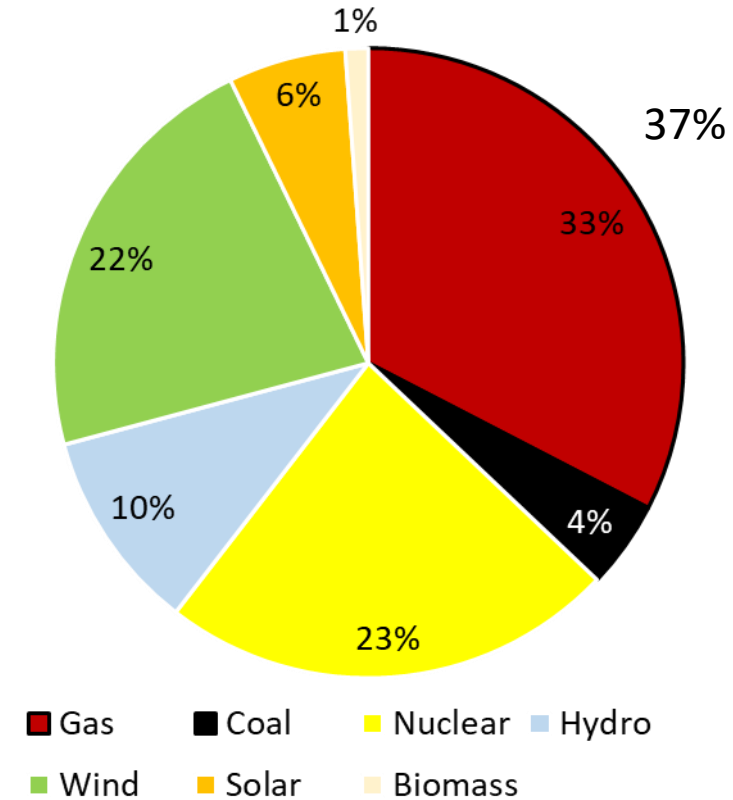


The Iberian Power Systems

Portuguese Generation



Spanish Generation

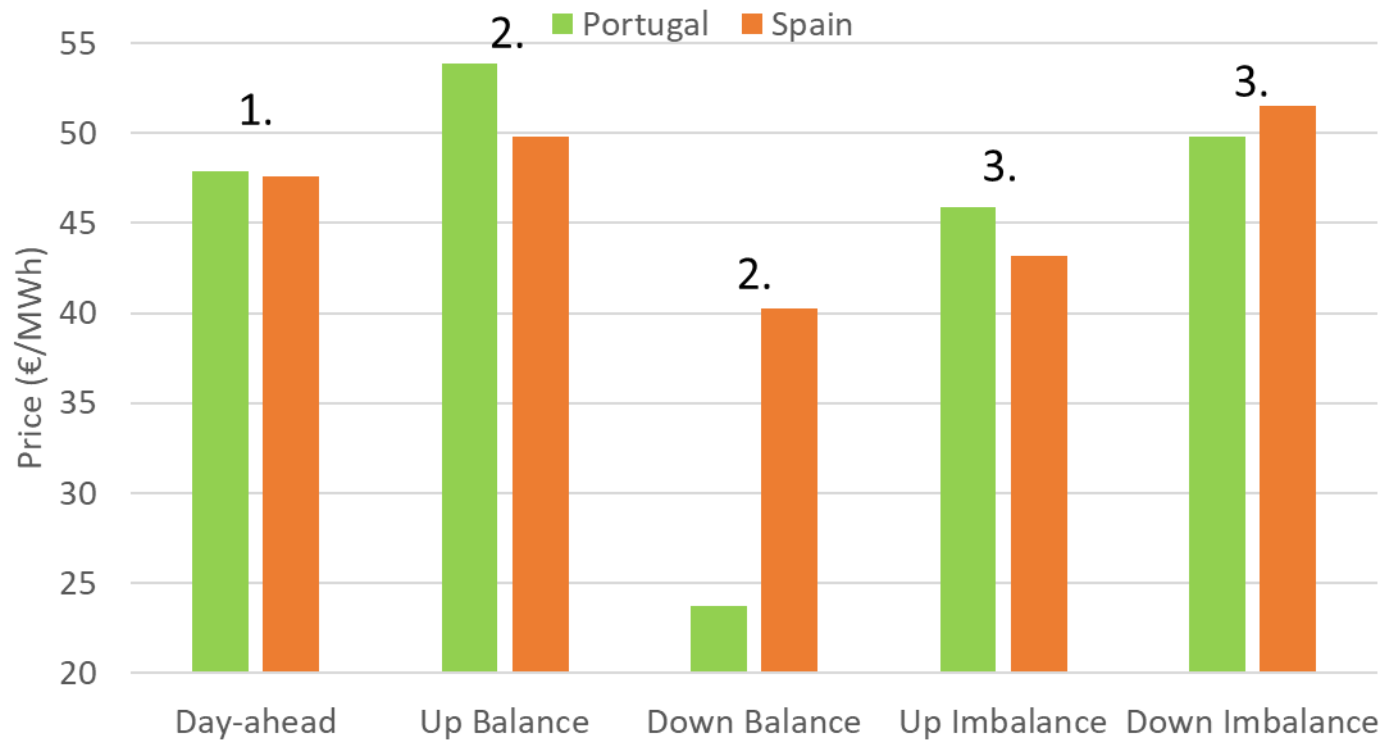




Iberian Simulation

- Agent-based MATREM and RESTrade simulators:
 - Day-ahead, balancing and imbalance settlement markets were simulated using bids of agent-based market players
- Input conditions:
 - 2019 power plants capacity, consumption, market designs and commodity prices
- **Support/market remunerations schemes studies:**
 1. Variable premium
 2. One-way CfDs
 3. Two-way CfDs
 4. Capped premium
 5. Fixed premium

2019 Iberian Results

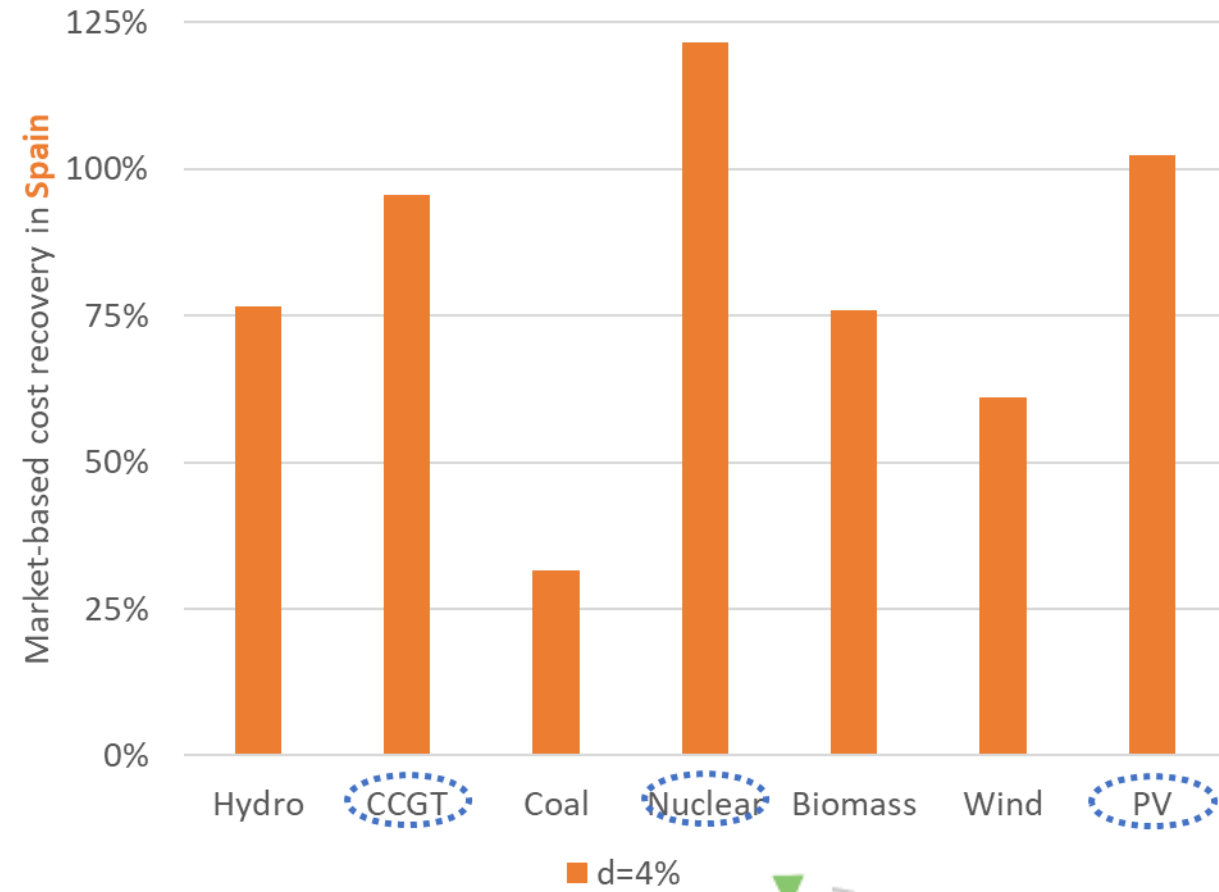
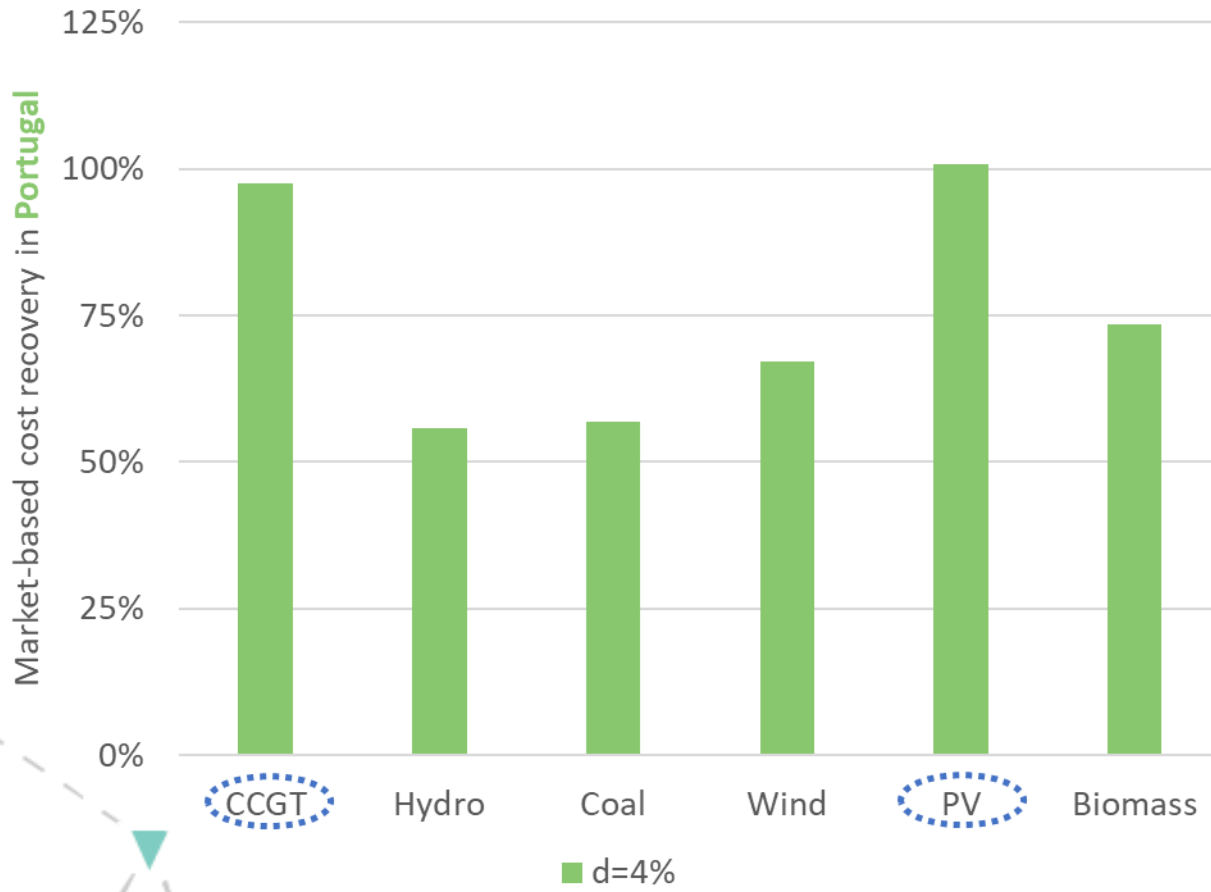


1. Day-ahead prices harmonized
2. Portuguese balancing markets are more expensive
3. Spanish penalties (~4 €/MWh) doubles the Portuguese ones



2019 Market-based cost recovery

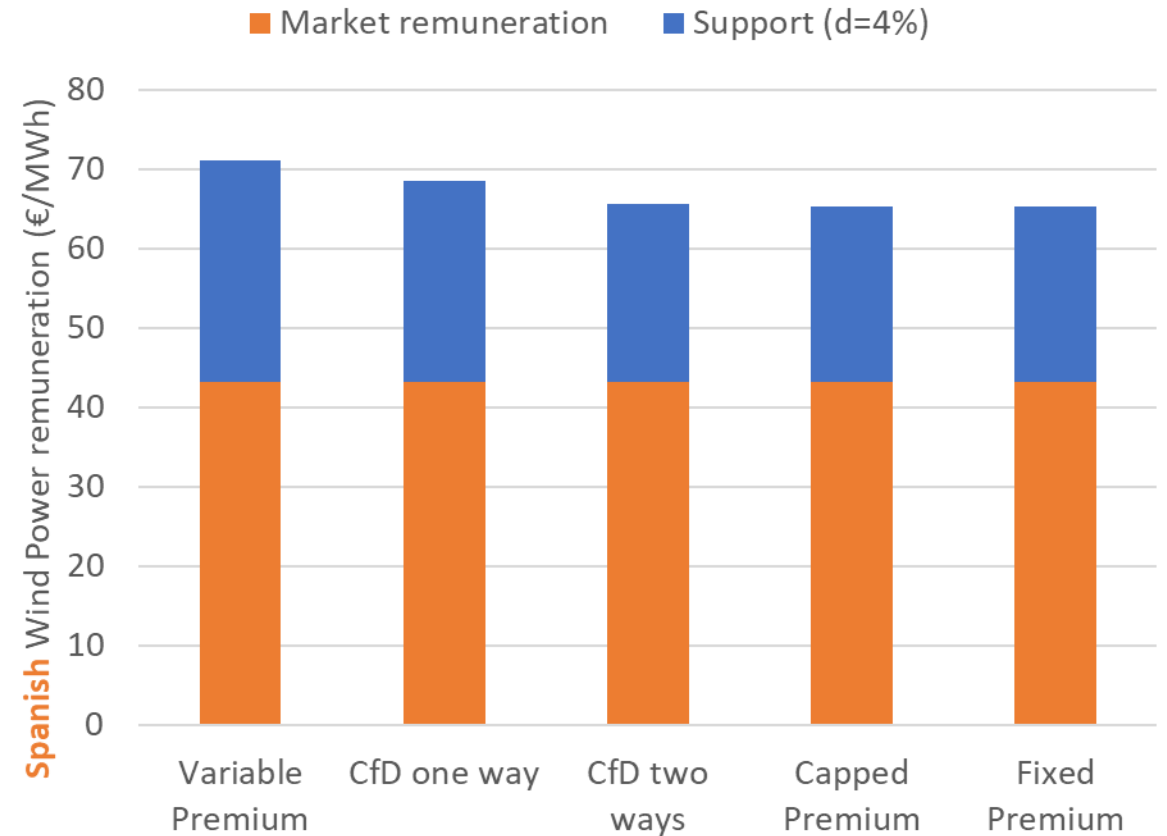
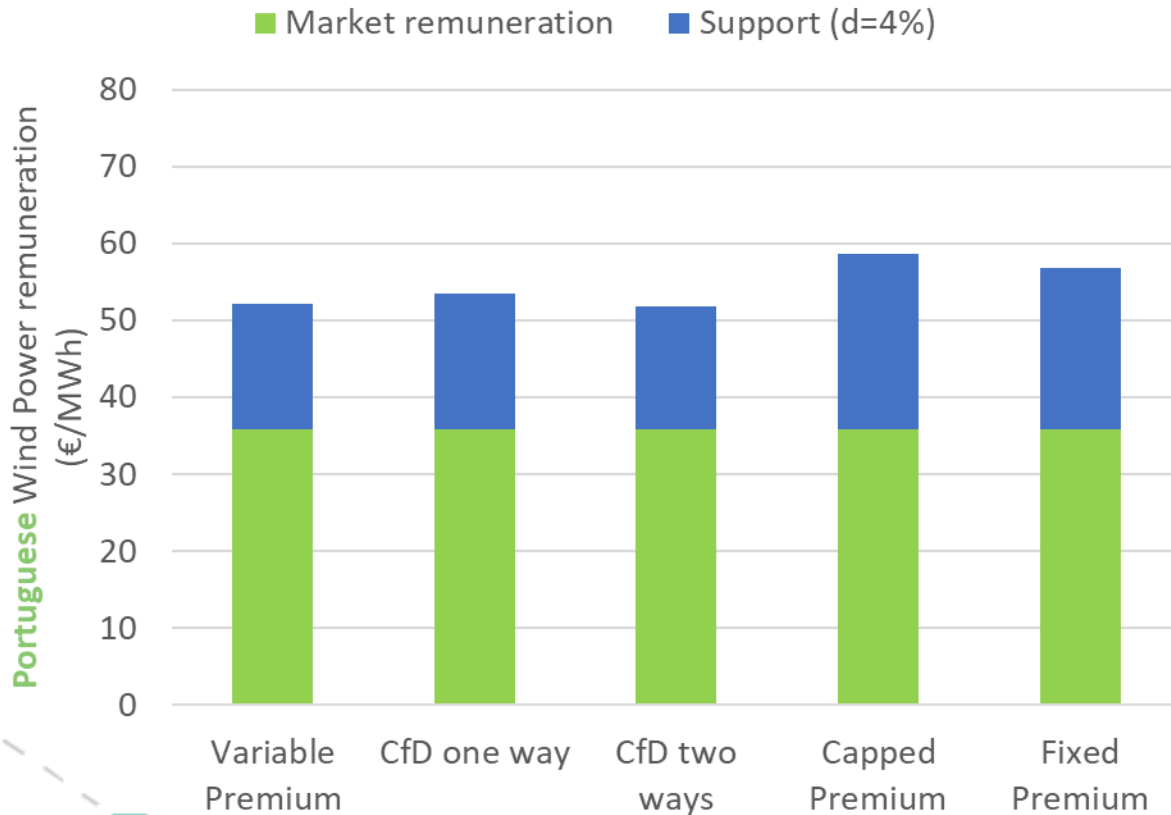
- Considering a discount rate (d) of 4%:





2019 support schemes

- The specific case of the wind power producers:*





Conclusions

Portugal and Spain had 55% and 63% shares of non-fossil generation in 2019, respectively.

Can energy-only marginal markets remunerate power plants?

- High shares of renewable power plants with near zero marginal costs decrease the market prices of marginal markets
- Furthermore, the transition to a nearly 100% renewable share will reduce the working hours of fossil fuel power plants
- Support schemes and other incentives are needed to guarantee investments

New market designs shall guarantee the financing viability of new assets with practically only CAPEX costs.



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Thank you for your attention. Questions?

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