



TradeRES

New Markets Design & Models for
100% Renewable Power Systems

Electricity market modeling and simulation with MASCEM and RESTrade

Gabriel Santos, ISEP and **Hugo Algarvio, LNEG**

8th June 2023



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

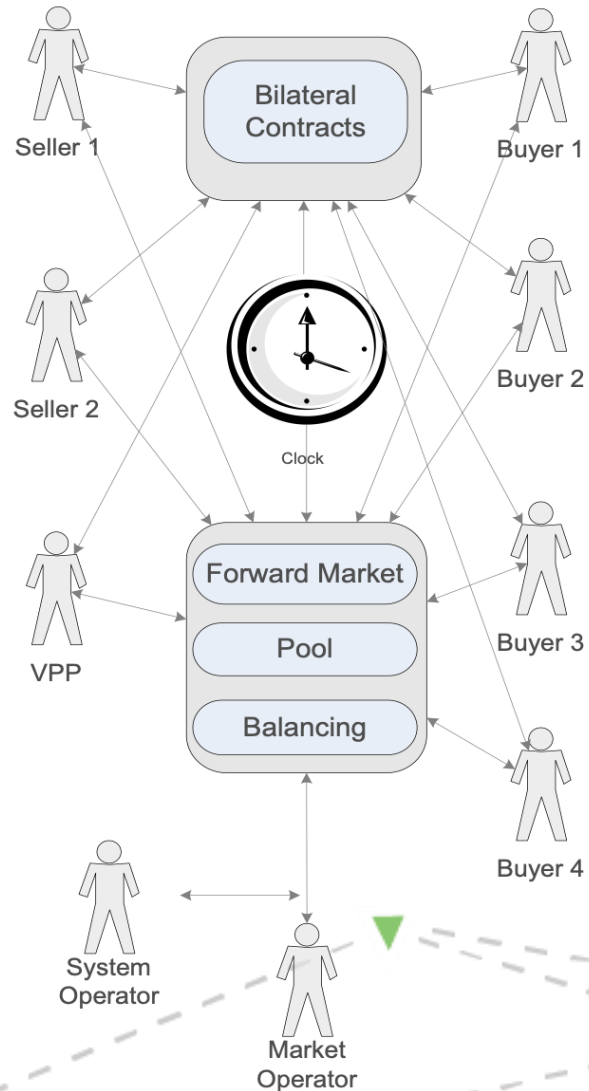
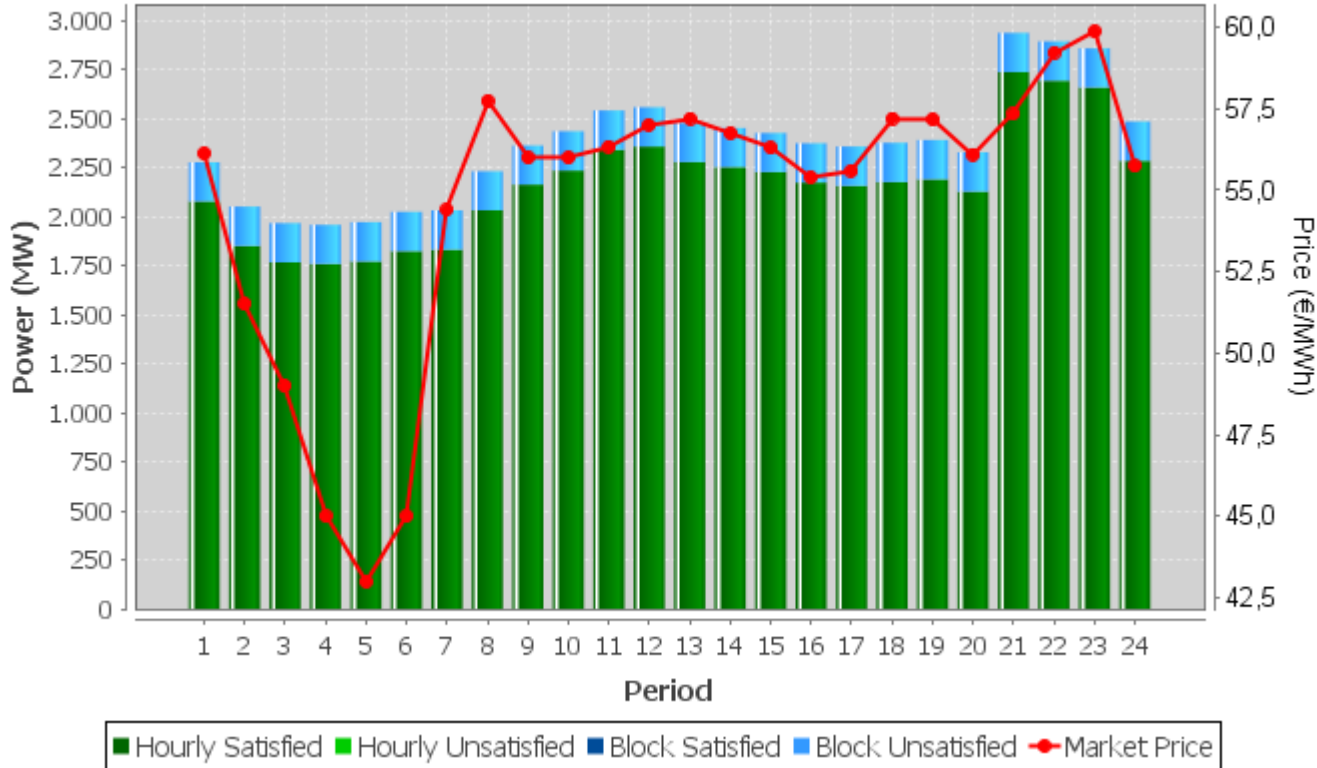


MASCEM : Multi-Agent Simulator of Competitive Electricity Markets

Gabriel Santos, ISEP

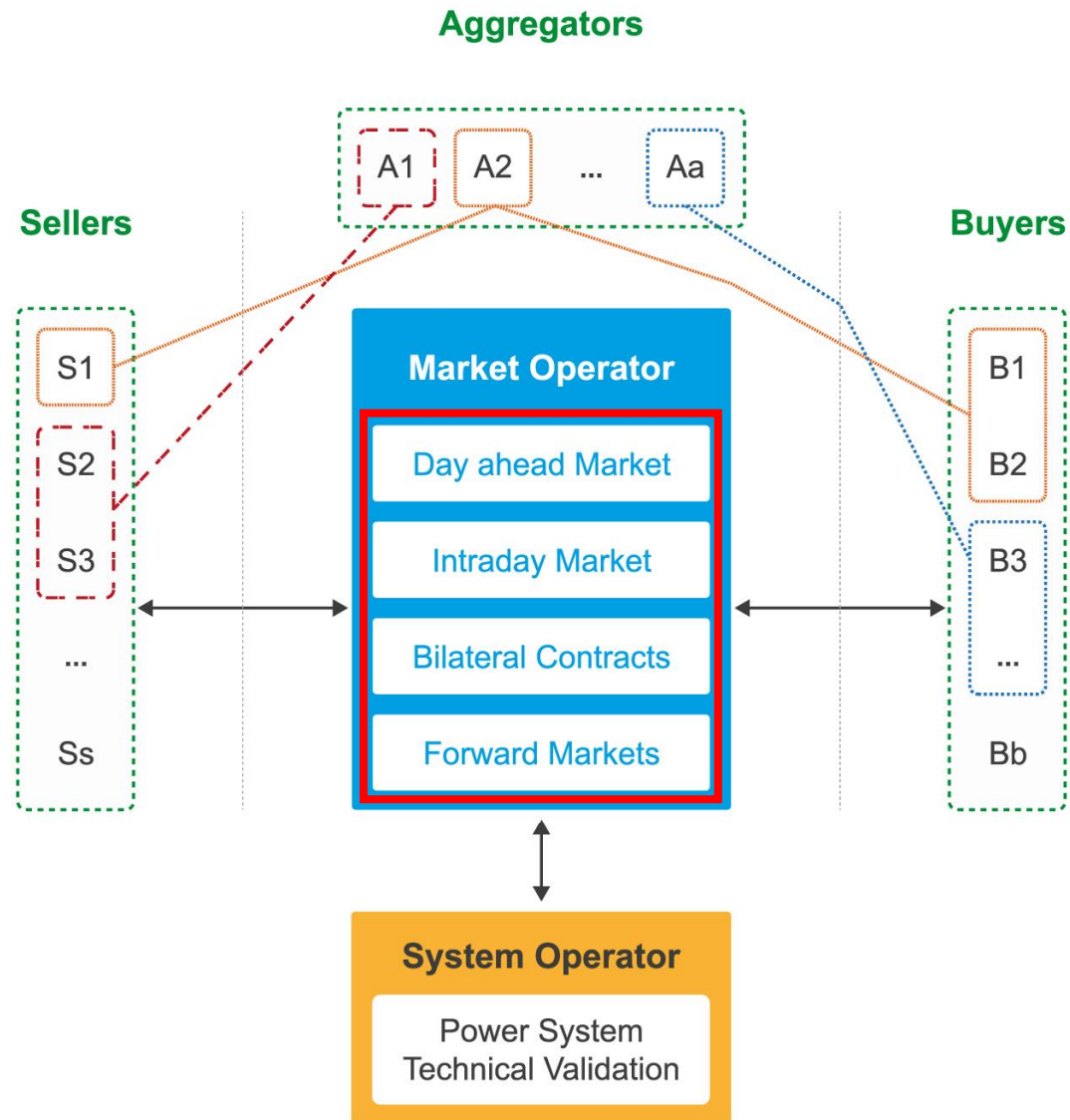
MASCEM

Seller 22's Satisfied Supply





MASCEM Overview



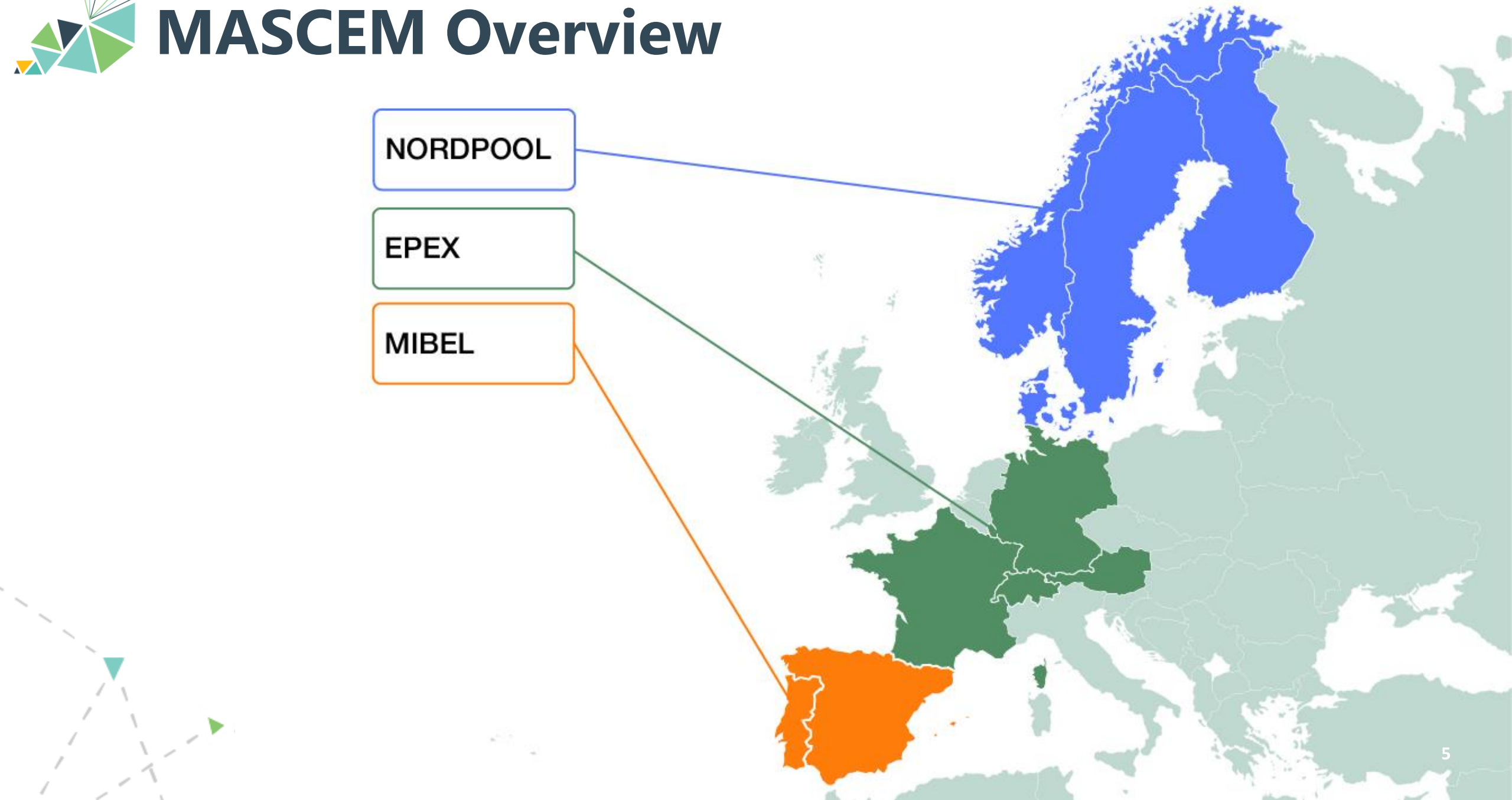


MASCEM Overview

NORDPOOL

EPEX

MIBEL





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

mascem

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

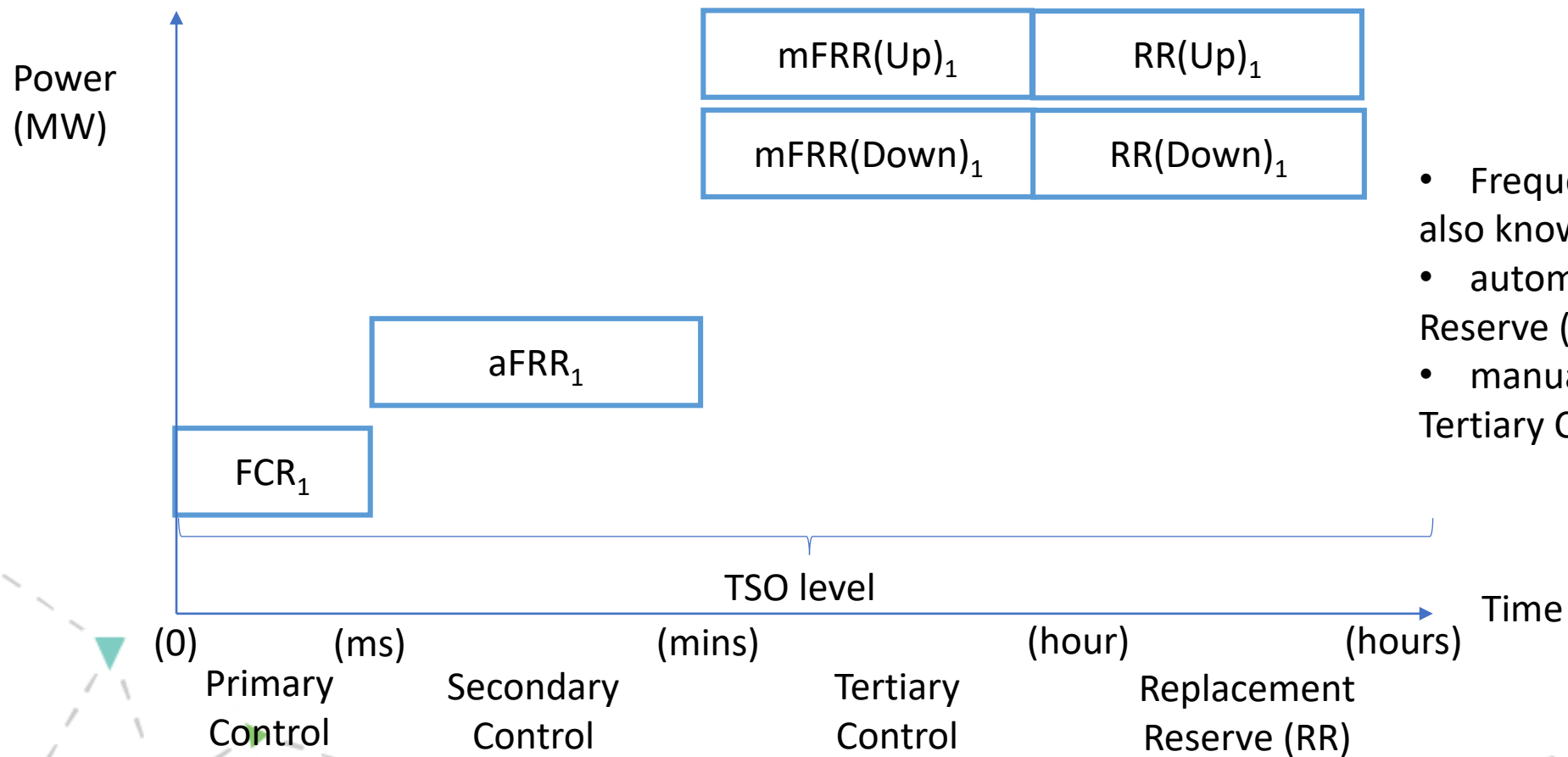


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Traditional Balancing Markets

Typical Balancing Markets managed by each country TSO

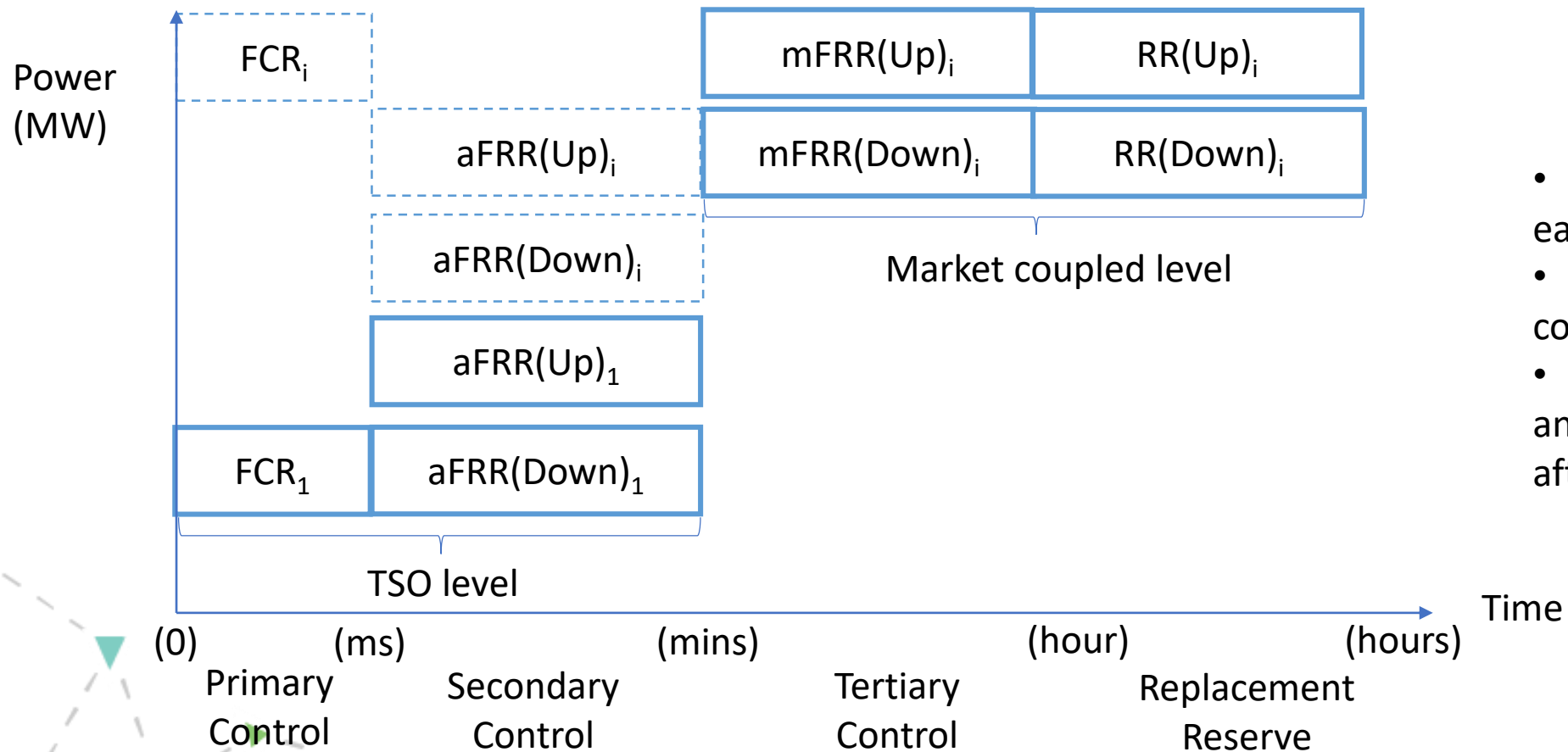


- Frequency Containment Reserve (FCR) also known as Primary Control;
- automatic-Frequency Restoration Reserve (aFRR) or Secondary Control;
- manual-FRR (mFRR) also known as Tertiary Control;



Balancing Markets Reform

Reform of Balancing Markets (from 1 to i countries):

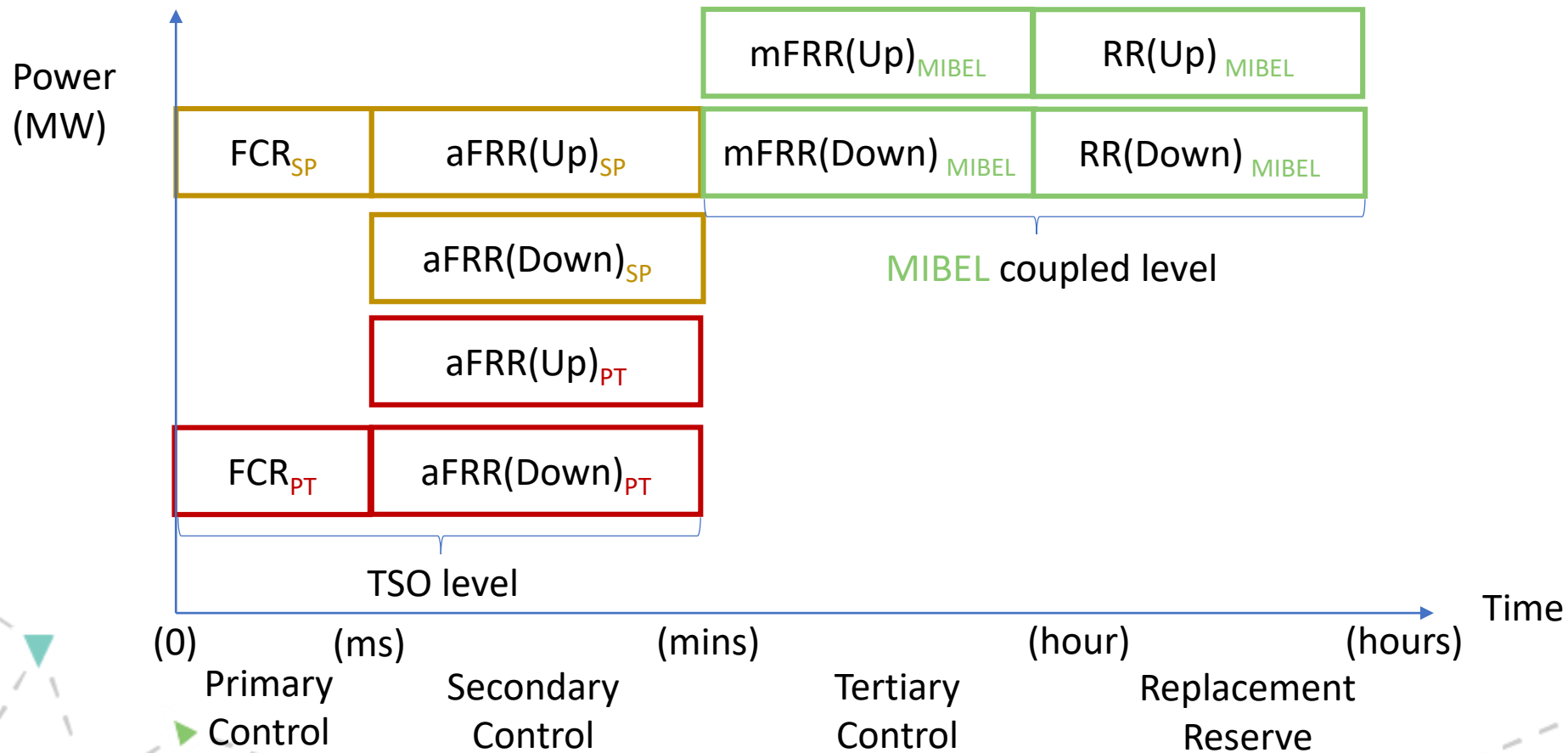


- FCR and aFRR managed by each TSO;
- mFRR and RR managed by coupled TSOs;
- Separate procurement of up and down reserve power/energy after primary control.



Iberian Balancing Markets Reform

Reform of Balancing Market (Iberian case):





Features of RESTrade 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

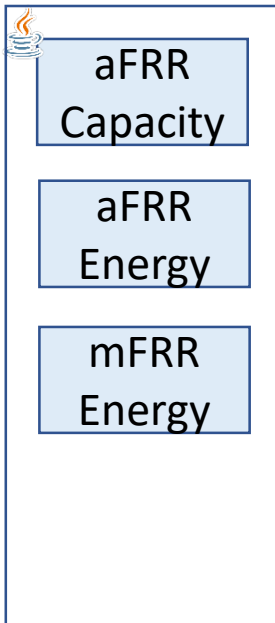
Dynamic Secondary capacity procurement New design

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



Features of RESTrade Tool

Market mechanisms



Marginal Pricing

Asymmetrical auction clearing

Pay-as-bid

Automatic match of opposite bids



Features of RESTrade Tool

Imbalance Settlement



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

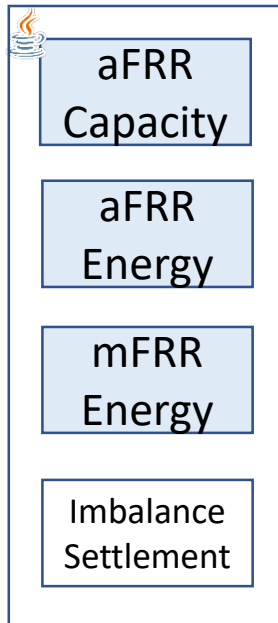
New design

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 RESTrade Tool

New market designs

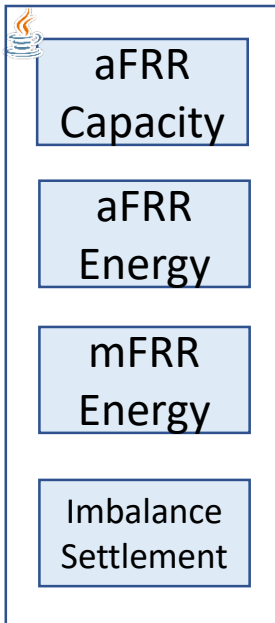


Rolling gate closures closer to real-time operation



Features of RESTrade Tool

New market designs



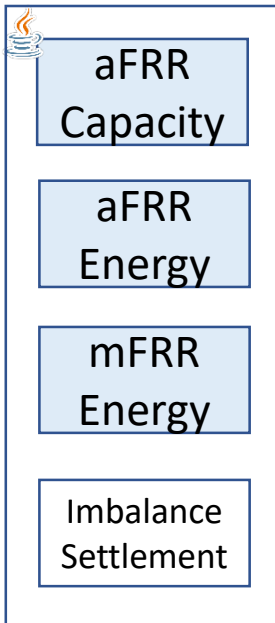
Rolling gate closures closer to real-time operation

Shorter market time units



Features of RESTrade Tool

New market designs



Rolling gate closures closer to real-time operation

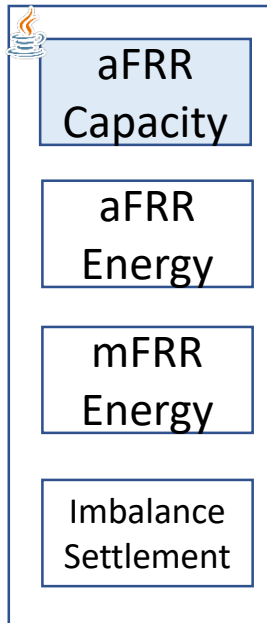
Shorter market time units

Shorter products



Features of RESTrade Tool

New market designs



Rolling gate closures closer to real-time operation

Shorter market time units

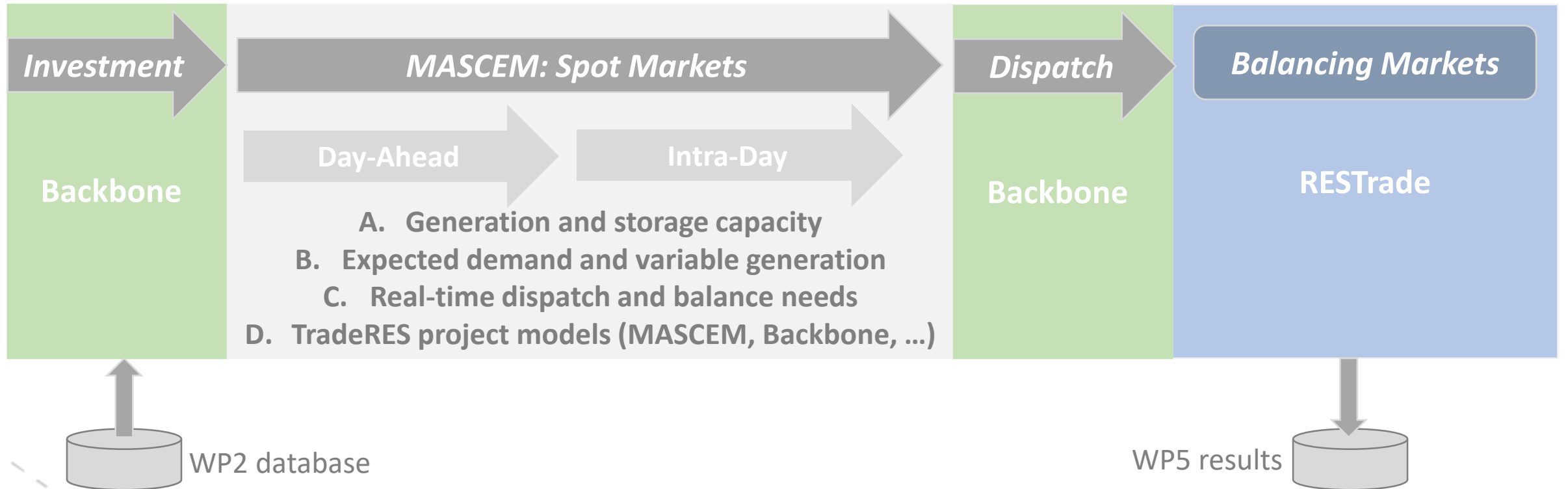
Shorter products

Separate procurement of upward and downward capacity



RESTrade coupled with other systems

Input Data





Results



Scenario

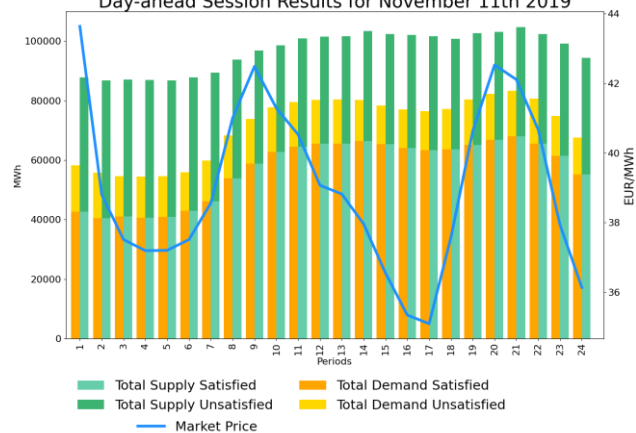
- Day-ahead & Intraday Auction markets
- April & November 2019
- Data
<https://www.omie.es/es/file-access-list>



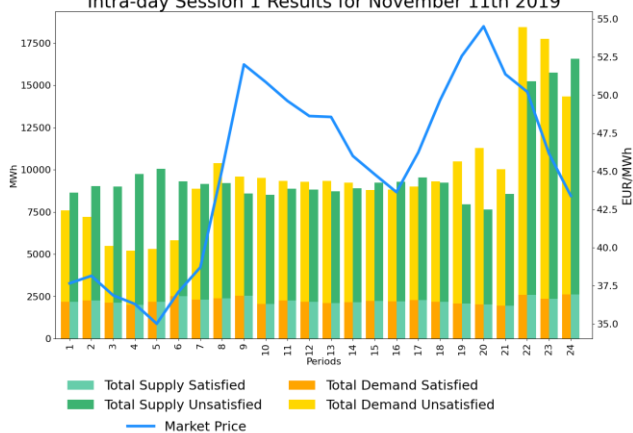


Results

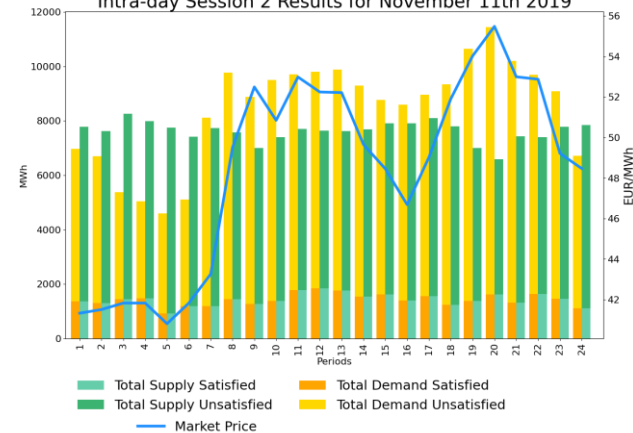
Day-ahead Session Results for November 11th 2019



Intra-day Session 1 Results for November 11th 2019



Intra-day Session 2 Results for November 11th 2019



Intra-day Session 3 Results for November 11th 2019



Intra-day Session 4 Results for November 11th 2019



Intra-day Session 5 Results for November 11th 2019



Intra-day Session 6 Results for November 11th 2019





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**Thank you for your attention.
Questions?**

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