Towards the use of pricing methods by Transmission System Operators on electricity balancing markets

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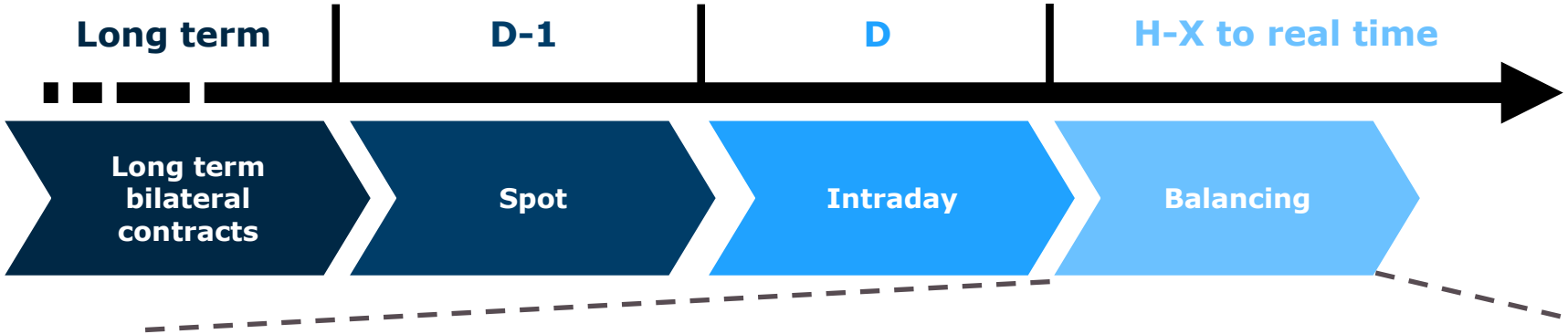
Electricity markets evolution



Historic framework

Local and diverse processes accross Europe

EU target framework

FCR market Frequency Containment Reserve	aFRR market Automatic Frequency Restoration Reserve	mFRR market Manual Frequency Restoration Reserve	RR market Replacement Reserve
FCR Cooperation	*Picasso platform*	*MARI platform*	*TERRE platform*

Literature review on actor behavior modeling in common balancing markets

Balancing Services Providers

Offer upward and downward reserves

Various studies look at the strategic behavior of BSPs:

- Poplavskaya, Lago & De Vries, *Effect of market design on strategic bidding behavior: Model-based analysis of European electricity balancing markets*, 2019
- Koch & Hirth, *Short-term electricity trading for system balancing: An empirical analysis of the role of intraday trading in balancing Germany's electricity system*, 2019

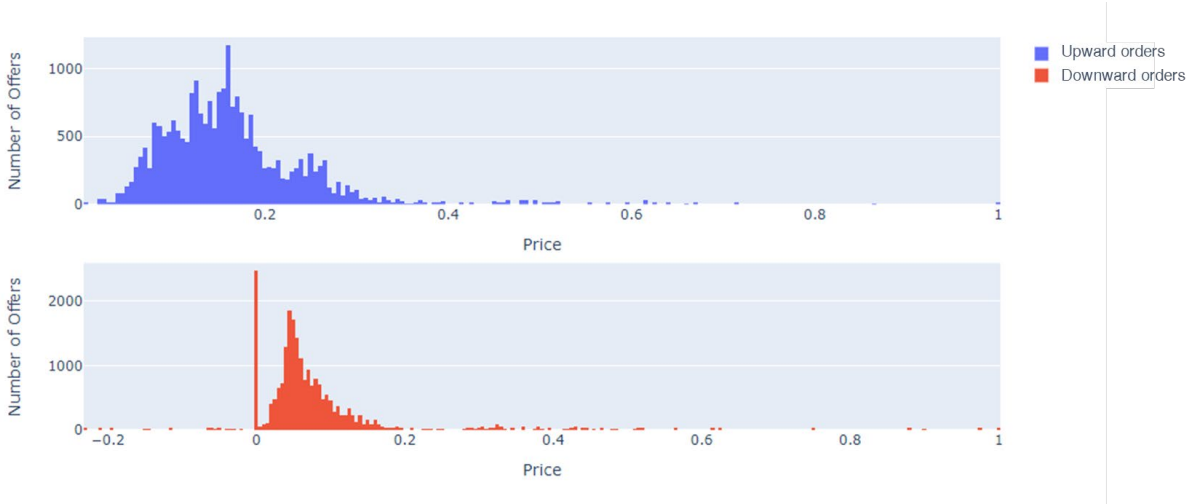
Transmission System Operators

Create balancing demands on their area

TSOs are always modeled as price takers.

Empirical analysis on operational balancing markets and the French Balancing Mechanism

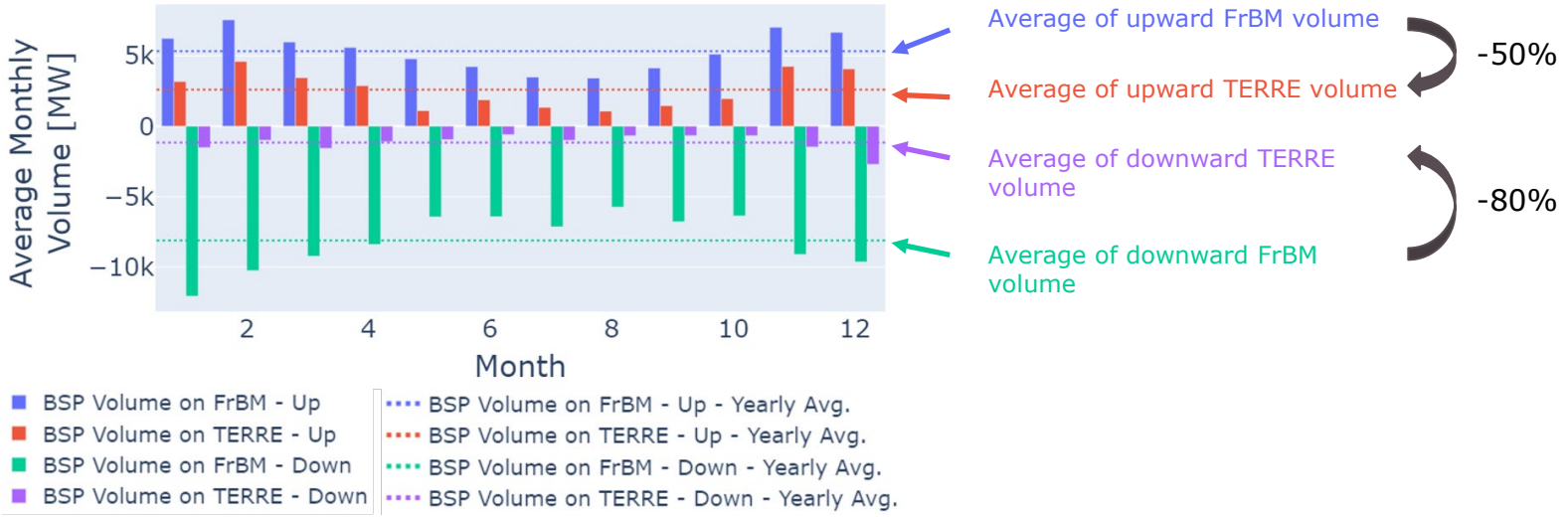
Are TSOs actually price takers on the TERRE market ?



Distribution of normalized prices of RTE's market orders on TERRE over 2022

Empirical analysis on operational balancing markets and the French Balancing Mechanism

If not, can we identify explanations for this ?



Comparison of BSPs reserves volume submitted to TERRE and on the FrBM over 2022

TSOs can actually compute demand prices based on available alternatives

- Several alternatives exist or will exist, and can induce different pricing methods:

Local balancing processes still running

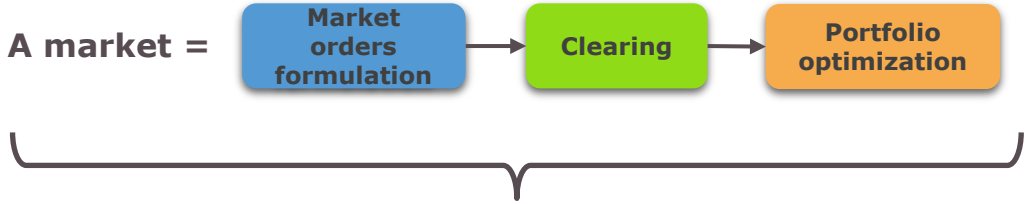
Future balancing markets (mFRR for instance)

Curtailment / Load shedding

- These pricings methods are also influenced by risk adversion.
- Important remark: By not being price takers, **TSOs** are not trying to adopt a strategic behavior (to maximise their profits), but rather to **accurately reflect their balancing costs**.

Introducing the topic of TSO demands formulation on balancing markets, by highlighting the benefits of using an appropriate pricing method associated to a specific alternative to the TERRE market

Modeling balancing markets using ATLAS



antaressimulator

Antares input data (RTE's Energy Pathways to 2050 in this study)

Data conversion to ATLAS and pre-market preparation

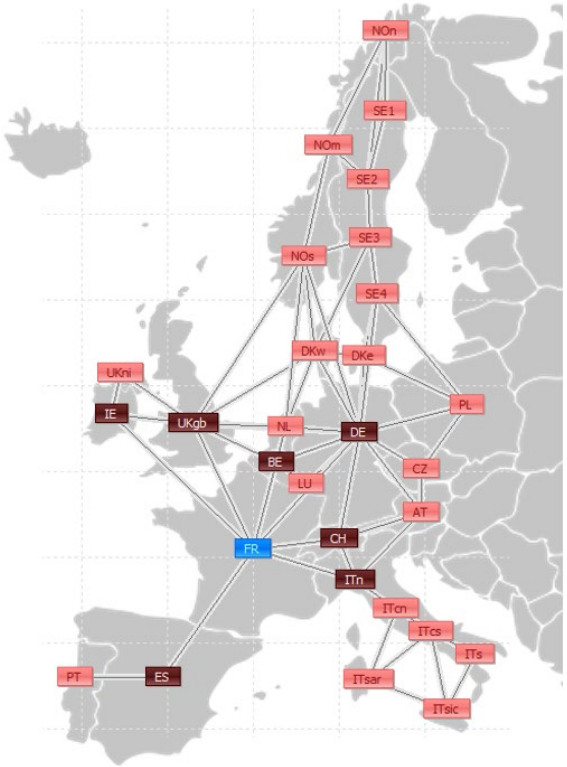
- Inclusion of **load, wind and solar production forecasts** with a 15 minutes step.

ATLAS electricity market model

DayAhead → Intraday → TERRE → MARI

- Multiple successive sessions of markets in a day:
  - 24 Intraday sessions
  - 24 TERRE sessions
  - 96 MARI sessions
- **Generation plans** are created/updated after each market.
- **Evolutive view of consumption, wind and solar creates imbalances** adressed by Intraday, and eventually Balancing markets

Input data : Energy Pathways to 2050, RTE



Power system map (2030)

Type of unit	Number of unit per area
Thermal	5 up to 20
Hydraulic	1 reservoir, 1 STEP
Wind	1
Solar	1
Storage	1 EV, 1 Battery
P2G	1
Other (non dispatchable)	1 hydraulic ROR, 1 other
Load	1

Power system unit types

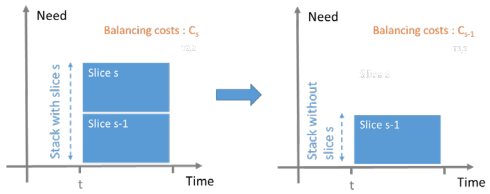
Methodology : Studied pricing methods and scenarios

2 pricing methods compared

At all cost

$$p_{o_{AAC,t}} = \pm 10{,}000\ €/MWh$$

Deterministic

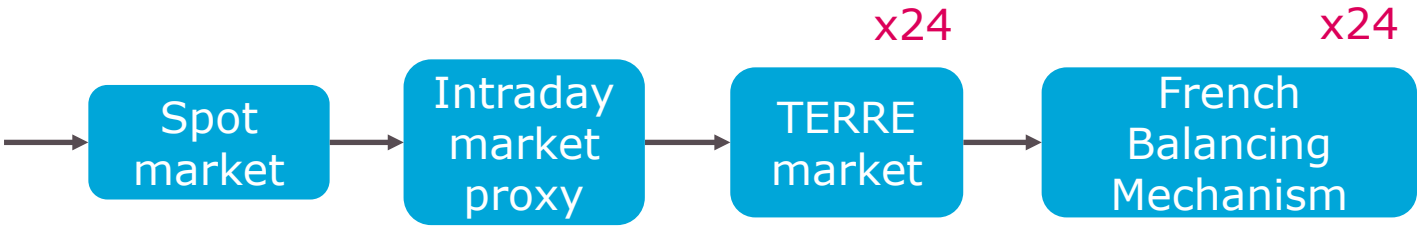


$$p_{o_{Det,t}} = \frac{C_s}{V_s} - \frac{C_{s-1}}{V_{s-1}}$$

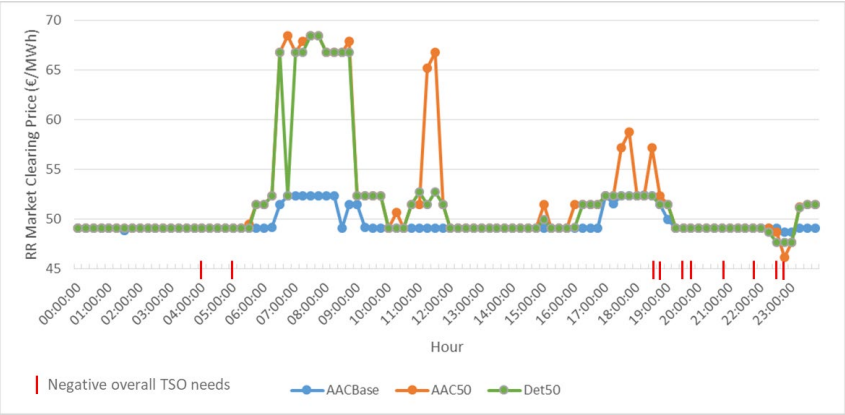
Leading to 3 scenarios, including a benchmark

Scenario	Percentage of BSP orders formulated on TERRE	TSO pricing method
Basecase AAC	100%	At all cost
AAC50	50%	At all cost
Det50	50%	Deterministic

A entire day of TERRE markets simulated



Results



TERRE market prices for each scenarios

Scenario	Studied TSO balancing costs (k€)				
	RR markets upward costs	*RR markets downward costs*	*Total RR markets costs*	*Local balancing costs*	*Total costs*
AACBase	6684.3	-3352.9	3,331.4	0	3,331.4
AAC50	7470.7	-3099.9	4,370.8	0	4,370.8
Det50	3327.7	-3097.1	231	3,135	3,365.7

An appropriate pricing method reduces balancing costs, eventually reducing social costs

Future work

Extension of the empirical analysis on RR markets.

Refinements of the example study:

- Inclusion of a **pricing** that considers **mFRR markets** as an alternative to RR markets.
- **Sensitivity analysis**, notably regarding gaming behavior of BSPs and their interaction with pricing methods, or the power system used.

Conclusion and key takeaways

TSOs are not price takers on balancing markets, which is proven by an empirical analysis, and can rely on alternatives to exhibit a demand price.

Given an alternative, an appropriate pricing method seems to yield benefits regarding balancing costs.

TSOs demand orders formulation on balancing markets is a topic of interest and several subjects could be studied:

- **Existing alternatives**, possibly different for each TSO
- **Definition of an optimal pricing method**, that would accurately reflect balancing costs, for a given set of alternatives

Thanks ! Any question ?