EMPIRICAL ANALYSIS OF TRANSMISSION SYSTEM OPERATORS PRICING BEHAVIORS ON ELECTRICITY BALANCING MARKETS

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Overview

In a context of liberalization of power systems in Europe, a series of markets have been created, ranging from several months or years prior to real-time to Intraday markets (up to one hour before real-time). The balancing stage refers to the period after the last Intraday market, during which Transmission System Operators (TSOs) are responsible for taking necessary actions to achieve balance between supply and demand in real-time. This stage was historically managed by each TSO in their own area, using local processes, leading to an heterogeneous state of balancing in Europe ([1], [2]). To improve efficiency and to allow for a better integration of renewable energy sources by providing an adapted and transparent market design notably, it was decided to harmonize the balancing stage by creating 4 standard types of balancing reserves that will be traded on specific markets:

- Frequency Containment Reserve (FCR), activated automatically within a few seconds to stop frequency deviations.
- Automatic Frequency Restoration Reserve (aFRR), activated automatically under a few minutes in order to restore the frequency back to its nominal value of 50 Hz.
- Manual Frequency Restoration Reserve (mFRR), that serves the same role as aFRR but is activated manually under 15 minutes.
- Replacement Reserve (RR), that are activated in 30 minutes to replenish the three faster reserve types described previously.

Amongst these reserve types, this study focuses on RR reserves. Their manual activation process makes it suited for an activation market, taking place on the cross-border platform TERRE that was launched at the beginning of 2020, and on which reserves orders formulated by Balancing Services Providers (BSPs) and balancing needs orders made by TSOs are matched. In academic literature modelling balancing markets, while the behavior of BSPs has already been studied (for instance, in [3]), TSOs are, to the authors' knowledge, always considered as price-takers. This assumption is challenged in this paper, using an empirical analysis of data from the operational TERRE market to prove that it is incorrect, and to identify possible reasons leading to this behaviour. In addition, an illustrative example of the benefits of pricing methods use for TSOs is also presented, through simulations on the electricity market model ATLAS.

Methods

We conducted an empirical analysis of TERRE data over 2 years (2021-2022), using databases of ENTSO-E Transparency Platform[1] and RTE[2]. Although data from 2020 is also available, it was left aside as many TSOs and BSPs were still merely testing the platform and were not submitting orders consistently. Orders quantity and prices from both BSPs and TSOs are analysed, as well as market results (market prices, orders accepted). Data coming from the French historical balancing process, called Balancing Mechanism (FrBM), was also used, especially the volume submitted by BSPs and the outputs of the process (activated quantities and average activation prices). The FrBM is currently still running on top of balancing markets, and cross-referencing data from both sources provides useful insights about the state of these markets. In particular, it shows that not all BSPs are formulating orders on the RR market and are still relying on the historical process, which sets an alternative for TSOs to price their orders.

To illustrates how such an alternative can be used as reference by TSOs, simulations are carried on the the ATLAS model. It is an agent-based electricity market model, detailed in [4], previously used in the European project OSMOSE [5] and in academic studies ([6] or [7]). It models Day-Ahead, Intraday and balancing markets as well as the FrBM in an environment with uncertainties regarding load and renewable energy generation. An entire day of electricity markets (comprised of a Day-Ahead, an Intraday, and 24 RR markets) was simulated for multiple scenarios, in which the quantity of orders formulated by BSPs and the pricing methods used by TSOs vary. The most basic pricing method,

[1] https://transparency.entsoe.eu/dashboard/show
[2] https://www.services-rte.com/en/home.html

that describes TSOs as price takers, is compared to a specific pricing method based on the opportunity cost of using the FrBM.

Results

The empirical analysis shows that TSOs are not price-takers on balancing markets, as they almost never set the price of their orders to the maximum (or minimum, depending on the direction of their needs) price allowed on the TERRE platform. This is illustrated in the figure on the right side, that plots a normalized distribution of order prices from the French TSO RTE[3] (upward orders indicating a need of positive energy activation, and downward orders a need of negative energy activation).

Figure 1 - French TSO RR market orders prices

The comparison between orders submitted by BSPs on the RR market and the volume they send to the FrBM shows that, over 2022, approximatively 50% of the power that could be formulated as upward reserves on the market is not and goes directly to the local balancing process. This share is even greater for downward reserves, as more than 80% of the available power is not formulated on TERRE. Reasons for this lack of orders are discussed in the paper. It could be an explanation as to why TSOs are using pricing methods on TERRE. Indeed, results of the ATLAS simulations indicate that under this circumstances, the illustrative pricing method yields important benefits for the TSOs and for society as a whole through reduced balancing costs, and an improved social welfare.

Conclusions

This paper discusses the state of TSOs on electricity balancing markets, by advocating the fact that they should not be considered as price-takers on these markets. Using an empirical analysis of the RR markets, joined by simulations done on the ATLAS agent-based model, the study shows that TSO are indeed actually using pricing methods, develops possible reasons for this observed situation, and highlights the benefits for TSOs and society of using pricing methods when alternative to balancing markets exist. It raises new questions that will be further explored in our work, such as: from the point of view of a TSO, what are all the alternatives to a specific balancing market ? Given an alternative, what is the optimal pricing method that would reflect a TSO's balancing costs ?

References

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[3] We are currently waiting for authorizations to publish similar data for other TSOs in Europe, RTE being the only TSO to publish the prices of their orders.