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The interplay between imbalance pricing mechanisms and network congestions – Analysis of the German electricity market

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ABSTRACT

With a high penetration of intermittent energy sources in Europe, the relevance of the balancing mechanisms increases, as these sources may require additional balancing actions and increase network congestions. Germany has experienced a significant penetration of intermittent energy sources and network congestions. This paper analyses the functioning of the German balancing mechanisms, with a special focus on the interplay between imbalance pricing and network congestions. We demonstrate the existence of adverse price signals caused by a flawed design of imbalance pricing in relation to network congestions. This paper proposes alternatives options for imbalance pricing that can improve price signals even in the situation of network congestion.

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1. Introduction

The electricity markets were originally designed for dispatchable power sources. The increasing share of intermittent energy sources (IES) in Europe in order to fulfill the European targets[1] may require a redesign of electricity markets to ensure their well-functioning. The increase of IES, mainly wind and solar photovoltaic, impacts the electricity systems and markets in different ways: IES may increase network congestions, influence market prices and the energy balance, and create new bidding strategies (Chaves-Ávila et al., January 2013).

Market parties may trade electricity bilaterally or through organized markets, such as the day-ahead markets or intraday markets. However, they may deviate from earlier commitments. On the other hand, the System Operator (SO) is responsible for maintaining the system balance. For this, in the context of a liberalized market, the system operator purchases balancing services from the market parties. Through the imbalance prices, the system operator allocates part of the balancing services' costs to the markets parties that have deviated from their commitments. In addition, the imbalance price may give incentives to market parties to support the system balance in real time. The design of the balancing mechanism is key to guarantee an efficient functioning of the market and integration of IES, such as wind (Vandezande et al., July 2010).

The design of the imbalance pricing mechanisms has been studied before (Vandezande et al., July 2010; van der Veen and Hakvoort, April 2010; van der Veen et al., July 2012). However, in literature the interplay between imbalance pricing and network congestions has not yet been studied in detail. More IES results in a higher occurrence of congestions, especially in the case of wind power which is generally located far from consumption. We argue that, under congestions, imbalance prices may give misleading price signals, depending on the design of the imbalance pricing mechanisms. The conditions for these adverse imbalance price signals are explained in detail.

The German market is an interesting case study to analyze the interplay between the imbalance pricing and network congestions. Germany applies a single imbalance pricing mechanism for the whole country even in the case of internal congestions, while the country has a significant penetration of IES and internal congestions are increasing. Additionally, Germany is divided in different control zones. Each SO publishes its own control area imbalances and as well as zonal congestion data. Based on an analysis of the German market, evidence is offered for adverse price signals being given to market participants as a result of the interplay between

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[1] The European Commission' s Directive 2009/28/EC establishes a mandatory national target of 20% share of energy produced from renewable sources. Wind power will significantly contribute to fulfill these targets. Since 2000, 27.7% of new capacity installed has been wind power in the European Union, and already it represents a significant share of total electricity consumption in the European countries in 2012: 27% in Denmark, 17% in Portugal, 15% in Spain, 13% in Ireland and 11% in Germany (European Wind Energy Association EWEA, February 2013).

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imbalance pricing design and network congestions. The analysis of the German imbalance pricing can also be extended to other European countries that share similar market designs and an increase of network congestions due to the increase of IES.

This paper continues as follows: Section 2 describes the literature review on European balancing mechanisms. Section 3 describes balancing mechanisms in Germany, mainly the imbalance pricing. Section 4 focuses on the German internal congestion management. Section 5 shows how the imbalance prices can give misleading incentives in the context of internal congestions and provides empirical evidence from the German market. Section 6 gives some alternative designs for the imbalance pricing that avoid adverse imbalance price signals in case of network congestion. Section 7 discusses the relevance of the analysis and results for policy markers. Finally, Section 8 highlights the main findings.

2. Literature review on European balancing mechanisms

In the European countries, market parties can trade electricity bilaterally or in centralized wholesale electricity markets, through power exchanges. These markets provide national prices. The market parties have the obligations to fulfill their energy schedules. In case of deviations from those schedules and network congestions, the SOs are the entities in charge of keeping the power balance and security in their control zones. As part of this task, after the clearance of the day-ahead and intraday markets, and considering bilateral trading, a congestion management mechanism (redispatch) takes place to solve foreseen congestions. In addition, the electricity systems have the requirement that supply and demand should be equal in each instant. The market parties are incentivized to participate actively in the balancing mechanisms, by sending accurate schedules to the SOs and by participating in the provision of balancing services. These balancing mechanisms can be divided into three main pillars (van der Veen and Hakvoort, May 2009): balance responsibility, balancing service provision and imbalance settlement.

The balance responsibility defines the obligation of the market participants (generators, consumers and traders) to send schedules (for both consumption and production) to the SO and the financial responsibility for the deviation from those schedules. The market participants, in this sense, are called Balance Responsible Parties (BRPs). In Germany before 2012, IES did not directly participate in the market, instead the SOs were obliged to sell the electricity from renewable sources in the day-ahead and intraday markets (Eclareon, 2011). Since 2012, the IES can choose to be fully balance responsible, participate in the market and receive a feed-in premium on the top of the market prices (Gawel and Purkus, October 2013).[2] The participation of IES in the market gives the challenges to incentivize these units to improve energy forecast through the markets. For this, proper market signals are required as IES can bid in the markets differently from their expected energy if it is profitable for them (Chaves-Ávila et al., January 2013).

The balancing service provision defines how different balancing services (i.e. active power reserves) are bought, and how the producers are remunerated. The SOs usually buy the balancing services in the balancing markets. These services can have a capacity and energy component. The capacity component corresponds to the availability to provide balancing energy in real-time. The participants in those markets are called Balance Service Providers (BSPs). The European SOs use active power balancing services (reserves),

[2] For 2014, the German TSOs expect that the wind energy delivered under the premium scheme represent around 87% of total wind generation (German TSOs, October 2013).

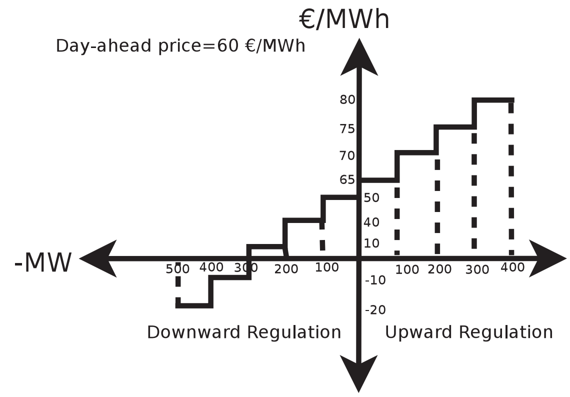

Fig. 1. Illustrative example of merit order of energy balancing services.

that can be generally divided in (European Network of Transmission System Operators for Electricity ENTSO-E and May 2012): Frequency Containment Reserves (FCR), Frequency Restoration Reserves (FRR) and Replacement Reserves (RR).[3] These reserves are differentiated by the activation time, activation mode and their functionalities. In Germany, FRR are called secondary reserves and RR correspond to minute reserves.

The third pillar of balancing mechanism deals with how the imbalances and the imbalance prices are determined, and thereby, how the balancing costs are allocated to BRPs. BRPs are incentivized to send accurate schedules, because they pay/receive the imbalance prices for the deviations (however, under certain imbalance pricing rules and price levels, BRPs might be incentivized to deviate from their schedules). The Settlement Time Unit (STU) is the interval over which the energy imbalances and imbalance prices are computed. The balancing costs that are allocated to market parties depend on the capacity and energy costs of the reserves. However, the reserves capacity (FCR, FRR and RR) and the energy cost of FCR (in case it is remunerated) are usually allocated through grid fees, whereas the energy component of FRR and RR are allocated for every STU to the market parties that have deviations from the energy schedules.

The electricity system imbalance is the sum of the market parties' imbalances. Therefore, if the system is short (less generation or more consumption than scheduled), there is a need for upward regulation, whereas if the system is long (more generation or less consumption than scheduled), there is a need for downward regulation. The system balance can also be affected by the network and the power flows, consequently, there could be local imbalances that can be in the opposite direction to that of the overall system imbalance.

2.1. Design of balancing service provision

This paper does not study in detail how the procurement of balancing services is organized. However, it is important to highlight some relevant aspects of the procurement of FRR and RR, as their costs are used to determine the imbalance prices. A further description of the procurement organization of FRR and RR in some European countries can be found in European Network of Transmission System Operators for Electricity ENTSO-E and September (2012) and Chaves-Ávila and Hakvoort (2013).

If the balancing services are bought after the day-ahead market, the price levels of these bids are similar to what is shown in Fig. 1. When there is a need for upward regulation, those units

[3] Previously in Continental Europe (former UCTE area), these services were called primary, secondary and tertiary reserves, respectively.

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