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# Balancing energy strategies in electricity portfolio management

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ABSTRACT

Traditional management of electricity portfolios is focused on the day-ahead market and futures of longer maturity. Within limits, market participants can however also resort to the balancing energy market to close their positions. In this paper, we determine strategic positions in the balancing energy market and identify corresponding economic incentives in an analysis of the German balancing energy demand. We find that those strategies allow an economically optimal starting point for real-time balancing and create a marketplace for flexible capacity that is more open than alternative marketplaces. The strategies we proffer in this paper we believe will contribute to an effective functioning of the electricity market.



## 1. Introduction

In the late 20th century, electricity markets were liberalized across the world. Since this restructuring, integrated companies have separated into specialized individual market participants. In addition, institutional investors such as banks and hedge funds have entered the market not solely to exploit its opportunities but also for risk diversification. All these players face not only the risk of a highly volatile energy market, but also the inner-market risk of the electricity market. Naturally, market participants want to actively trade and hedge this risk.

Alongside with traditional bilateral over-the-counter (OTC) contracts, electricity exchange-traded contracts have emerged as instruments for these inner-market trades. Among these contracts, the day-ahead futures contract is the principal instrument. This futures contract offers the shortest delivery period — often 1 h — and serves as the reference price for longer-dated futures contracts. For this reason, the day-ahead futures contract is sometimes referred to as the spot contract. The properties of the day-ahead market and the market for futures written on day-ahead contracts have been analyzed using various modeling approaches (see, for example, Geman and Roncoroni, 2006; Trück et al., 2007; Römisch and Wegner-Specht, 2005). In addition, the interdependence of the day-ahead market and the futures market has been investigated (see, for example, Bessembinder and Lemmon, 2002; de Jong and Huisman, 2002).

The aggregate positions in the futures and day-ahead markets serve as a preliminary schedule for operating an electricity network. However, because electricity is practically non-storable, the market for electricity consumption and delivery also requires a marketplace for ancillary services so that blackouts may be avoided. The *capacity reserve market* is one such marketplace. Capacity reserve is provided by installations such as the fraction of power stations or factories that are readily adjustable to counter deviations from the preliminary schedule. The capacity of these installations can be traded on the electricity exchange as well as on the capacity reserve market. Thus, the day-ahead market and the capacity reserve market are interchangeable marketplaces for trading this capacity. It should be noted that ancillary services value the flexibility of electricity interchange, whereas the focus of the futures market is energy content. Nonetheless, it is recognized that the competition between these two marketplaces should be taken into account in formulating optimal bidding strategies in both trading forums (see Weigt and Riedel, 2007; Simoglou and Bakirtzis, 2008). In this paper, we extend this notion of interchangeable marketplaces to another ancillary services market, the *balancing energy market* where electricity transactions relative to the preliminary schedule are settled.

The market design of the balancing energy market is a crucial component of electricity markets as it mediates between the liberalized futures and day-ahead markets, and the natural monopoly of the grid and its operation (see ETSO, 2007). In view of the stated objective of increasing renewable generation in the future (see EU, 2008 and U.S.

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Congress, 2009), this importance is likely to become even more pronounced. Clearly the value of flexible electricity interchange increases with a higher market share of renewables such as wind energy (see EU, 2005). Therefore, a harmonization of the balancing energy markets is being pursued in Europe.

Several studies compare and analyze the current European market designs to identify potential approaches to achieve harmonization (see ETSO, 2007; Belmans et al., 2009). However, all these studies are focused on the point of view of system security and disregard the implications of strategic positions in the balancing energy market. In fact, such positions are controversial. It has been argued that any use of the balancing energy market, apart from the settlement of imbalances caused by unpredictable events, might endanger the system operation by adding the uncertainty associated with market participants' strategic positions. As a consequence, the balancing energy market is reduced to a marketplace with a single focus on secure system operation and blackout prevention (see Belmans et al., 2009; ERGEG, 2006). In analyzing these positions, we add the perspective of market equilibria with interchangeable marketplaces in our discussion of European market designs. Outside European markets, this notion is recognized in the PJM electricity market, for example, that even allows purely financial positions to enhance market price convergence (see Zhou et al., 2003 Longstaff and Wang, 2004).

In the context of interchangeable marketplaces, we focus on two aspects of the balancing energy market. We first look at the balancing energy market as an alternative marketplace for reserve capacity. By comparison, it offers market access to a wider and technically less demanding range of installations such as power stations or factories. Second, we investigate the balancing energy market's interplay with the marketplace for electricity consumption and delivery. Because the price formation of the balancing energy market and the day-ahead market differ, this alternative marketplace potentially dampens the effects of electricity price spikes on the electricity portfolio of market participants.

In this paper, we provide evidence of the balancing energy market being utilized as an alternative market for both the electricity exchange and reserve capacity in Germany. The German market is chosen for this analysis due to the combination of its market design and generation stock. More specifically, among European markets, the German market is the only major market that does not impose implicit transaction costs or even penalties on electricity transactions in the balancing energy market. In fact, Boogert and Dupont, 2005 show that the level of penalties effectively prohibits strategic positions in the Netherlands. Therefore, it is only in the German market that strategic positions can be observed undistorted. Moreover, the German market features a thermal-based generation stock, allowing transferring results to similar markets. In this respect, a renewable power market share of 15% also reflects the importance of the balancing energy market for the integration of renewables (see BMU, 2009). The share of inflexible thermal and renewable generation translates into a high value of load flexibility as reflected in a high spread between balancing energy prices during periods of positive and negative net deviation. This spread enhances the economic incentive for strategic positions. Finally, different fundamental periods of the balancing energy market and the day-ahead market allow analyzing the interaction with the capacity reserve market and the day-ahead market separately. Therefore, Germany provides a suitable setting to observe the interaction with interchangeable marketplaces described earlier.

The paper is organized as follows. Section 2 provides a brief review of balancing energy settlement schemes, followed by a description of the German market design and the motivation for the chosen setting in Section 3. Section 4 describes the data and introduces the proposed modeling approach. A quarter–hourly pattern is analyzed in Section 5. Section 6 focuses on an hourly pattern, and the interdependence with the day-ahead market. At the same time, we look at the incentive structure leading to the observed patterns at these two timeframes. Additionally, we look at incentives for positions in the balancing energy market persistent over longer periods of time in Section 7. Section 8 summarizes our results and their implications.

## 2. Balancing energy review

In the electricity market, supply and demand have to be in exact equilibrium at all times due to the practically non-storable character of electricity. The equilibrium is monitored and maintained by the transmission system operator (TSO) in a specific control area. All parties connected to the grid within this control area are required to provide the TSO with a balanced forecast of feed-ins and withdrawals. Several market participants may pool this responsibility and form a *balancing responsible party* (BRP). The sum over all forecasts of all BRPs provides a preliminary schedule that the TSO can use for balancing. However, a BRP can take a strategic position by concealing part of its electricity portfolio. Along with any unforeseen changes to a BRP's portfolio, these positions are settled with the TSO as so-called *balancing energy*. Therefore, every BRP's deviation from its provided forecast is calculated for a given settlement period.

Some of the costs of balancing — mainly the cost of short-lived disturbances and capacity procurement — are socialized in grid tariffs. The cost of lasting disturbances — disturbances implying energy transactions — are attributed to the originator, however. That is, a BRP consuming electricity in excess of its forecast pays the balancing energy price, while a BRP providing the network with electricity relative to its forecast is compensated.

In this paper, the deviation is defined as the difference between the actual load and the forecasted load. Accordingly, we will use the following sign convention throughout this paper: a positive sign means an undersupply and a negative sign means an oversupply. It is important to note that an individual BRP might deviate with the opposite sign to the control area's net deviation. In effect such deviations reduce the net deviation. Therefore, BRP's deviations do not incur cost per se, but might enhance system security in a given period in the same way the TSO's active balancing does.

The design of balancing energy markets is diverse, reflecting local specifics as generation stock and customary operation policies. Many electricity markets rely on a real-time market to organize the settlement of balancing energy (California, New York, and Pennsylvania–New Jersey–Maryland). In contrast, balancing energy is settled at prices set after the real-time balancing in European electricity markets. There are two general settlement schemes in Europe: single-price and dual-price settlement. These settlement schemes reflect a different view on the stabilizing effect of deviations countering the control area's net deviation (see ETSO, 2003, 2007).

In a single-price scheme the TSO will set one price for both charging positive and compensating negative deviations in each settlement period. Naturally, this price is high during periods with a positive net deviation as on the whole there is a shortage of electricity. Equivalently, the price is low during periods with a negative net deviation and an oversupply of electricity. Thus, the single-price approach sets an incentive to deviate in the opposite direction to the net deviation in the control area (i.e., receive payments during high price periods and make payments during periods of low prices). If feasible, a strategic position following this incentive will reduce the net deviation in much the same way as the deployment of capacity reserve.

Like the day-ahead market, the balancing energy market also is a market for energy transactions. If the spread between the day-ahead and the expected balancing energy price is positive, it is beneficial for BRPs to be in undersupply on the day-ahead market with a countering position in the balancing energy market, and vice versa for a negative spread. Note that the balancing energy price is set by the TSO after the settlement period. Consequently, the balancing energy market can only offer statistical-arbitrage opportunities.

The dual-price system is designed to suppress such statistical-arbitrage activity. In the dual-price settlement scheme, the TSO will