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ANALYSIS OF THE IMPACT OF IMBALANCE SETTLEMENT DESIGN ON MARKET BEHAVIOUR IN ELECTRICITY BALANCING MARKETS

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OVERVIEW

The imbalance settlement design is the part of an electricity balancing market design that stimulates so-called Balance Responsible Parties (BRPs) to balance their electricity production and consumption portfolio and to stick to their energy schedules by penalizing any deviations from these schedules with an imbalance price [1]. There are numerous imbalance settlement design options, each of which gives different incentives to BRPs. The aim of this work is to analyze the impact of the imbalance settlement design on BRP behaviour, and thereby on balancing market performance. Because the behaviour of Balance Responsible Parties determines for a large part the imbalance prices and these imbalance prices influence the behaviour of BRPs again, balancing market performance is dynamic. Therefore, the analysis of alternative imbalance settlement designs requires a model that incorporates individual decision-making by BRPs, and adaptation of operational strategies on the basis of balancing market outcomes – an agent-based model. We have built such a model with Matlab. This model includes a simplified representation of the balancing market, and different autonomous agents representing the BRPs. The analysis results are formed by differences in imbalance settlement performance indicators for different imbalance settlement designs, on the basis of which we can conclude on the relative value of these designs. More generally, we will gain insight into the dynamics of the balancing market, and into the relevance of imbalance settlement design.

METHODS

In order to analyze the impact of imbalance settlement designs on balancing market performance, we have built a simplified agent-based model of the imbalance settlement system. The conceptual model is shown in Figure 1. To start, we assume a certain number of BRPs (1…N), who have to decide on an intentional imbalance within each round (1..M). The sum of the intentional and the unintentional imbalance is the individual BRP imbalance. For each round, the net sum of the individual imbalances is equal to the system imbalance. This system imbalance is removed by an equal activation of balancing energy bids from the fixed bid ladder. Given the imbalance settlement design, this results in two imbalance prices in each round: one for negative imbalances (shortages) and one for positive imbalances (surpluses). Then, the actual BRP costs for each round can be calculated according to Equation (1). In this equation, $AIC_{n,m}$ are the actual imbalance costs for BRP n in round m, P_{ni} is the imbalance price applied to negative imbalances, P_{pi} is the imbalance price applied to positive imbalances, P_{da} is the day-ahead price, and IV_n is the imbalance volume of BRP n. Based on the actual BRP costs in the past round(s), the BRPs will decide on their intentional imbalance in the next round, resulting in evolving balancing market performance.

$$AIC_{n,m} = \begin{cases} (P_{ni,m} - P_{da,m}) * IV_{n,m} & \text{if } IV_n < 0 \\ (P_{da,m} - P_{pi,m}) * IV_{n,m} & \text{if } IV_n > 0 \\ 0 & \text{if } IV_n = 0 \end{cases} \qquad (1)$$

The fixed bid ladders consist of different balancing energy bids with different volumes and prices, ordered on the basis of bid price. The system imbalance in each round is solved by activation of an amount of bids equal to the system imbalance. The reference imbalance pricing mechanism is that both the positive imbalance price and the negative imbalance price become the bid price of the last activated bid in price order. In different imbalance settlement designs, alternative pricing mechanisms will be applied. The decision rules of all the BRPs will relate input (intentional imbalance) to output (actual BRP costs) in previous rounds, and concern the calculation of an input for the next round that will minimize the expected actual BRP costs.

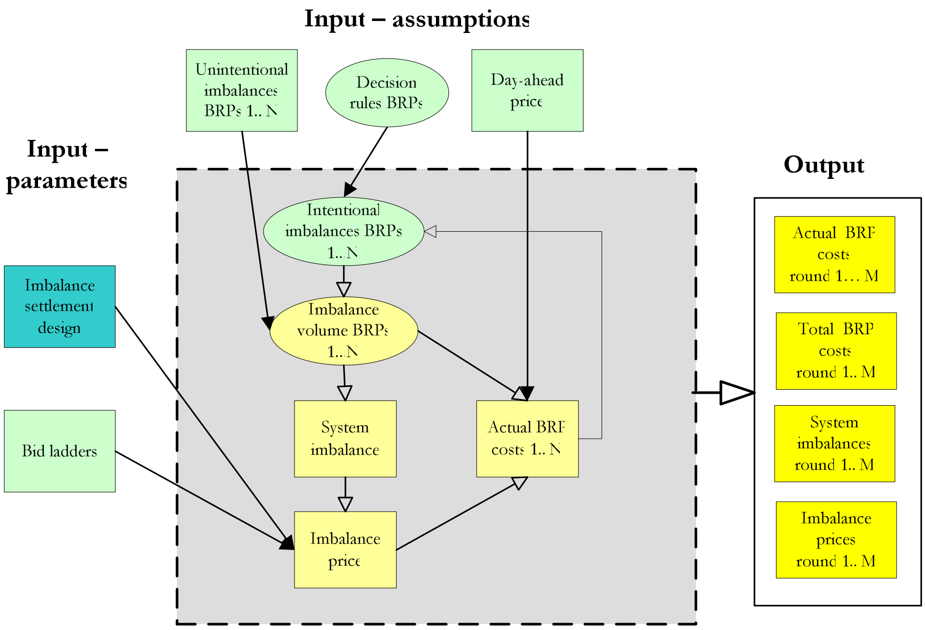

Fig. 1. Conceptual model of the imbalance settlement system

RESULTS

The results are formed by the differences in output, which are represented by the actual BRP costs, total BRP costs, system imbalances, and imbalance prices, for different imbalance settlement designs. In addition, differences in output for different fixed bid ladders will be presented.

CONCLUSIONS

We conclude that different imbalance pricing mechanisms will lead to significant changes in BRP strategies, system imbalances and imbalance prices. However, a 'balancing market equilibrium' appears to develop for all designs. Furthermore, we conclude that due to the interrelations between imbalance settlement and the balancing energy market (bid ladders), final statements about the impact of imbalance settlement design on balancing market performance cannot be made on the basis of this analysis.

REFERENCES

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